

**EFFECTS OF EXPERIMENTAL APPROACH OF TEACHING ON KNOWLEDGE  
MASTERY AND SKILLS ACQUISITION IN CHEMISTRY IN SECONDARY  
SCHOOLS OF TESO SOUTH**

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**A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
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## DECLARATION

### DECLARATION BY CANDIDATE

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## **DEDICATION**

This work I dedicate to my dear wife Eunice and beloved children Joy and Juniperro.

This research thesis is dedicated to all chemistry teachers for their efforts of making sure the Kenyan child excels in the science and technology world.

I also dedicate the study to the Ministry of Education, Teachers Service Commission and Kenya Institute of Curriculum Development for management and implementation of secondary school curriculum.

## ABSTRACT

Chemistry as a subject is one of the very important science subject in the Kenyan secondary schools curriculum. Being a science, the subject is experimental in nature where learning should start with hands on experiences and not abstract definitions. In this approach of teaching, the learners interact with apparatus, make observations and come up with conclusions. In addition, it should conform to the Science, Technology, Engineering and Mathematics since the country is geared towards achieving vision 2030. The study looked at the effects of experiments on knowledge mastery and science process skills acquisition in Chemistry in Teso South Sub-County secondary schools. The Kenya National Examination Council reports of 2014, 2016, and 2017 which pointed out the need for practical work among secondary school learners hence the choice of the study. Specifically the objectives of the study were two; to determine the effects of experimental work on students' knowledge mastery in chemistry and also effects of experimental work on students' acquisition of science process skills. Piaget theory of constructivism formed the theoretical framework of this study. The units of analysis in this study were the form three students. This study targeted 1216 form 3 students in 18 secondary schools of Teso South Sub-County since chemistry is one of the compulsory subjects in the region. Of this, 333 form three students from six secondary schools were sampled out. The methodology employed in this research study was both quantitative and qualitative. The design used was quasi-experimental design. Stratified random sampling was used to obtain six mixed secondary schools; three treated as experimental while the other three control. The study employed three instruments namely: A Pretest, Observation Checklist for acquisition of skills and Post-test. The data obtained was analyzed using both descriptive and inferential statistics. For the first objective, the means for pre-tests for experimental group is  $15.4 \pm 1.3$  and that of the control group  $17.3 \pm 1.8$  while those of post-tests for experimental group  $34.2 \pm 1.3$  and that of control group is  $32.0 \pm 1.4$ . The *p values* were used to determine the significance of the study. In this research study, a  $p=0.001$  was obtained; therefore there was significant difference in the learners' performance for the experimental group of learners and the control group. For the second objective, seven science skills (of observing, measuring, recording, classifying, setting-up apparatus, reading scales, manipulating data) were examined whether students acquired them proficiently or to small extent or unable. The t-test of these three dimensions gave  $p=0.0026$ ,  $p=0.0016$  and  $p=0.0238$  respectively, to mean that there was a significant difference in the science process skills acquisition for the leaners in the experiments group and those in the control group. In a nut shell, experimental group of learners performed better than the control group of learners in both mastery of knowledge and acquisition of process skills. Therefore, the study recommended teachers of chemistry to use experimental approach in teaching chemistry to enhance students' performance. The findings of this study would be useful to chemistry and other science subjects, teacher training institutions, Kenya National Examination Council and finally Ministry of Education.

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**ABBREVIATIONS / ACRONYMS**

<b>ASEI</b>	Activity-focused, Student-centered learning with Experiment and Improvisation.
<b>CDF</b>	Constituency Development Fund
<b>DCC</b>	Deputy County Commissioner
<b>ICT</b>	Information Communication Technology
<b>ILE</b>	Improvised Laboratory Experimentation.
<b>JICA</b>	Japanese International Cooperation Agency
<b>KCSE</b>	Kenya Certificate of Secondary Education
<b>KICD</b>	Kenya Institute of Curriculum Development.
<b>KNEC</b>	Kenya National Examinations Council
<b>MSS</b>	Mean Standard Score
<b>NACOSTI</b>	National Commission for Science, Technology and Innovation
<b>OCFSA</b>	Observational Checklist for Skills Acquisition
<b>POE</b>	Predict-Observe-Explain
<b>SAT</b>	Students Achievement Test
<b>STEM</b>	Science, Technology, Engineering and Mathematics
<b>SCORE</b>	Science Community Representing Education.
<b>SEPU</b>	Science Equipment Production Unit

<b>SI</b>	System International
<b>SMASSE</b>	Strengthening Mathematics and Science in Secondary Education
<b>SPSS</b>	Statistical Package for Social Science
<b>VC</b>	Vice-Chancellor

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## **CHAPTER ONE**

### **INTRODUCTION TO THE STUDY**

#### **1.1 Chapter Introduction**

This chapter looks at the background information of the study, which entails the importance of the practical work and where practical work has worked best. The background also looks at the need to support practical work. The chapter in addition brings out the statement of the problem, purpose of the study, objectives of the study, hypothesis, significance of the study, assumptions of the study, scope and limitations of the study, theoretical and conceptual framework definition of operational terms and summary of the chapter.

#### **1.2 Background of the study**

According to Sharples, M., de Roock, R., Ferguson, R., Gaved, M., Herodotus, C., Kho, E., & Weller, M. (2016), practical work is any science teaching that involves students working individually or in small groups, manipulating and or observing real objects and materials as opposed to the virtual teaching. Schutt (2018) defined practical work as a learning experience where students interact with materials (both apparatus and reagents) or with secondary sources like textbooks and journals in order to observe and understand the natural world. Morrison, G. R., Ross, S. J., Morrison, J. R., & Kalman, H. K. (2019), defined the term ‘practical work’ as any science instruction in which students, work either individually or in small groups. This depends on what they are doing, for instance manipulating and/or observing real objects and materials requires individual efforts as

opposed to virtual objects and materials such as those obtained from a DVD, computer simulation or even from a text-based account, these require group work.

Therefore, practical approach of teaching is a modern technique that involves first-hand experience through observation, manipulation of apparatus and analysis of results obtained (Fadzil & Saat 2017). In a nutshell, practical work is the interaction of learners with real apparatus and content in a given special room in order to achieve a given set objectives. Education is the key to any development in a country. Science education on the other hand is very important for the development of methods and standards of living. It is close to unimaginable for a society to develop without science education in-put. Scientific knowledge heavily relies on the evidence from laboratory or field activities. The mastery of knowledge gained through science education is literary high as a result of the practical work and application; therefore priority has been given to science education worldwide (Hansen, et al., 2016).

To improve technological aspect, greater emphasis on science education has been placed by most of the middle income countries in the world (Rodney, 2018). These countries spend a lot of money to improve the quality of science education (Ganimian & Murnane 2016). According to Ganimian and Murnane (2016), there has been poor quality science education in many developing countries in the world: this has been more evident by the low enrolment into science subjects at secondary school level in these countries in fact with even fewer pursuing science-related courses in tertiary level (Holmes, 2018). He further adds that, inadequacy of practical work is a major contributing factor to students' poor content knowledge in most developing countries. Chemistry as a subject is seen to be abstract, difficult to understand and conceptualize in many countries. The chemistry



concepts are usually learnt via rote memorization; this is where teachers transfer content knowledge directly to the students, filling their minds with facts, concepts, principles and laws.

Many studies have brought out the important role that practical work play in science teaching and learning. Comparatively it makes understanding of the concepts easier and also strengthens students' mastery or retention of knowledge than other expository methods of teaching. According to Kalman, (2017) the theoretical teaching of science subjects makes students perceive the science subjects as abstract and only useful in passing of examinations hence taking them beyond their sphere of experience and understanding. Practicals therefore, are essential part of teaching and learning of science for the development of students' science knowledge (Keeley, 2015). The inadequate use of practical work in most science classrooms or lessons might be the major contributor in the students' poor content knowledge and understanding of chemistry at secondary school level.

A research study by Abrahams and Millar, (2014) in the area of practical work and the assessment of science education by Bernholt, S., Neumann, K., and Nentwig, P. (2012) described the significant influence of the curriculum particularly it's associated summative assessment on the practical work done by teachers and their students. In application to our Kenyan curriculum, most teachers have been trying to do practicals on behalf of their students up to and including during national exams (impersonation of the students).

Students are the future of a nation, and scientifically-literate students can build a developed nation (Baran, E., Bilici, S. C., Mesutoglu, C., & Ocak, C. 2016). Since secondary school level is the foundation level for higher education, it needs to be as strong as possible.

Chemistry is one of the most important subjects among the physical and biological sciences. A study by Hill and Finster (2016) on students attitudes towards science, found out that students who would like to study in the fields related to chemistry like medicine or engineering must have strong background knowledge of chemistry. Emphasis should be on providing secondary students with clear and standard basic chemistry content knowledge, which they understand and can utilize in their future study or in doing research.

Practical work has worked in some countries in the world, for instance in United Kingdom (UK) and England. Most science teachers in the UK take practical work as part and parcel of what teaching and learning in science is all about. According to Collins and Halverson (2018), 13-14 year old pupils in England like spending their lesson time doing practical science activities as opposed to their international counterparts. The study also found that a 'hands-on' approach of teaching was adopted by most of the science teachers in England. In practical learning, the core activities involve investigations, laboratory procedure and techniques and fieldwork. These 'hands-on' activities in the long run result to development of practical skills, and also help to shape students' understanding of scientific concepts, theories, principles and laws (Cossa & Uamusse, 2015). Directly related activities involve demonstrations, experiencing phenomena, designing and planning, results or data analysis using ICT (Ibieta, A., Hinostroza, J. E., Labbé, C., & Claro, M. (2017). The activities are either a key component of an investigation, or provide first-hand experiences for students.

Several other activities were identified as complement, but should not be a substitute for practical work. According Keter (2018), the complementary activities included science-related visits, surveys presentation and role-play, simulations using ICT, models and modeling, group discussion, and group text-based activities. These activities play an

important role in supporting practical work especially in developing understanding of science concepts. A study by Hasanefendic, S., Heitor, M., and Horta, H. (2016), on the role of technical and vocational training commented that:

“In our view, practical work, including fieldwork is very important part of science education since it helps students develop the understanding of science, appreciate science based on evidence and acquire hands-on skills that are very vital for the progress of students in science. Students should be given the opportunity to do exciting and varied experimental and investigative work” (Pp.301)

In another research study by Bell, (2016) on Science, Technology, Engineering, and Mathematics skills, highlights the quality of school science laboratories as a key concern. This is a vital part of students learning experience and should play an important role in encouraging students to study [science] at higher levels (Butler, 2009).

Experimental approach of teaching has many advantages in comparison to other approaches of teaching. This is why many teachers attempt to use the approach in their teaching of chemistry. Despite all these, many science educators have expressed lots of doubts about the effectiveness of the approach in the teaching of science knowledge and skills (Qian & Clark, 2016). This could be due to the nature of experiments carried out in schools. In this regard, Monica, I., Nicholas, T., & David, K. (2015) argued that, such recipe-based experiments are not sufficient to develop students' knowledge because they involve simply performing experiments with little thinking throughout the process. Effective experimental work should enable learners connect between observation, hands-on activities and scientific ideas that account to the observations (minds-on). For the chemistry experiments to be more effective in producing meaningful learning, the teachers ought to develop activities that engage the learners in scientific investigations and focus their minds on the activity and its outcome. Monica, *et al.*, (2015), continued to argue that

chemistry lessons in most secondary school are characterized by ‘chalk-and-talk’ (Lecture method) and little experimental work. Some educators also concur with this study, that experimental work should involve a learner-centered teaching environment that involves absorption of information (Boggs, 2018). Indeed for practical work to achieve the desired objective, the learner should be given enough room to discover new knowledge and manipulate the apparatus.

A study by Ziegler and Lehner (2018), on science in African context concluded that, the transfer of indigenous science knowledge and the application of such knowledge is part of multiple knowing. The teaching can be demystified once it is grounded in local knowledge and surrounding knowledge for learners to know that such knowledge is not after all alien to their cosmological knowing. The interconnections of science, culture and development indicate the important place of science education in our schools and society. The emphasis on science and technology education in schools can improve African development, if the teaching is pursued in a way that connects practical with learners’ social, physical and cultural values. Therefore, a study by Sillitoe (2016) on indigenous knowledge further emphasized on the interconnection of indigenous ways of knowing with so-called western science knowledge given the multiple and collective dimensions of knowledge.

Experimental work in chemistry for most secondary schools takes the form of laboratory experiments and demonstrations. Chemistry teachers’ innovativeness and creativity could introduce various modes of practical investigations. According to Ng’ethe (2016), the innovations in Kenya include: Micro-kits, also known as Science Equipment Production Unit (SEPU) kits and improvisations of various laboratory equipment or apparatus. Of late,

a lot of efforts are being made to utilize virtual laboratories that rely on the interplay of the computer and the internet (Georgiadis, Streu & Lee, 2018).

According to Beck (2018), Kenya can only be more competitive in the global arena and industrial world if the knowledge and understanding of the scientific aspects can be enhanced. Therefore, various efforts should be put in place at the secondary school level to increase students' interest and competency in science (Collins & Halverson 2018). This method of teaching has not attained the full attention it requires in Kenyan secondary schools. This is due to some reforms and transformations the schools are undergoing. In most secondary schools in Kenyan, practical work focuses mainly on the development of students' knowledge in chemistry, rather than understanding of the scientific investigative procedures. For a long period of time experimental work has been a cookbook trend with instructions carried out like a recipe which reduces the meaningfulness of learning. Therefore, the learners do not use scientific knowledge in guiding their actions during experiments and reflect upon the data they collect.

A study by Usman and Sabo (2018), on effects of practical skills on students' achievements in physics found out that most experiments are sterile, un-illuminating exercise whose purpose is often lost on the learners. Actually whatever goes on in the laboratory has little to do with students learning science. Demonstrations are usually done by the teachers who also sometimes misinterpret or misunderstand some concepts (Kalman, 2017). Students sometimes are subdivided into small groups during the experiment but the follow-up discussions on the purpose of the exercise are very minimal on the side of the teacher. The students follow a fixed laboratory procedure that involves observations and manipulation of apparatus set by the teacher.

Generally, there have been claims over poor performance in chemistry as a subject in the Kenya National Examination since 2016 to date. This is a clear indication that the learning of chemistry in most secondary schools may have not been as effective as required. According to Ural (2016), the teaching of chemistry in most cases has followed expository approach; where the teacher does a lot of work compared to learners. In cases where practical work has been implemented, students only require to follow instructions developed by the teacher or from textbooks or manuals for them to strictly carry out the activities as per those instructions; sometimes without much interest on what they are doing. Learners do follow the teachers' guidance and instructions to the later. From this, teachers are asked to change their practice so as to achieve meaningful learning in practical work.

Studies have shown that one of the means of improving learning in chemistry is by the use of investigative approaches of science learning through practical work (Berland, *et al.*, 2016). Investigative and inquiry-based approaches of learning content have been of key interest in recent years though challenges to investigative teaching remain evident hence shifting from traditional methods of teaching has been slow (Muijs & Reynolds, 2017). On the other hand, Monica, *et al.*, (2015) argue that experimental activities in science do not guarantee scientific investigations. Changing practicals to theory type of activities from hands-on activities require proper management of all stages of the activity. Practical are normally carried out in four main steps: planning, implementation/activity, discussion and conclusion. If all these steps are well-managed, then they can result to conceptualization of scientific knowledge and acquisition of skills.

A study by Krajcik, J.S., Reiser, B. Moje, J E., & Marx, R. (2003), noted that research-based curriculum is a better option that could address the challenges and also provide improved tools for learning among students' and teachers through development of appropriate instructional materials. A study by Yandila, C.D., Komane, S.S., & Moganane, S.V. (2003) found out that inadequate and inappropriate teaching and learning materials are some of the factors that contribute to the challenges that teachers face in the implementation of learner-centered approach.

All in all, this study is of great importance because the 21<sup>st</sup> century learner has developed the following characteristics towards the obvious teaching method: lack of organization in regard to work, writing and interpretation of concepts, lack of pre-requisite knowledge in regard to content related to computation, lack of motivation that results to interest other than school, lack of social, cultural and / or professional ambitions. A study by Abdalla (2019), pointed out that students' have negative attitudes towards learning process, difficulties in regard to concentration but have interests and motivations in things that do not regard school like Boy-Girl relationship, social media and others.

The use of experimental work in the science curriculum remains exclusive in terms of the quantity and amount of time devoted to it in all countries in the world (Bennett, 2005). For most science teachers or educators, practical work encompasses what teaching and learning of science is all about (Woodley, 2009). However, there is a growing debate surrounding the effective and affective value practicals have on students especially in mastering concepts in chemistry as a subject (Abrahams, 2009). Many teachers in Kenya make reference to the adage, 'I hear and forget, I see and remember, I do and understand', by Confucius. Chemistry teachers in Kenya tend to drill learners on simple concepts towards

the end of their course in secondary school. They believe that practical's contribute a good portion in final examination. It has been suggested that teachers find using practical work to be a method of behavior management.

Why experimental work? Scientific knowledge provides material explanations for the behavior of different phenomena in the world, in terms of the entities that make up that world and their properties (SCORE 2009). Science is valued as a product, an enquiry process, and as a social institution because of its success in explaining phenomena in elegant and other ways which are intellectually satisfying. This facilitates the purposeful manipulation of objects, materials and events. This observation or manipulation of objects can take place either in a school laboratory or even out-of-school setting, such as the students home, farm, industry or in the field (e.g. when studying aspects of biology or Earth science).

### **1.3 Statement of the problem**

The researcher appreciates the work done by teachers but nowadays most teachers do contrary to what they were trained in their colleges. Chemistry teachers have moved the subject from hands-on activities to more of theoretical activities by not exposing learners to laboratory practical activities. Therefore, learners have not been given their time and room to construct their own knowledge. For an effective learning process, knowledge consolidation and mastery, then experimentation, confirmation of theories and mobilization of the acquired concepts are fundamental. The evaluation reports have encouraged teachers to put more emphasis on practical aspects in science subjects (KNEC 2016, 2017 & 2018). All these reports highlighted the weaknesses of the candidates especially in chemistry paper



233/3 where most learners were unable to record data for titration, read and record temperatures accurately, plotting graphs poorly, not able to carry out molar calculations. In a nutshell most schools have not conformed to STEM in Teso South sub-county.

#### **1.4 Justification of the study**

This research study was carried out in Teso South Sub- County because it is a poorly performing Sub County in chemistry among the 7 Sub-Counties in Busia County (KNEC analysis 2016, 2017 & 2018). This clearly shows that most of the candidates end up in non-professional science oriented courses which might lead hiring of professionals from other regions in the country.

#### **1.5 Purpose of the study**

The key purpose of this study was to assess the effectiveness of experimentation method of teaching in knowledge mastery and skills acquisition in chemistry as a subject in secondary schools of Teso South Sub-County.

#### **1.6 Objectives of the study**

##### **1.6.1 Main objective of the study**

The main objective of the study was to investigate the effects of experimental approach of teaching chemistry to knowledge mastery and science process skills acquisition among form three learners in secondary schools in Teso South Sub-County.

### **1.6.2 Specific objectives of the study**

The study was guided by the following specific research objectives:

- i. To determine the effects of experimental approach of teaching chemistry on knowledge mastery among form three students in Teso South Sub-County.
- ii. To determine the effects of experimental approach of teaching on science process skills acquisition among form three students in Teso South-County.

### **1.7 Hypotheses of the study**

The study was guided by the following null hypotheses:

H<sub>01</sub>: There is no significant difference in knowledge mastery for students taught through experimental approach and those taught through traditional expository methods.

H<sub>02</sub>: There is no significant difference in science process skills acquisition for students taught chemistry through experimental approach and those not taught through experimental approach.

### **1.8 Significance of the study**

Kenya is struggling to get citizens who are fully equipped with knowledge and skills towards Vision 2030. It is important for every learner to be equipped with science knowledge and skills that are applicable in solving problems in the society. Through practical work learners consolidate their understanding of concepts and they develop inquiry skills (Abraham, 2011). Therefore this calls for the deeper understanding of the integration of content and pedagogical knowledge by the teachers. Content knowledge is the teachers' knowledge about the subject matter while pedagogical knowledge is

knowledge about the process of teaching and learning. The study findings would be of more importance to teacher training institutions to change or tailor their training approaches towards experimental work. Educators and instructional tool designers have to make right decisions on which tool to choose when and how to use it in order to facilitate learning (Andersen, 2013). The findings may be used by the Ministry of Education in curriculum development and provision of learning materials to secondary schools.

### **1.9 Assumption of the study**

This study took into the account of the following assumptions:

- i. All the students in the sampled schools had covered the form one and two syllabi.
- ii. The schools sampled had the necessary apparatus required for the experimental activities.
- iii. All teachers who administered the treatment were qualified teachers of chemistry education.
- iv. It was assumed that the study area was to produce findings that would be applicable to other areas.

### **1.10 Scope and Limitation of the study**

#### **1.10.1 Scope**

This study focused on the effects of experimental approach of teaching chemistry in secondary schools of Teso South Sub-county in Busia County. Only the Form Three classes were involved in the study. The topic in equation was The Mole. It's the second topic in form three Syllabus. The topic was chosen since it tests all the practical aspects like

measuring, recording, manipulating apparatus, calculating and drawing of graphs. The topic is normally taught in 40 lessons which is an equivalent of 8 weeks.

### **1.10.2 Limitation**

The study was limited to syllabus as required by the Kenya Institute of Curriculum Development. The researcher had to adhere to the schemes of work that was provided by the school. Therefore, had no freedom of choice of what to be taught. The researcher had also to abide by the number of lessons taught per week as required by the syllabus. The study was limited to the study findings in making generalizations.

### **1.11 Theoretical framework**

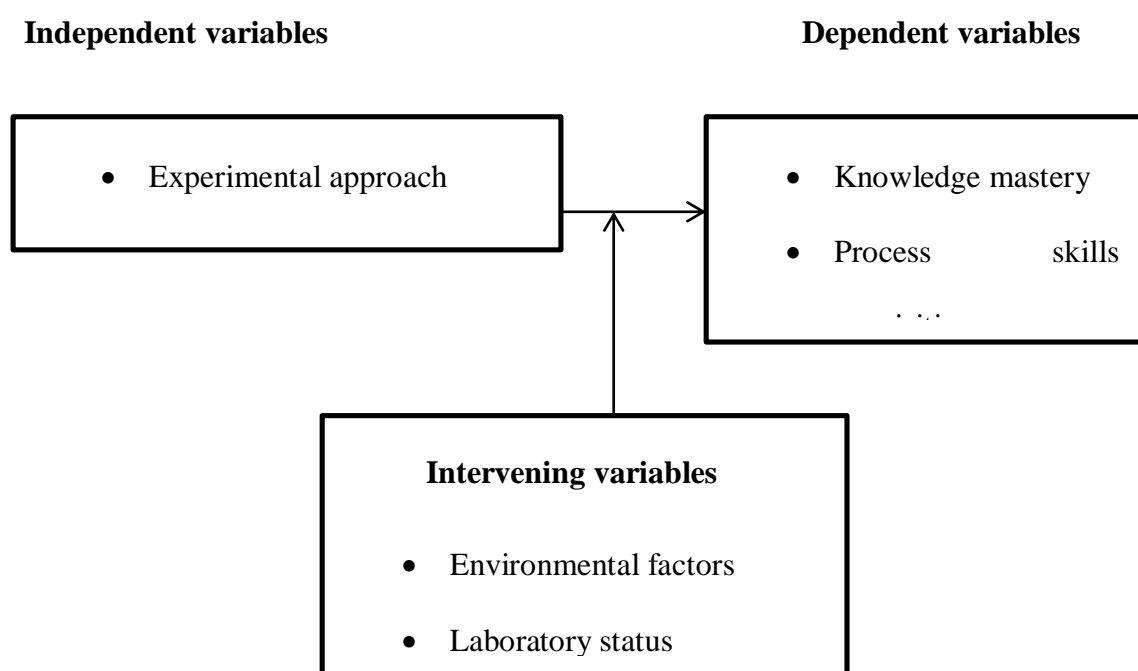
This study was based on Jean Piaget's constructivism theory. The theory assumes that when children are exposed to various hands-on-experiences, they tend to understand and are able to construct new levels of knowledge from what they do. Active involvement of learners is required so as to reflect on their learning and inferring.

The theory further explains that, children learn by interacting with the environment through which they build and develop their own knowledge and understanding. The inference of this theory to the study was that a child learns better through manipulating the environment around him or her. The child finds it difficult to learn from a teacher who just feeds him or her with information. This theory emphasized that the child's meaningful learning is by doing and manipulating the environment. After interacting with the objects from the environment, a child will be able to construct or develop new field of knowledge. The constructivism theory was used to anchor the study because experiments in chemistry

involve manipulation of the laboratory apparatus and equipment so as to understand concepts.

### 1.12 Conceptual Framework

This conceptualization of the experimental approach of teaching in this study was as illustrated in figure 1.1. For effective implementation of experiments there should be interaction between all the three variables



**Figure 1.1: Interaction of variables in experimental approach**

(Source: Author, 2019)

The figure shows the interrelation of three variables, Independent and intervening variables interact so as to achieve the objectives. In a nutshell, the key purpose of science education is developing students' understanding of scientific enquiry and the nature of scientific knowledge. Therefore, subjects whose purpose is to enhance students literacy and practical/ experimental work is a means to an end, rather than an end in itself. Some students may

engage in systematic enquiry which is not the same thing as scientific enquiry. Therefore, they are consumers of scientific knowledge, not producers of it. To become more intelligent consumers, they may benefit from some experiences of practical work, but the aims need to center on developing the knowledge and understandings required to respond intelligently to scientific information as it is encountered in out of school contexts, rather than on the ability to conduct a practical investigation or enquiry. The teacher is satisfied having learners who find it important to participate, thrilled with what they observe and majorly with what they experiment; it is not needed to impose the activities, which are sufficiently appealing in themselves so as to make the students more efficient and become possible for them to carry out and reach their conclusions (Adongo, 2018). This means that for the positive interaction of the three variables, the teacher is the pivot in terms of pedagogy.

### 1.13 DEFINITION OF OPERATIONAL TERMS

**Conventional Method:**-refers to a technique of teaching chemistry through lecture method with only a few teacher demonstrations.

**Curriculum:** Refers to all the experiences (either in class room or out of class) learners undergo while in any learning institution. These experiences include both time-tabled content (subject) and other non-time-tabled activities (co-curricular).

**Effectiveness:** In this study it refers to how easy the method of teaching is likely to achieve the general objective.

**Experimental approach of teaching:** This is a learner centered approach of teaching where the teacher is a facilitator while the learners engage on hands on activities.

**An experiment:** In science teaching, this refers to integration of students experience with their content understanding from class through the guidance of a teacher or secondary reference material like textbooks.

**Instruction:** In this study instruction refers to structured process that is concerned with the development of manipulative skills through guided experimental experience assessment and regular feedback.

**Knowledge mastery:** This is the understanding of the chemistry concepts and being able to apply them in real life situations.

**Science Process Skills:** This refers to experimental skills like observation, measurement, manipulation of apparatus and equipment, drawing, recording and analysis of results collected.

**Practical Work:** Is interaction of students with laboratory apparatus or equipment and/ or with secondary sources of data in order to observe and understand the material world.

**Science Process Skills Acquisition:** This is the gaining of both manipulative and experimental skills.

**Paper 233/3:** Is the code for chemistry paper 3 or practical paper.

**Dry practicals:** This is the use of data generated theoretically without interacting with real apparatus or reagents in the laboratory.

### **1.14 Chapter Summary**

This chapter has discussed about the background of the study which has given the insight on the need for experiments or practical's. The background has also shown as how practicals are treated in other countries outside and inside Africa as a continent. Statement of the problem has brought out why the study was carried. The objectives gave the aim of the study. Hypothesis meant to predict the outcome of the study. Significance of the study explains the importance of the study. Assumptions shows the factors kept constant during the study. The scope and Limitations give the extent to which the study covers in terms of location, subject, respondents and topics covered. Theoretical framework gives the theory that guided the study. Conceptual framework indicates the interaction of independent, intervening and dependent variables to achieve the set objectives. Finally the definition of operational terms gives a brief explanation of the common terms used in the study.



## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Chapter Introduction

This chapter critically looked at the existing research that is significant to the work that the researcher carried out. This chapter reviews the literature on experimentation-versus-knowledge mastery in science, experimentation-versus-process skills acquisition and experimental work-versus- students' achievement.

#### 2.2 Experimentation versus knowledge mastery

A study by Anderson (2018), on the national science education standards in the United States and other contemporary science education suggested that the potential medium for introducing students to central conceptual and procedural knowledge and skills in science is through science laboratories. This finding was supported by another research study by Reimers and Chun (2019), on the teaching and learning for the 21<sup>st</sup> century which established that, the many challenges and opportunities facing 21<sup>st</sup> century students are caused by the shortcomings and inadequacy of the models of education designed since they were meant to meet the industrial past. The new trends in education require different ways and methods of designing experiments for students as well as new approaches to teaching. Apart from gaining entrepreneurial spirit, fostering intellectual development and showing ethical citizenship, students through a process of inquiry and discovery of knowledge should also develop competencies. Students collaborate to create new knowledge as well as

learn how to “think critically and creatively, which may to discoveries-through experimentation, reflection and exploration” (Alberta Education, 2010).

A study by Tristin (2014) concluded that “for learners to achieve full potential, education must make the child the center of all decisions related to learning”. This was after using two groups in the study. The first group was taught through the traditional method of “talk-and-chalk” while the second group was given apparatus and instructions. The study findings showed that the second group had a higher score in the provincial achievement tests (P.A.Ts) for grade 6 and 9. Tristin (2014) further added that “teachers instead of being instructors would be an architect of learning-one who plans, designs and oversees learning”. Pp56.

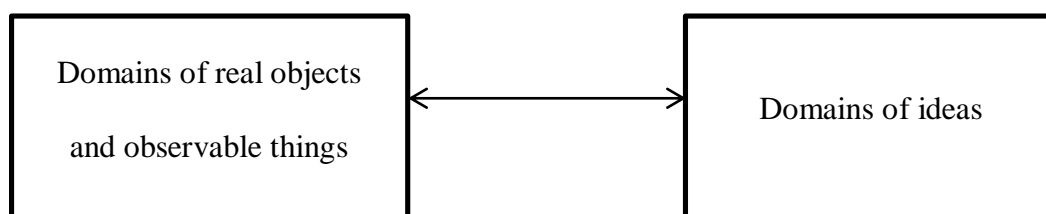
According to Burgin and Sadler (2016), in their book “*learning nature through research*”, indicated that newly emerging empirical findings in the teaching and learning of sciences indicate that, traditional methods of teaching emphasized on the ability to recall facts and follow some laid down set of rules. These traditional methods and should be replaced by teaching and learning that supports problem-solving, critical thinking, transfer of skills and use of knowledge in new situations. In connection to this, Tattum and Tattum (2017), also in their book “*social education and personal development*” directed that students should be given opportunities to interact with their environment especially how knowledge is created and communicated within specific disciplines.

A research study by Otieno (2012), found out that for easy understanding of the subject matter, important questions that guide knowledge developed from the content or concepts are required. Chemistry experiments should have essential questions that guide the learners

when carrying out experiments in the laboratory. For instance, when experimenting on indicator colour changes, the essential question is: “where can this be applied in real life situation?” This enables learners to think critically and come up with big ideas that can be helpful to science. Furthermore, Scott and Abbott (2012), highlighted a growing body of literature that promote purposeful practical/ experimental techniques and frameworks that enrich content understanding and also promote the apprehension of disciplinary means and processes. A study by Mukwa (2013), on integration of education technology in teacher education found out that there is need of shifting away from the common information-transmission pedagogies to practical oriented methods that promote critical thinking that helps in mastery of knowledge by the students.

According to Schmidt, Rotgans and Yew (2019), in their handbook of problem-based learning, assert that direct instruction i.e., Lecture method is preferable to experimentation learning especially in terms of developing students’ basic knowledge of a domain. The researchers examined two groups of students who were asked to design experiments to evaluate the variables associated with the speed of a ball travelling down a ramp. The researchers were interested in the students’ understanding of the experimental design and ability to control the “confounding variables”. In one class students were given direct instruction on the importance of not confounding variables in experiments while in the other, students were simply asked to design the experiment on their own. These findings are against, Darling-Hammonds (2008), who found out that there was a good relationship between experimentation and direct instruction despite the fact that the direct instruction yielded better learning outcome.

Therefore, the conclusion that experimentation requires certain instructional support is contrary to this study. In relation to this study, Tharp (2018) indicated that any engagement requires students' attention and focus so as to achieve related contents and tasks. He added that students with more positive motivational profiles in a particular subject area are likely to take courses in that area and to choose related college majors and career paths. Most of these observations are made by using at least one or more of the five senses. According to Otieno (2012), students' performance in experimental work is determined by proper use of laboratory tools (glassware, and equipment) and the correct execution of procedural techniques (filtration, titration, preparation of solutions).



**Figure 2.1: Experimental work: linking two domains of knowledge**

Figure 2.1 shows the relationship between carrying out an experiment and the theoretical background of the same experiment. This is to mean that, some theories can only be well understood (domains of ideas) through carrying out an experiment on it (domain of real objects and observable things). In a nutshell, confirmation of theories, principles and laws through hands-on experiments should be integrated to achieve objectives of education.

Experimental work is used to link two domains as illustrated by the Figure 2.1. Teachers are expected to help learners to link the two domains. For instance, when students measure the temperature of water or any solvent in beakers over a period of time with and without

insulating material, they tend to perceive this phenomenon theoretically as energy shifting from regions of higher content to that of low content. Similarly, when students measure electric current at different points of electric circuit with parallel arrangement they tend to imagine the circuit in terms of current as a flow of something (electric charge) which is not used up as it goes and adds at junction. The teacher is therefore expected to expound on the ideas represented by these experiments.

A study by Linus (2018), on Namibian students' abilities in scientific reasoning and inquiry further outlined some of the strategies used in improving and developing of scientific knowledge. First, the Predict-Observe-Explain (POE) structure is useful only if the students already have enough theoretical background of the phenomenon in question to make testable predictions. In a POE task, students are first asked to predict what they would expect to happen in a given situation and to write this down, then carry out the task and make some observations, and finally to explain what they have observed. Secondly, sequence of introducing ideas to represent and discuss an analogy to which observations and measurements can be directly related. For example, in teaching about electrochemical cells, students might be asked to relate their observations to a given analogy of circuit behavior, noting where these agree with what the analogy would lead you to expect, and where they diverge. In a nutshell, strategies for improving experimental work intending to develop students' scientific knowledge have a common aim, to make the students think as well as act (Hofer, Abels, & Lembens, 2018).

According to Park, Abraham and Song (2016), in their study about the impact of primary science practical lessons to secondary students understanding of the subject matter

indicated that: all the practicals that teachers planned was either for verification of knowledge or followed discovery-based approach with step-by-step instruction from the teachers. This denied learners an opportunity to interact with subject matter.

According to Muhammad-Lawal (2015), who asserted that, meaningful learning is possible in the laboratory if the students are given opportunities to interact with equipment and materials in an environment suitable for them to construct their own knowledge of the phenomena and related scientific concepts. He added that appropriate laboratory procedures can be effective in helping students construct their own knowledge, develop logical and inquiry-type skills that can lead to problem-solving. They can also aid in the development of psychomotor skills (manipulative skills). The laboratory is designed to help learners come up with better ideas on the nature of scientific investigation through emphasis on the discovery approach. Observation of chemical systems and gathering of useful data meant for the development of principles subsequently discussed in the textbooks and class occurs in the laboratory.

There is a cloud of dullness that has obstructed the curriculum implementers (science teachers) in Kenya from the core business especially in the assessment of experimental/practical work. A study by Abrahams and Saglem (2010), revealed that the changes in the way science is assessed has to some extent changed the way teachers see practical work, from being used as a teaching method to aid general learning of science to passing of the examinations. The spirit and the urge of scientific knowledge are 'killed' at the foundation level (lower forms). At this level the teacher is the center of learning. Most of them use teacher demonstrations, class practical with all learners on similar tasks and problem-

solving activities. This makes learners spectators and not participants in knowledge creation. In support of this, Myrrh, L., Karaharju-Suvanto, T., Vesalainen, M., Virtala, A. M., Raekallio, M., Salminen, and Nevgi, A. (2019) concluded that teachers nowadays teach students to pass the examination, and not for the retention of knowledge for future application.

According to Skinner (2016), practical work needs successive use of brain stimulus to work on the problem unlike theoretical knowledge concerned with the 'why' something happens. In addition to this, laboratory experiences speed up students' understanding of specific facts, concepts and the way the facts and concepts are organized. This study found out that those students who were taught through experimental approach gained more knowledge compared to those taught through the conventional methods.

Experimental work alone is not sufficient for promoting more scientific reasoning abilities, such as asking relevant and appropriate questions, designing experiments and drawing inferences. In line with this, Elbaz, (2018) found out that, conceptual understanding, scientific reasoning and practical skills are three capabilities that are not mutually exclusive. Therefore, an educational program that partitions the teaching and learning of content from that of process skills is likely to be inefficient in helping students develop scientific reasoning skills and an understanding of science as a way of knowing.

According to Kaplan (2017), it is impossible for one to retain even a slight knowledge of chemistry without either making experiments or seeing them performed. In addition to that, for one to become proficient in science, much practices as well as extensive reading is required. In support of this, Wang and Degol (2017) also found that laboratory experiences

have the potential to help students attain several scientific goals including mastery of science subject matter, increased interest in science and development of scientific reasoning.

Another study by Lee *et al.* (2016), on the integrated instructional methods has shown that engagement with laboratory experiments and other forms of instruction over a timeframe of between 6 to 16 weeks can increase student's mastery of complex science matter and ideas of a given topic. In line to this, Auer *et al.*, (2018), also indicated that students who are actively involved in the laboratory experiments together with other learning activities made more progress both in mastery of content and increased interest in science compared to students who participate only in the traditional program of instruction.

In most practical work, learning is about objects and observations. Students are expected to recall what they have felt or observed (Arry, D. *et al.*, 2018). In addition to this, students are required to link between observations and scientific ideas. Therefore, for this to be achieved, the learning objectives should be clear and relatively fewer in number for any given task. Supporting this, another strategy can be used to stimulate the students thinking before hands on activities, so that the practical task answers a question the student is already thinking about.

According to Berkenkotter and Huckin (2016), there is a significant difference between experimental work in the laboratory and knowledge acquisition through theory. As educators it is very important to draw a clear line between research scientists exploring the boundaries of the known and students trying to come to terms with already accepted



knowledge. Hence, in the context of teaching scientific knowledge, practical work is best seen as communication and not as discovery.

### **2.2.1 Experimentation versus knowledge mastery in related science-physics**

Students start learning about electricity and conductivity in primary school. They get in contact with some phenomena in their day-to-day life. This is a good start for misconceptions. Electrical charging is the basis for the other concepts like electric fields, capacitors, electric current and voltage. A study by Osborne (2015), asserted that; students need to have clear understanding of the phenomena and concepts related to the phenomena. This is why many researchers find it important to investigate students' knowledge and understanding of concepts in electricity in all educational levels. Osborne (2015), continued to comment that: "many misconceptions have their roots in the textbooks representations" pp146.

A research by Aufschnaiter Von *et al.*, (2007), found that experimental work in science education gives more quality knowledge, but only if the experiment is structured in a way that allows students to discover rules of physics. This keeps the students in higher order of thinking i.e. analyzing, synthesizing, drawing conclusions etc. Afterwards, the students focus on the analysis of the results, synthesizing and creation of formula and /or law hence evaluate what they have obtained.

### **2.3 Experimentation versus process skills acquisition**

According to Zimmerman and Klahr (2018), scientific process skills are tools that scientist use when they practice science. They went ahead and categorized the skills into two:

manipulative and process skills. Manipulative skills are those needed in handling science apparatus or equipment and maintaining apparatus while process skills are tools that scientist use in inquiry to investigate and explore the world and to learn scientific concepts. This study focused more on process skills. The process skills considered in this study are: observation, measurement, recording, classification, reading scales, setting of apparatus and analyzing data.

The role of the teacher is to offer expertise and instructor in the learning of process skills. Teachers should therefore have a comprehensive and authority in the science knowledge that includes mastery of process skills (Keiler, 2018). Teachers play a vital role in instructing the students on how they can correctly handle apparatus and materials. For instance, through demonstration, a teacher should ensure that students obtain correct and proper techniques in using apparatus by directly involving them. During practicals done in groups, teachers assist students by correcting and guiding those who encounter difficulties in handling the given task. In support of this, Suryawati and Osman (2018), believe that teaching and learning should involve activities that help learners to understand the nature of science as this may help build positive attitude towards science.

A study by Opara (2013), concluded that laboratory activities are perceived as a means of developing students scientific thinking, understanding and higher order cognitive skills. Apart from cognitive skills, students should also be enabled to develop other skills (such as communicative, critical thinking and problem solving, team work and leadership skills) which are embedded in experiments involving quantitative chemical analysis. Another study by Zeidan and Jayosi (2015), on the students' science process skills within cognitive

domain framework showed that private school students had higher scores compared to public school students. This is clearly depicted in the Kenyan set up where Private schools expose their learners to more practical work than public schools. This is as a result of their small numbers in comparison to those in public schools.

In related studies done in the United Kingdom, a report on a small-scale study that explored University staff views on laboratory skills in new undergraduates within Russell Group Universities (the top 24 research universities in the UK) also concluded that students were joining University, with inadequate appropriate practical skills and confidence to carry out practical work within a laboratory, (Wheeler *et al.*, 2019). Indeed, a study by Elbaz (2018), on practical knowledge found that practical skills had declined over the last five years and that a factor in the lack of practical skills was the limited time dedicated to practical work at school.

Some studies indicates that typical laboratory experiments especially those focused on learning practical skills can be of great help to students' progress towards scientific goals. For example, a study by Bonney *et al.*, (2016) found out that some students were deficient in the skills needed to successfully carry out typical laboratory experiment, for instance using instruments to make measurements and collect accurate data. Other studies have revealed that helping students to develop relevant instrumentation skills in controlled "prelab" activities can reduce the chances of compromising important measurements in a laboratory practical due to students' lack of expertise with apparatus (Saija *et al.*, 2018). This study suggests that development of process skills may increase the probability that students will achieve the intended results in the laboratory experiments.

Chemistry is a field of study which can promote students intellectual, experimental and professional skills required to be successful and scientifically informed citizens if the content is adequately understood. Laboratory activities are meant to offer students opportunities and experiences on what they are to learn in a direct way and to monitor the effectiveness of their own experimental method. In addition, Campbell and Stanley (2015), assert that students are also expected to link previous theoretical knowledge with experimental designs, data analysis with experimental interpretation and laboratory results with theory.

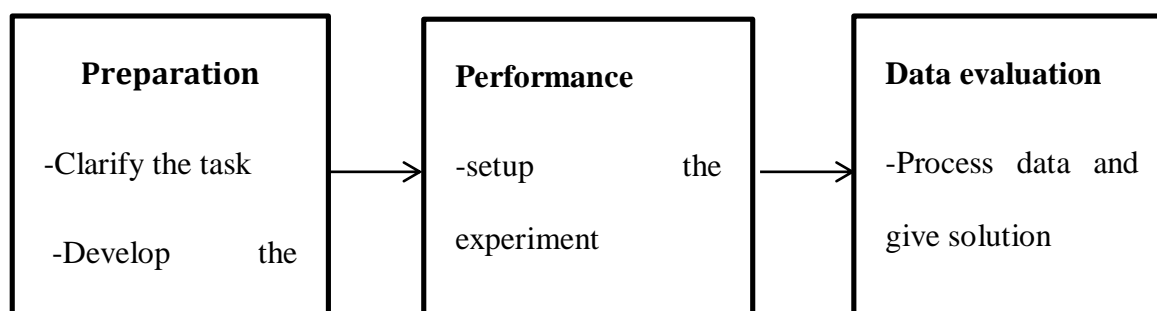
According to Willoughby *et al.*, (2013) students are needed to frequently work with scientific apparatus to help in their future learning. Thus, the experiences in science class can therefore be used fruitfully in other settings. In support of this, Wickman and Ostman (2002) cited in Mohd Fadzil (2014), demonstrated that students learn science through previous experiences of science in school. If students are not given much opportunity to perform experiments, they may encounter difficulties in future due to their lack of skills and experience to handle science apparatus and equipment. The skills gained in class or laboratories are very vital in real life situations. In a study by Lal *et al.* (2017), students were observed to lack cohesiveness in laboratory experiments. They were passive and preferred to work in groups when carrying out experiments as they merely observed the final results or copied results from their friends or colleagues. This is caused by students' expectations of which Mohd Fadzil (2014) highlighted that students' expectations of science in secondary school were very high. They thought that they would use specialized facilities and apparatus in the laboratory but this was contrary to the real situation they met

on the ground. Therefore, they looked forward to maintain their positive attitudes towards science but most of them get discouraged along the way.

According to Fadzil and Saat (2013), in primary school level, the teaching and learning of science is more about retention of knowledge. Pupils were involved with too much writing and too little practical work. The insufficient skills lead to the re-teaching of the basic skills of using and handling apparatus in secondary school level. In relation to the Kenyan curriculum so much is covered in primary school science with fewer practicals. This has pushed the government to make changes to the curriculum so as to cater for the psychomotor skills of the learner through the competency-based learning.

According to Abrahams (2017), Practical / experimental work is considered as engaging the learner in observing or manipulating real or virtual objects and materials. Appropriate experimental work enhances students' experience, skills and arouses interest in science. It also enables students to critically think and acts like a scientist. Practical work in chemistry helps learners familiarize with apparatus, instruments and equipment through which manipulative skills are acquired. The observations made and results obtained are therefore used to gain understanding of chemistry concepts. A study by Clark et al., (2016) on crafting usable knowledge for sustainable development found that science process skills, necessary for the world of work are systematically developed. They also realized that students learn better in activity-based courses where they can manipulate apparatus to gain insight of the content. A study by Adeyemo (2009), asserts that skills represent particular ways of using capacities in relation to environmental demands, with human being and external situation together forming a functional system.

According to Millar (2004) cited in Adeyemo (2009), the subject of science is the material world, it seems natural, and rather obvious, that learning science should involve observing, handling and manipulating real objects and materials and teaching that involve act of ‘showing’ as well as ‘telling’. In addition, the learning associated with a practical activity takes place through the process of talking about the observations and measurements that have been made, and what they might mean both to learners and the teacher. So, a typical practical activity will be followed by a period of discussion of the observation and measurements made, of patterns in them, and how they might be interpreted and explained. Therefore, practical activity constitutes; data collection phase and data interpretation phase. Figure 2.2 shows how an experiment is supposed to achieve the intended objectives of acquiring experimental skills.



**Figure 2.2: Model of experimental skill**

According to Ndoro (2017), there are two approaches to assessing acquisition of science process skills from experimental work. (1) Direct assessment where learners demonstrate their ability and behavior during the performance of an experiment and (2) indirect assessment where learners’ performance is assessed through data from their experimental

or scientific reports. The experimental reports have been criticized for artificially organizing skills in a systematic way that is not natural to doing science. This study employed direct assessment of process skills to ascertain how the learner interacts with real apparatus so as to achieve the given science objective.

According to a study by Bang and Baker (2013), on the effect of high school tenth-grade students' acquisition of science process skills, the results indicated that students from mixed secondary schools had significantly better science skills than those in single gender schools. This was supported by another study carried out by Al-rabaani (2014), on acquisition of science process skills by Omani's pre-service social studies teachers, which showed that the teachers acquired science process skills moderately and there was no difference pertaining to their gender. This clearly indicates that gender does not play a big role in science process skills acquisition.

The findings from a study by Blagdanic, Kadijevic, and Kovacevic (2019), on gender-stereotyping in science, showed that girls handle laboratory apparatus less frequently than boys, and that this tendency is associated with self-confidence in science ability among girls. The girls' interest in science can be enhanced by helping them develop instrumentation skills and participate more actively in learning science. This research has not focused on acquisition of science process skills across gender.

In conclusion, a study by Opara (2013) emphasized on students active participation in the learning process and conversations in the classroom during experiments or practicals engenders a deeper understanding of science concepts. The researcher concurs with this; that experiments should be married together with classroom discussions of the laboratory results.

### **2.3.1 SMASE on experimentation approach of teaching**

The teaching and learning of science, has been a subject of debate for a long time relative to the content of the curriculum and the teaching approach. To enhance the use of practicals or experiments, the Government of Kenya came up with the programs geared at Strengthening Mathematics and Science in Education (SMASE) in 2003 that are basically focused on improving students' ability in both mathematics and science. This is by providing a regular in-service course for teachers of mathematics and sciences (JICA, 2001). The in-service training generally improves educational background of teachers' and also provides them with the knowledge and skills linked to the ever changing needs of the dynamic society (Creed & Robinson, 2003). SMASE has walked the talk (SMASE 2017). To date teachers do attend the in-service courses every August holiday for a week. Despite these efforts, some teachers take it for granted and think that this is an economic activity where they get the allowances and forget about what they are trained.

The low-cost equipment produced through improvisation provides opportunities for innovation, creativity and development of manipulative abilities of the students. The concepts learnt can be internalized by use of concrete and speculative work as opposed to proceeding with chalk and talk in the teaching of science (Pimpro, 2005). Improvised laboratory experiments (ILE), for instance, have been used as a remedy to the situation where there are inadequate teaching resources (Ndirangu, *et al.*, 2003). Improvisation creates awareness of the unlimited opportunities that exist in seeking and using locally available materials. To assist the teachers in their planning, SMASE advocates for activity-focused, students-centered learning with experiment and improvisation (ASEI) lesson plan,



where the lesson notes are merged with plan of activities. Within this context, the use of experiments can be enhanced through virtual experimentation especially in cases where highly sophisticated equipment is involved.

### **2.3.2 Experimental work and students' achievement of both knowledge and skills**

Frequency of experimental work / classes is an important school factor since scientific process skills such as observation and prediction involves “doing” and doing means practical activity. It is assumed that frequent use of laboratory for practical lessons by the teacher can translate chemical knowledge to the understanding of the scientific facts, laws and theories. According to Nwosu and Jimoh (2011), Student acquisition of practical skills with reasonable accuracy in laboratory based teaching is in the heart of experimental subjects like chemistry; the use of the laboratory activities outweighs other methods of science teaching. This is to show that the efficacy of frequency of practical teaching to unravel the mystery behind perception of chemistry concepts is not in doubt. Saat (2013), observed that the “talk and chalk” method hardly increased students' enthusiasm and interest. It is observed that students “develop conceptual understanding through engagement in hands-on-activity”.

A study by Garuma and Tesfaye (2012), on the effects of guided discovery on students, found out the following: (1) the traditional method of teaching was the least in improving students' achievements. This was closely followed by teacher demonstrations then finally guided discovery was more effective. (2) The background achievement levels (high-, medium-, and low-achiever) of students' have a very strong relationship with the general students' achievements besides the effect of the instructional methods. Therefore, the study

recommended chemistry teachers to implement guided discovery. This is because the guided discovery helps learners to create, integrate, and generalize knowledge through problem solving by providing them with available chemistry laboratory equipment and apparatus or locally improvised teaching aids.

Giving experimental or practical work experience in learning science is something that should be done in our curriculum. In support of this, Irvine (2017), reminds us of the 3 domains of the Bloom theory in learning. First, the domain of cognitive which affirms to laboratory activities will provide the experience and the introduction of science concept and scientific method. Secondly, the domain of psychomotor; useful for the development of motor skills such as caution, careful observation and create sense of responsibility. Finally, the affective domain, to develop confidence, curiosity and attitude so that worry in carrying out experiments can be avoided.

Performance in practical examination is vital since KNEC has a rule that for a candidate to have a good pass in science, Chemistry included, a pass in practical paper is compulsory. The extent to which students access learning resources particularly those that aid in application of chemical concepts in practical lessons is accompanied by the determination of students' overall performance in Chemistry.

According to the Daily Nation Newspaper of 8<sup>th</sup> May, 2019, report on Mass failure in science and subjects, more than 90% of candidates who sat for Mathematics and science in K.C.S.E in 2018 failed. Only less than 10% qualified for degree courses related to the sciences, a report by the Vice Chancellors (VCs) shows. Therefore from this report, the VCs warned that in the near future, important courses that are core to the country's

development will be scrapped for lack of students. This report went ahead and brought out a clear picture of the academic status of the 2018 candidates. In 2018, the results recorded in KCSE were poor especially in the following subjects; Chemistry, Biology, Mathematics and English. The report showed that 280 degree programs need at least a C+ in Biology, 355 require C+ in Chemistry and 187 in Physics. In chemistry, out of 650,898 candidates, only 73,566 scored C+ and above.

### **2.3.3 The Kenya national examination council reports on experimental / practical work**

The KNEC (2010) report found out that many candidates' failed in questions dependent on experiments. Therefore students should be capable of doing practical/ experiments because they contribute positively to performance in practical examinations, at the same time improving their response to theoretical questions dependent on experiment. The KNEC report of 2008 also commented that practicals supplement good marks to those students who are weak in theory hence influencing performance in KCSE chemistry. Ability to do practicals influences performance in chemistry and as a result qualification for science-based courses at higher levels. Chemistry experiments/ practicals are deemed far much better. Therefore, students who are able to perform experiments efficiently are well placed in terms of subject performance and mastery of practical skills and knowledge. According to Backe (2005), a personal experience in the learning process accounts for 80% of knowledge retention. Experiments help students to put what they have learnt into reality thus, making the subject livelier. Practical entails application of theoretical concept by performing experiments. According to and Gut (2012), large-scale assessments the analysis

of students' performance in experimental tasks is usually based on the products of experimenting.

The KNEC reports of 2016 and 2017 recommended that science teachers in secondary schools should adopt the practical approach of teaching. This was after the realization of poor experimental skills in chemistry paper 3 by the candidates. In addition, the report also emphasized on equipping the schools with the necessary apparatus and chemicals and training of the students on how to take precautions in order to make accurate observations. Finally, students should be guided on how to communicate their findings using acceptable language and how to utilize knowledge and skills learnt in their everyday life.

#### **2.4 Critique of the literature reviewed**

The section that is preceded by this, in this chapter has reviewed studies that have been carried out on the methods of teaching science subjects especially physics and chemistry. Therefore, this part highlights some of the key research studies undertaken and identifies gaps in which the current study was based. A research study by Abraham and Saglem (2010) on teachers views on practical work in secondary schools in England and Wales, found out that assessment in science has changed the way teachers view practical work from a teaching method to drilling in order to pass examinations. Otieno (2012) carried out a study to investigate the effect of practicals on students' achievements in one science subject- physics. He found out that students' performance in experimental work is determined by proper use of laboratory tools. Saat (2013) carried out a study on variety and anti-variety science teacher education in chemistry and found that talk and chalk hardly increased students' enthusiasm and interest. From the literature, little work has been done

on this topic. Therefore, this topic comes handy to close the gap on how the experimental approach of teaching can be used by students to master the knowledge in science and acquire scientific skills all together.

## **2.5 Gaps in Literature review**

This study therefore would like to address the following gaps: Change of practical work from teaching method to drilling in order to pass examinations. Students' achievement in practicals can only be determined through the proper use of laboratory materials and equipment.

## **2.6 Chapter summary**

This chapter generally has reviewed the literature related to the current research study. the literature specifically, has been reviewed on the experimentation versus knowledge mastery in chemistry, and related science-physics, experimentation versus process skills acquisition, SMASEs views on experimentation approach of teaching, experimentation versus students' achievements in chemistry, and KNEC reports on experimental work. However, the study is committed to identifying the effect of experimentation approach of chemistry teaching in knowledge mastery and process skills acquisition in Teso South Sub County.

## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **3.1 Introduction**

The chapter has focused on the research methodology applied in the study. The issues addressed are as follows ; the design of the study, location of the study, sampling procedure, target population, research instruments, validity and reliability of the instruments, data collection, methods of data analysis and ethical considerations.

#### **3.2 Research methodology**

This study employed both quantitative and qualitative research methodology. Quantitative in that the researcher was seeking to quantify the number of students who can be able to manipulate and use the laboratory apparatus to acquire process skills. According to Creswell (2013), a quantitative study seeks to find out the number of individuals who are able to perform a given task.

#### **3.3 Research Design**

The study adapted a quasi-experimental research design. A study by Cohen, Manion & Morrison (2007), found that in educational settings, true experimental designs where participants are randomly selected are difficult to conduct and in most cases researchers have to use pre-existing classes as participants which is then a quasi-experimental design. This was supported by another study by Creswell (2013), argued that experimental design, treatments are manipulated to establish their influence on the outcome. In this study six

schools in two categories: I and II were involved. Three schools were drawn from each category. The first Category was composed of experimental and the second Category was composed of control group. A pre-test was administered to the two categories two weeks before the study commenced. During the study or the treatment administration, experimental group was taught through laboratory experiments where respondents were given hands-on activities while the control group was taught through the conventional methods like lecture, teacher-demonstrations, and dry practical's. This was done for a half a term (i.e. 8 weeks). Then the post-test was administered and the results of the test analyzed.

**Table 3.1: Research design summary**

<b>Time limit (weeks)</b>		<b>Experimental group</b>	<b>Control group</b>
<b>1&amp;2</b>	Phase 1	Pre-test	Pre-test
<b>3-7</b>	Phase 2	Hands-on practical's	Dry practical's  Lecture  Teacher- demonstration
<b>8</b>	Phase 3	Post-test	Post-test

The table shows the three phases the study took. The first and second weeks of the study, respondents were given pre-test. Phase 2 took four weeks where experimental group were subjected to hands-on experiments while control group were given dry practicals, lecture and teacher-demonstrations. The last phase was done in the 8<sup>th</sup> week where respondents were given post-test.

### **3.4 Area of the study**

The area of study was secondary schools found in Teso South sub-county of Busia County (Appendix I). The sub-county has 18 secondary schools. The area covers 293.60km<sup>2</sup>. The road network is slightly good except some parts. The area was chosen because the performance in chemistry was poor as per quality assurance records and KNEC reports.

### **3.5 Target population**

The term population refers to the group of people or subjects who are similar in one or more ways and which form the subject of the study in a particular study. The study area was Teso South sub-county. The unit of study comprised of all form three learners from the 18 public secondary schools. The target population was chosen because the subject in question is one of the compulsory science subjects in Teso South sub-county. Three hundred and thirty three (333) out of 1216 form threes were sampled and actively participated in the research study.

### **3.6 Sampling techniques**

Stratified random sampling was employed to select the sample schools in the area. Therefore, Day mixed secondary schools were categorized into two; the ones with defined MSS ranging between 2.5 - 3.5 and the ones with MSS ranging between 2.0- 3.0 in the 2016 and 2017 KCSE results. Three schools were chosen randomly from each stratum



therefore totaling to a sample size of six. The sampled schools were far apart from each other in order to minimize interaction and influence. The schools also had similar characteristics in terms of entry behavior (mostly sub-county and county schools) and infrastructure. The three schools in each stratum also showed similar characteristics in the following areas: KCSE achievements for the past three consecutive years, well-equipped chemistry laboratory and all had qualified teachers of chemistry. In addition, they were all mixed (Boys & Girls) schools so as to capture the gender component. Boarding schools are part of the secondary schools population but were not part of the sampled population since it could have contributed to some bias in the results. This is because of the big difference in terms of environment and the facilities. The great focus of the study was on mixed secondary schools. Therefore, Boarding schools and day girl schools did not participate since they are single-gender schools.

**Table 3.2: Secondary schools distribution in Teso South**

Type of school	Boarding	Day	Total
<b>Boys</b>	1	0	1
<b>Girls</b>	1	2	3
<b>Mixed</b>	0	14	14
<b>Total</b>	2	16	18

**Source:** Deputy County Commissioner's office- Teso South sub-county

Table 3.2 shows secondary schools distribution in Teso South sub-county from which the six secondary schools were sampled.

**Table 1.3: Sampling table**

Schools	KCSE Mean for the past three years			Number streams	Number students
	2016	2017	2018		
<b>Experimental</b>					
<b>K</b>	2.123	2.427	2.376	1	37
<b>A</b>	2.206	2.333	2.479	1	45
<b>F</b>	3.039	2.954	3.123	2	85
<b>Control</b>					
<b>O</b>	2.620	2.320	2.563	1	41
<b>N</b>	2.722	2.821	2.718	1	42
<b>J</b>	3.401	3.644	3.900	2	83

Source: Teso South Sub-county director of education

### **3.7 Research Instruments**

Three (3) instruments were used in the study. The development of the instruments and their roles are explained in the section below.

#### **3.7.1 Pre-Test**

Pre-test (Appendix II) was used to measure the performance of the learners in chemistry of both the experimental and the control group before the treatment was administered. This was aimed at ensuring that both groups are of relative same ability in performance in chemistry. The achievements tests were composed of structured questions which took 1 hour.

### **3.7.2 Observation Checklists for Skills Acquisition (OCFSA)**

This was part of the treatment and it was administered to each of the study group (control and experimental). This instrument was meant to determine proficiency of the students in the acquisition of science process skills. The observation checklist consisted of science process skills like observation, taking measurements, recording, classification, setting-up apparatus, reading scales and manipulation of data. This instrument was administered during the treatment five times per week for both the group. The results of the study were analysed through both descriptive and inferential statistics.

### **3.7.3 Post-test**

This is a type of Students Achievement Test (SAT), (Appendix IV) administered to both the experimental and control groups on week eight of the term. The evaluation of the work specifically done in each of the sub-topic was given at the end of the topic. The test was marked graded and the marks finally compiled at the end of the term.

### **3.8 Piloting**

The researcher carried out a pilot study for the purposes of testing the reliability of the research instruments and the validity of the study. This was also done to determine the time required for the study to be carried out in one school. The school in the neighboring Nambale sub-county was chosen purposefully for the piloting in order to capture the key characteristics of this study. The school was chosen because it had similar characteristics and of same status as the sampled schools of Teso South sub-county. The subjects were not involved in the real study.

### **3.9 Validity of the Instruments**

According to Patton (2002), validity is a quality attributed to proposition or measure to the degree to which they conform to establish knowledge or truth. In addition, is an indication of the extent to which the instrument measures what it is intended to measure (Vogt, 2007). Both the content and construct validity of the instruments were initiated at the design stage. In both the pre-test and post-test, some the test items used were derived from the KCSE examinations of 2013, 2014 and 2015. The test items were adapted and constructed through strict adherence to the Form Three syllabus. This was to strengthen both content and construct validity. The pre-test and post-tests achievement tests were developed by two chemistry examiners in chemistry paper one and three from the sub-county to avoid bias of the test items.

### **3.10 Reliability of the instrument**

Reliability of an instrument is the measure of the degree to which a research instrument yields consistent results or data after repeated trials. In order to test the reliability of the instrument used in the study, the pre-test and post-test were used. The reliability (internal consistency) of the tests was explored using Cronbach's alpha ( $\alpha$ ). A pilot test on form three students from one secondary in Nambale sub-county ( $N = 43$ ) was used to establish the reliability of this study. The Cronbach's  $\alpha$  for the study was (0.95). This reliability made the instruments suitable for this study.

### **3.11 Data Collection Methods and Procedures**

#### **3.11.1 Collection of learner performance data; Pre-test**

The teachers involved in this study underwent an induction exercise at the beginning of the study, for three days so as to familiarize with the experimental approach of teaching. Two weeks before the study, the sampled schools were given a pre-test. The test was based on work covered in the first two weeks of teaching the topic of interest 'The Mole'. The test was meant to measure learners' performance before the treatment. The test was written under the examination conditions with both groups writing the test at the same time. The administration of the test was supervised by two invigilators and in some cases one depending on the number of respondents. The invigilators were; the researcher and a chemistry teacher from the sampled school. The lesson took a duration of 40 minutes which was one lesson period on the school timetable. The marking of all the pre-test scripts and recording was done by the researcher. The relative achievement levels of both the groups (experimental and control) was ascertained through the analysis of the results obtained from the two tests (the pre- and post-tests).

#### **3.11.2 The practical activity (Treatment)**

The students were taught on the topic 'The Mole' through learner-performed experiments for the experimental group and the traditional methods of teaching for the control group for a timeframe of 5 weeks. The instructional technique for the experimental group emphasized on practical work during the teaching of the topic. While carrying out experiments the respondents were actively engaged in setting up the common apparatus used in the chemistry laboratory. After experiments, the teachers and the learners intensively engaged

in classroom interaction. Some of the reviewed items in class included experiment procedures, data collection, manipulation and analysis. The conventional method of teaching employed to control group included lecture, dry practicals and teacher-demonstrations were used. For dry practicals the respondents were required to carry out calculations, using the data provided. Teacher- demonstrations were carried out by the teacher while students were observing and taking notes. The proficiency of the respondents' in experimental skills was obtained from each of the sub-topics learnt. The Observation Checklists for Skills Acquired (OCFSA) was used to determine the skills after it was administered to each of groups. The proficiency and competency in science process skills was also determined using the same OCFSA. This was done on weekly basis.

### **3.11.3 Collection of learner performance data; post-test.**

The post-test was administered to the learners of both control and experimental groups. The test was written a week after the practical treatment. The purpose of this test was to measure the performance of learners' after practical treatment. The administration of the test took a duration of 2 hours which was an equivalent of 3 lessons period on the school time table. Therefore, this prompted the research to administer it outside the normal school lesson time table. The test was marked then recorded by the researcher.

### **3.12 Methods of Data Analysis**

The data that was collected was analyzed using the Statistical Package for Social Sciences (SPSS) computer software version 2.1. The quantitative data for the science process skills was collected using the OCSFA (Appendix VI). The significant difference between the

means of experimental and control groups in the of students' achievements of science process skills was established using the *t*-test. . In addition, the t-test also was used to test for the hypotheses.

### **3.13 Ethical considerations**

The introductory letter to the National Commission for Science, Technology and Innovation (NACOSTI) was obtained by the researcher from University of Eldoret, School of Education. A research permit from NACOSTI (Appendix VII), aided him to carry out the research. In addition to the permit, permission letters from the Busia county commissioner (Appendix VIII) and Busia County Director of Education (Appendix IX) was obtained authorizing the researcher to carry out study in the area. The respective sampled school administrations were visited by the researcher to seek permission to carry out research from their schools. After obtaining permission from the school administration, the researcher went ahead and organized a meeting with all form three teachers of chemistry where he inducted them on the objectives of the study to be carried out. Confidentiality was assured to all the respondents' and teachers and that the information that will be provided was to be used for the purposes only.

### **3.14 Chapter summary**

The chapter has brought out the research methodology and design employed in the study. In addition, the area of study has also been looked in terms of geographical location of the study. The total population of all form three students in Teso South was taken as the target population because they were the main respondents in the study. Sampling techniques was how the sample population for this study was arrived at. Research instruments in this section are the instruments that were used to collect or obtain data for the study. Validity and reliability are the degree to which the instruments yield the consistent results. Methods of data analysis were also discussed. Data for the study was analysed using both inferential and descriptive statistics. Finally Ethical considerations which were the legal procedures followed before, during and after the study have also been discussed in this section.

## **CHAPTER FOUR**

### **DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION OF THE FINDINGS**

#### **4.1 Introduction**

The chapter presents an analysis, presentation and discussion of data from the findings generated in this study. The chapter specifically considers and explains effects of experimental approach on students' knowledge mastery and process skills acquisition in Chemistry.

#### **4.2 Analysis of test score results.**

##### **4.2.1 Effects of experimental approach of teaching on knowledge mastery.**

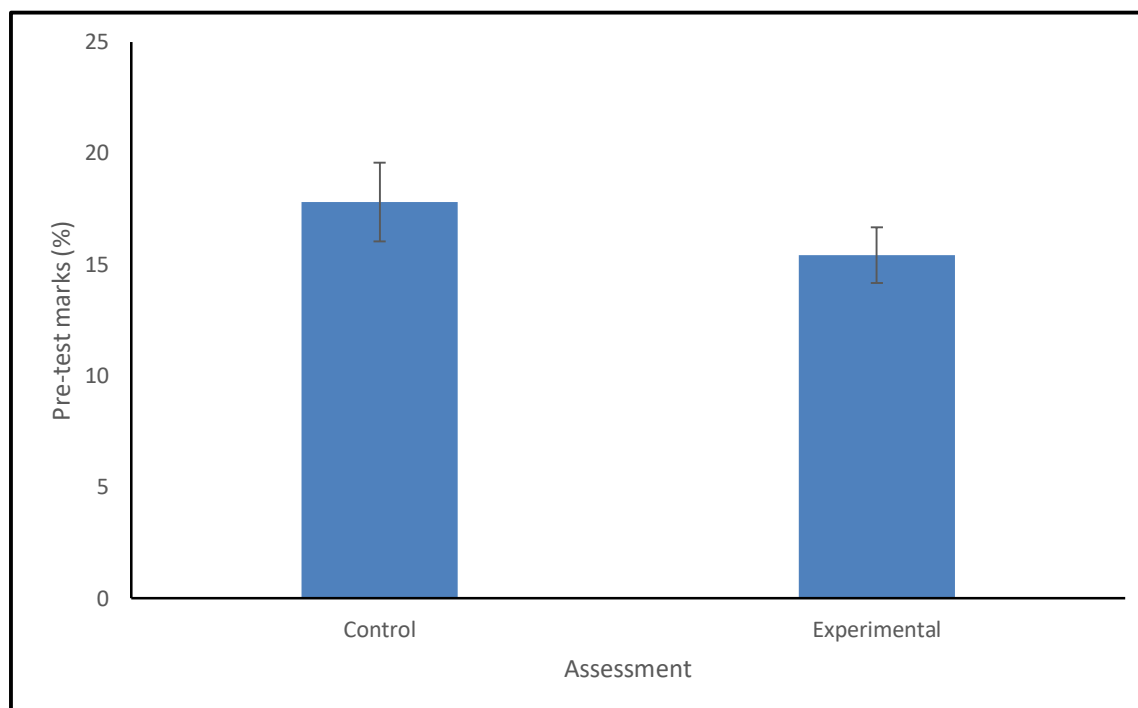
The results of student's performance in the Pre- and Post-test from the two groups of schools; Control and Experimental were analyzed through both descriptive and inferential. The equivalence in the chemistry abilities for the respondents was determined through the pre-tests administered. The pre-test and post-test means for the two groups were compared as shown in Table 4.1 and presented as in Figure 4.1 and Figure 4.2. The results in Table 4.2 were used to determine the significant difference of the means for experimental and control I groups hence test for the first null hypothesis.



Table 4.1 shows the means after administration of pre-test and post-test for both control and experimental groups.

Group	Assessment	Means
<b>Control</b>	Pre-test	17.79
	Post-test	32.05
<b>Experimental</b>	Pre-test	15.42
	Post-test	34.18

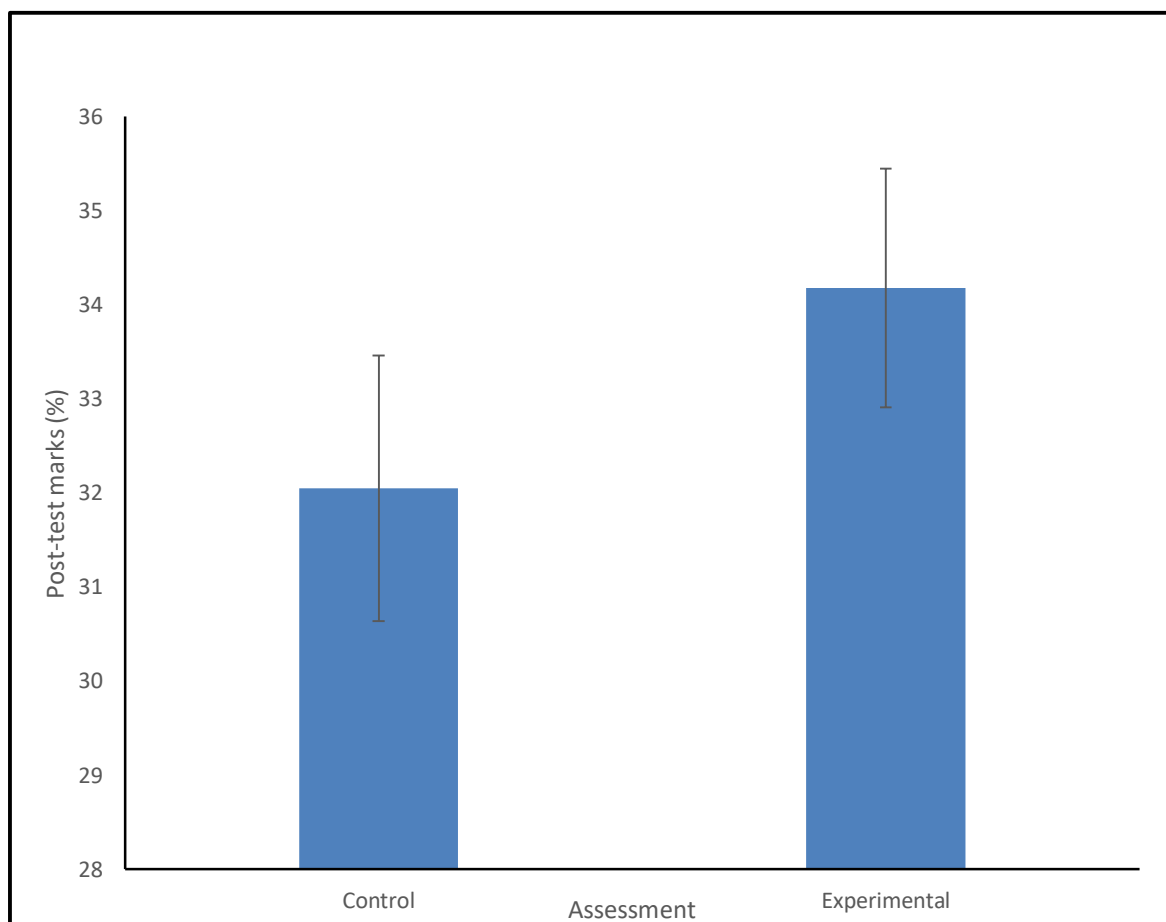
The results in table 4.1 translates to the Figures 4.1 and 4.2



**Figure 4.1: Groups mean comparison for the pre-test using bar graphs.**

The mean for the control group was slightly higher than that of the experimental in the pre-test. This indicates that control group had a better understanding of the prior knowledge than the experimental group. The two groups were exposed to this test before the treatment.

Both of the groups' dependent upon the introduction content of the topic 'The Mole' and part of form 1 and 2 work covered. Figure 4.2 shows the results for the post-test.



**Figure 4.2: Groups mean comparison for the post-test using bar graphs.**

In the post-test, the experimental group performed better than control group. This test was given after the treatment administered. Experimental had better mean than control group because the respondents understood the concepts and content during the treatment. Therefore, they were able to recall the concepts during the post-test.

#### 4.2.1 Statistical t-test analysis for the pre-test and post-test results.

In order to determine if there was any significant difference in learners' performance in pre- and post-test, t-test analysis were used in comparing pre- and post-test scores for learners in each group. The results for pre- and post-tests for both control and experimental groups are illustrated in table 4.2

**Table 4.2: t-test analysis for the pre-test and post-test**

Group	Test	Mean	P Value	t- Value	DF
<b>Experimental</b>	Pre-test	17.3	0.001	-6.30	168
	Post-test	34.2			
<b>Control</b>	Pre-test	15.4	0.001	-10.50	165
	Post-test	32.0			

The data shows the outcome of the t-test analysis of pre- and post-test mean scores for both control and experimental groups. The mean difference between the control and experimental group is statistically significant at 0.001 levels. The hypothesis of no significant difference in knowledge mastery for students taught through experimental approach and those not taught through experimental approach was therefore rejected. There was significant difference in learners' performances after the hands-on activities or treatment applied since a p-value of 0.001 was less than 0.005.

## 4.2.2 Experimental approach versus Process skills Acquisition

According to objective 2, a range of skills was investigated starting with observing, measuring, recording, classifying, reading scales, setting up apparatus and manipulation of experimental data. The observation check list (Appendix VI) was used to determine the proficiency in the seven process skills was determined using an. Then t-tests for both control and experimental groups were carried out and recorded as in Table 4.6

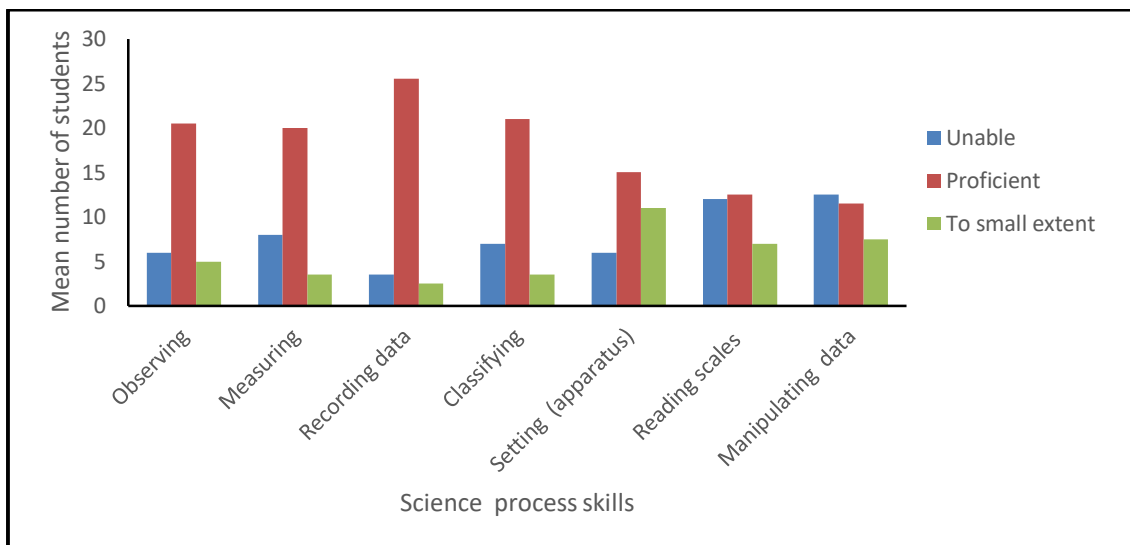
### 4.2.2.1 Representation of scientific process skills for control group

The checklist for the acquisition of process skills by the students was used and their competency in the seven process skills completed. The frequencies of competency or incompetence of students in each skill was tallied as realized in each school at 4<sup>th</sup> week of treatment then used to compute the means given in tables 4.3 for control group.

**Table 4.3 Students' competency in process skills for control group.**

Competence	Observing	Measuring	Recording data	Classifying	Setting (apparatus)	Reading scales	Manipulating data
Unable	6	8	3.5	7	6	12	12.5
Proficient	20.5	20	25.5	21	15	12.5	11.5
To small extent	5	3.5	2.5	3.5	11	7	7.5

From table 4.3 the results translate to the graphical representation by figure 4.3



**Figure 4.3: Scientific process skills for the control group using bar graph.**

In general, from three students competency in skills under study was low in the control group of schools. In all the seven skills, the number of students with proficient skills was slightly higher than the other competencies (unable and able to small extent) except for manipulation of data. A good number of students were unable to manipulate data and reading scales from the apparatus used. Their means were at 12.5 and 12 respectively. The number of students with incompetence in skills was higher than that with proficient in skills.

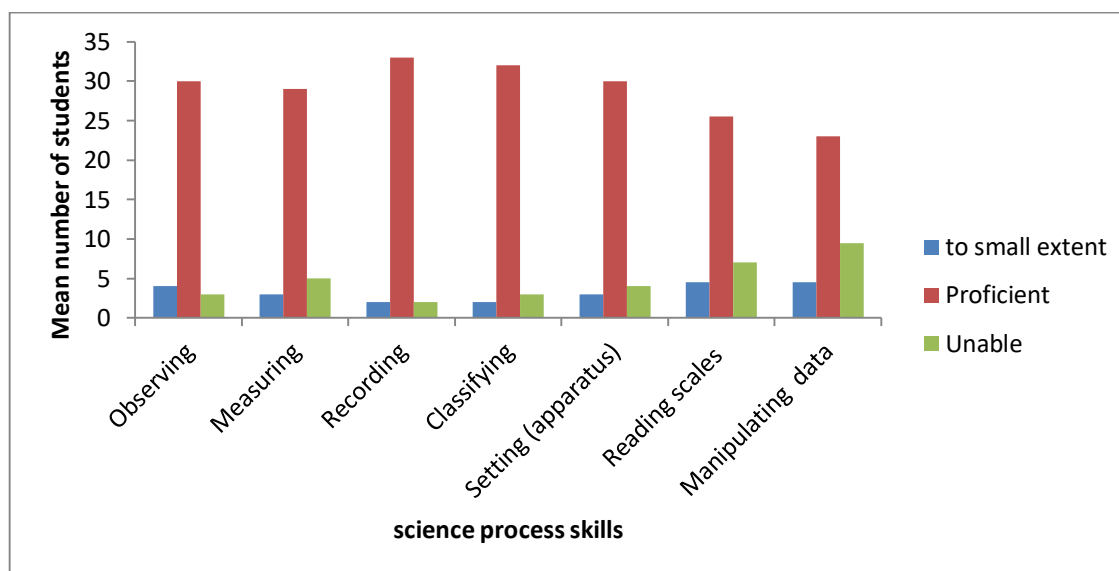
#### **4.2.2.2 Representation of scientific process skills for experimental group**

For the experimental group, a checklist for the acquisition of process skills by the students was the key instrument used in investigating the competency in the seven process skills. The checklist was filled weekly and the frequencies of competency or incompetence of students in each of the seven skills was tallied as realized in each school at 4<sup>th</sup> week of treatment then used to compute the means given in tables 4.4

**Table 4.4 Students' competency in process skills for experimental group**

Competence	Observing	Measuring	Recording data	Classifying	Setting (apparatus)	Reading scales	Manipulating data
<b>Unable</b>	3	5	2	3	4	7	9.5
<b>Proficient</b>	30	29	33	32	30	25.5	23
<b>To small extent</b>	4	3	2	2	3	4.5	4.5

Table 4.4 results translate graphically as follows:



**Figure 4.4: scientific process for the experimental group using bar graphs.**

Generally a good number of students were proficient (with means of above 25) in all the seven skills. This means that frequent exposure to practicals helps the learners acquire the scientific process skills.

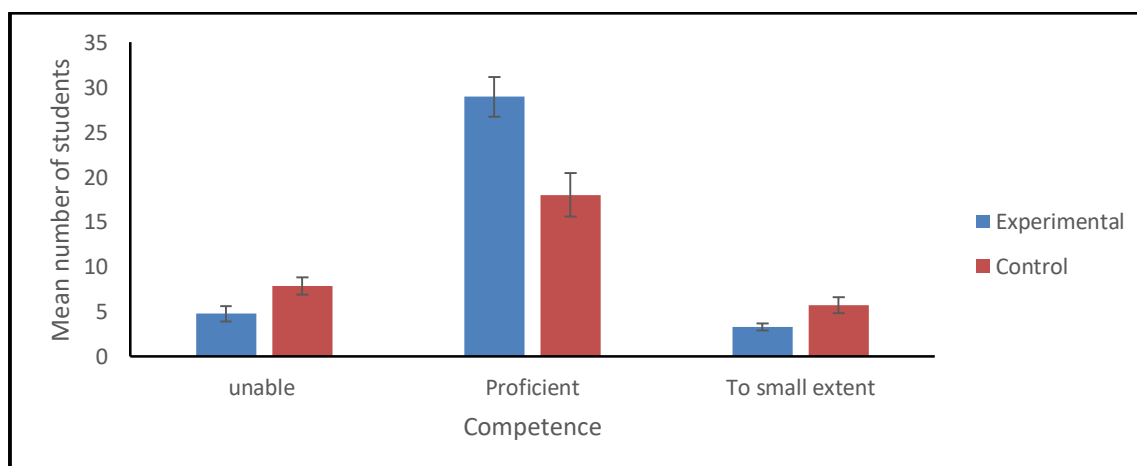
**Table 4.5 Comparison of competencies for control and experimental groups**

Competence	Experimental means	Control means
Unable	3.786	9.857
Proficient	28.93	16
To small extent	4.286	5.714

From Table 4.5, it is clear that the number of students with proficient skills is slightly high (experimental group with 28.93 and control group with 16) compared to those unable and able to small extent. The mean number for the unable (3.786) in the experimental group was the lowest, meaning that the treatment given played a big role in the acquisition of the process skills.

The mean number for the unable (9.857) in the control was second after proficient, this depicts that a good number of students had a challenge in acquiring the process skills.

These results translate to figure 4.5



**Figure 4.5: Comparison of experimental and control groups using bar graphs.**

Generally the control group had higher mean number of students for Unable and able to small extent competencies. This clearly shows that the teacher-centered approach of teaching does not encourage acquisition of process skills. It only benefits a few number of students. On the other hand the experimental group had higher mean of students for the proficient competency. This means that student-centered approach of teaching encourages acquisition of process skills among learners. Therefore, benefit a big number of students.

**Table 4.6: t-test analysis for process skills acquisition for control and experimental groups**

<b>Competence</b>	<b>Test</b>	<b>Average</b>	<b>Standard deviation</b>	<b>T-test</b>	<b>df</b>	<b>P-value</b>
<b>Unable</b>	Experimental	4.7857	3.2148	-2.4000	97	0.0238
	Control	7.8571	3.5487			
<b>To small extent</b>	Experimental	3.2857	1.3828	-2.5764	97	0.0160
	Control	5.7143	3.2446			
<b>Proficient</b>	Experimental	28.9286	8.2692	3.3294	97	0.0026
	Control	18.0000	9.0808			

The data in Table 4.6 shows the outcome of scientific process skills acquisition of the seven skills for both control and experimental groups. The results from Table 4.6 indicate the means, standard deviations and t-values. The seven skills were categorized in terms of the



students' competency: unable, to small extent and proficient. The experimental group means for very able competency were slightly higher than those of the control groups. This indicated that the practicals administered to this group had a positive impact to the group. From Table 4.6, the means for the experimental groups were slightly higher than those of the control groups. This indicated that the practicals administered to this group had a positive impact to the group. The p-values for all the three categories of competencies are below 0.05,(0.0238 for unable, 0.0160 for able to small extent and 0.0026 for proficient). This indicates that the hypothesis of no significant difference in acquisition of science process skills for experimental and control group is therefore rejected.

### **4.3 Discussion of Results**

For the first objective of the study, pre- and post-tests (From Table 4.1) show that before treatment, mean for the control group was 17.79 whereas that of the experimental group was 15.42. After treatment, the post-test mean showed that both control and experimental groups improved with the mean score of control increased from 17.79 to 32.0 while that of experimental increased from 15.42 to 34.2. The results clearly show that the control group performed slightly better in comparison to experimental group in the pre-test. This could be because the control group had prepaid well compared to experimental group. These results concur with the findings of the study by Sudi, (2012) who found out that well prepared students tend to perform better in any given test irrespective of the environment. The means for the pre-test were too close, indicating that both groups had prior knowledge of the topic.

The means after the treatment indicate that, better performance was realized by the experimental group compared to the control group. The treatment given to the experimental group must have contributed to this improvement. The tests therefore revealed that there is

a significant mean difference in learner performance, further confirming that practical work impacted positively on the learner. The results of this study are in tandem with others previously done. Experimental group did better since Lee, O., Llosa, L., Jiang, F., Haas, A., O'Connor, C., & Van Booven, C. D. (2016) found out that engagement with laboratory experiments increased students mastery of complex science matter and ideas. Therefore these findings make the control group disadvantaged.

Wang and Degol, (2017) found out that laboratory experiences have the potential of helping students attain scientific goals one of which is mastery of subject matter. The findings of this study also agree with those of Muhammad-Lawal (2015) who found out that meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment's and materials for them to construct knowledge. This is to say, traditional methods of teaching are now outdated if scientific knowledge is to be mastered and acquired. The strategies recommended by (Linus 2018) of predict –observe then explain in an experiment must have borne fruit for the experimental group. These strategies, according to him, improve learners reason scientifically hence master knowledge. On the other hand the findings of the study disagreed with the findings of Bell and Trundle (2010) who concluded that there was no significant difference between the performance of the experimental and control groups.

For the second objective on acquisition of scientific process skills, the results from descriptive analysis showed that many students in experimental group acquired the skills (from Tables 4.4 and 4.5) in comparison to control group. The means for experimental group were 25 and above. These findings concur with the findings of Bang and Baker (2013) which found out that, students in mixed secondary schools had good acquisition of process skills especially when exposed to experiments frequently. In addition, the findings affirm Ndoro (2017) use of direct assessment of skills is best for the novice scientists.

#### **4.4 Chapter summary**

In this chapter, the researcher has dealt with data analysis. The data for this study was analyzed using both descriptive to compare the means and inferential statistics to test for the hypotheses. The data was then presented in tables and bar graphs. Results from the tables and bar graphs were therefore discussed and related to other empirical studies as from Chapter 2. In the discussion, hypotheses for the study were tested.

## CHAPTER FIVE

### SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Introduction

The chapter presents the summary of the findings, draw conclusions and make recommendations based on the conclusions. The main purpose of this study was to assess the effectiveness of experimentation method of teaching in knowledge mastery and skills acquisition in chemistry as a subject. Data for analysis was obtained through pre-test, post-test and observation checklist for process skills acquisition.

#### 5.2 Summary of the Findings

From chapter four, the following was found; for the first objective of this study was to determine the effects of experimental work on students' knowledge mastery in chemistry. It was evident from the results that experimental schools performed better than control schools in the post-test. This shows that the practical treatment given to the experimental group enabled the students master the knowledge and retain to their minds.

An independent t-test revealed that there was a significant mean difference between experimental schools and control schools in the pre-test,  $t = -6.30$ ,  $p=0.001$ ,  $\alpha=0.05$ , it also showed that there was significant mean difference between experimental and control schools in the post-test  $t = -10.50$ ,  $p=0.001$ ,  $\alpha=0.05$ .

For the second objective, the study found out that the experimental schools acquired the skills better than control schools. The p-values for the different competencies are as follows

Not able  $p=0.0238$ , to small extent  $p=0.0160$ , perfect  $p=0.0026$  while the t-values are 2.4, 2.5764 and 3.3294 respectively.

### **5.3 Conclusion**

The results above indicate that experimental schools performed better than control groups. This means that the experimental schools mastered knowledge and acquired process skills than those taught through traditional methods. The null hypotheses, there is no significant difference in knowledge mastery and process skills acquisition for students taught through experimental approach and those not taught through experimental approach, is therefore rejected. Alternative hypotheses, there is significant difference in knowledge mastery and process skills acquisition for students taught through experimental approach, is therefore accepted.

### **5.4 Recommendations.**

The researcher would like to make the following recommendations:

1. Practical work improves mastery of scientific knowledge and acquisition of skills. Therefore, chemistry teachers in Kenya should use the practical approach in teaching for easier understanding of scientific concepts; knowledge mastery and skills acquisition that enables learners thrive well in this technological world.
2. The government should build more laboratories and hire more qualified personnel in schools, if this approach was to be successfully used. The school administrations and Boards of Management should equip the laboratories since practical demands more equipment for it to meet the objectives.

3. The policy makers to assess this approach of teaching and make informed decisions in order to promote quality of education.

### **5.5 Suggestions for further research**

From the results above, the researcher would like to suggest as follows:

1. Further research should be conducted in the larger Busia County on the effects of practical work on knowledge mastery and process skills acquisition in Chemistry and other science subjects.
2. Further research should be conducted on the effects of Gender on process skills acquisition in secondary schools in Busia county and other parts of Kenya.
3. Research should also be carried out on the level of the school versus knowledge mastery and process skills acquisition in Secondary schools of Busia County.

### **5.6 Chapter Summary**

This chapter has looked at the summary of the findings as discussed in chapter four, both analyzed by descriptive and inferential statistics. How relevant this data was to this study. Conclusion of the study was done based on whether the objective of the study was achieved or not. Recommendations to various bodies based on the study findings and finally the suggestions for further studies to be carried out.

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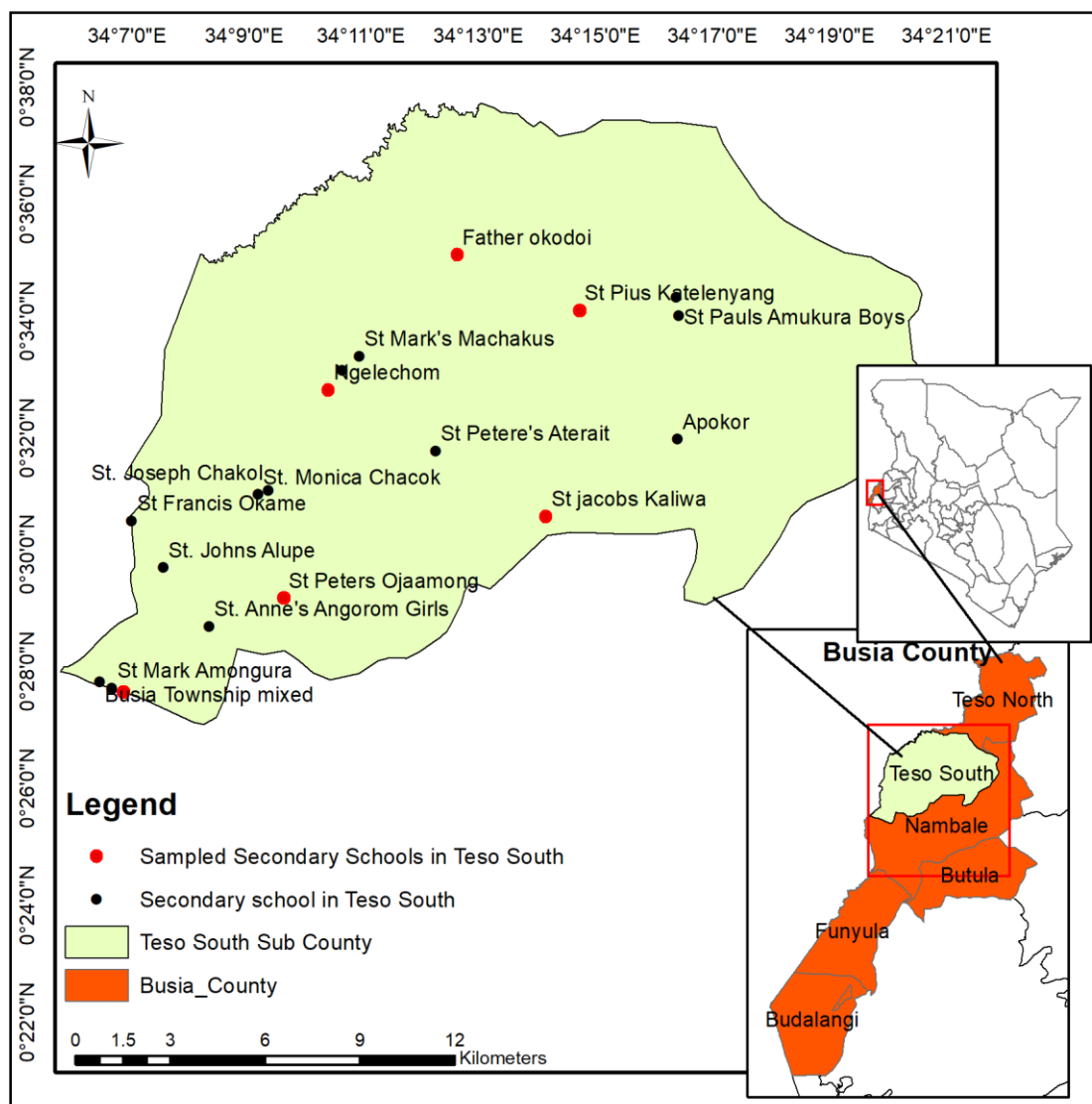
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## APPENDICES

## Appendix I: Map of the study area



(Source: Author, 2019)

**Appendix II: Pre-test****Time: 40 minutes****Instruction****Answer ALL questions in the spaces provided.****Do not write your name.**

1. Define the following terms as used in chemistry; (4 marks)

a) Mole

.....

b) Element

.....

c) Atom

.....

d) Relative atomic mass

.....

2. Calculate the relative formula mass of the following molecules:

i. Nitrogen (N=14) (1/2 mark)

.....

ii. Chlorine (Cl=35.5) (1/2 mark)

.....

iii. Hydrogen sulphide ( H= 1, S=32,) (1 mark)

.....

3. Determine the number of moles in 0.23g of sulphuric (VI) acid. (2 marks)

.....

4. Use the number of moles in 3 above to calculate the number of atoms (Avogadro's constant  $L = 6.022 \times 10^{23}$ ) (2 marks)

.....

5. The data below shows information obtained by a form three students after burning copper in air

Mass of boat = 15.6g

Mass of boat before heating = 19.1g

Mass of boat after heating = 18.4g

Use the information to calculate:

Mass of copper (ii) oxide formed (1 mark)

.....

Mass of oxygen used (1 mark)

.....



Mass of copper

(1 mark)

.....

6. The table below shows the relative atomic masses and the percentage abundance of the isotopes  $L_1$  and  $L_2$  of element L

	Relative atomic mass	% abundance
$L_1$	62.93	69.09
$L_2$	61.93	30.91

Calculate the relative atomic mass of element L

(3 marks)

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

7. Give the uses of the following laboratory apparatus.

Teat pipette

(1 mark)

.....

Volumetric flask

(1 mark)

.....

Burette

(1 mark)

.....

Conical flask

(1 mark)

.....

8. Fill the table below

(3 marks)

Indicator	Colour in acid	Colour in base
Methyl orange		
Phenolphthalein		
Litmus		

9. 1.60g of an oxide of magnesium contains 0.84g by mass of magnesium. Determine its empirical formulae (Mg=24, O=16) (3 marks)

.....

.....

.....

.....

10. When a hydrated sample of calcium sulphate  $\text{CaSO}_4 \cdot \text{XH}_2\text{O}$  was heated until all the water was lost, the following data recorded;

Mass of crucible = 30.296 g

Mass of crucible +hydrated salt = 33.111 g

Mass of crucible + anhydrous salt = 32.781 g

Determine the empirical formula of the hydrated salt (Relative formula mass of  $\text{CaSO}_4=136$ ,  $\text{H}_2\text{O}=18$ ). (4 marks)

.....

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

### **Appendix III: Marking Scheme for Pre-test**

1. Define the following terms as used in chemistry;

Mole-*Is the SI unit of the amount of substance*√

Element- *Is a pure substance that cannot be split into simpler substances by physical or chemical means.* √

Atom-*Is the smallest particle of an element that takes part in a chemical reaction*√.

Relative atomic mass—Is the mass of average atom of an element compared to 1/12 an atom of  $^{12}\text{C}$  isotope. ✓

2. Calculate the relative formula mass of the following molecules:

Nitrogen ( $\text{N}=14$ )

$$14 \times 2 = 28 \checkmark$$

Chlorine ( $\text{Cl}=35.5$ )

$$35.5 \times 2 = 71 \checkmark$$

Hydrogen sulphide ( $\text{H}=1, \text{S}=32$ )

$$\text{H}_2\text{S} = 1 \times 2 + 32$$

$$= 34 \checkmark$$

3. Determine the number of moles in 0.23g of sulphuric (VI) acid

$$\text{RFM of } \text{H}_2\text{SO}_4 = 1 \times 2 + 32 + 16 \times 4$$

$$= 98 \checkmark$$

$$\text{No of moles} = \frac{\text{mass}}{\text{RFM}}$$

$$\text{RFM}$$

$$\text{No of mole} = \frac{0.23}{98} \checkmark = 0.002347 \checkmark$$

4. Use the number of moles in 3 above to calculate the number of atoms (Avogadro's constant  $L=6.022 \times 10^{23}$ )

$$1 \text{ mole} \longrightarrow 6.022 \times 10^{23} \text{ atoms}$$

$$0.002347 \text{ moles} \longrightarrow ? \quad 0.002347 \times 6.022 \times 10^{23} \checkmark = 1.4134 \times 10^{21} \text{ atoms} \checkmark$$

5. The data below shows information obtained by a form three students after burning copper in air

Mass of boat = 15.6g

Mass of boat before heating = 19.1g

Mass of boat after heating = 18.4g

Use the information to calculate:

Mass of copper (ii) oxide used

$$19.1 - 15.6 = 3.5g\checkmark$$

Mass of oxygen used

$$19.1 - 18.4 = 0.7g\checkmark$$

Mass of copper

$$3.5 - 0.7 = 2.8g\checkmark$$

6. The table below shows the relative atomic masses and the percentage abundance of the isotopes  $L_1$  and  $L_2$  of element L

	Relative atomic mass	% abundance
$L_1$	62.93	69.09
$L_2$	61.93	30.91

Calculate the relative atomic mass of element L

$$\begin{aligned}
 RAM &= \frac{62.93 \times 69.09 + 61.93 \times 30.91}{100} \checkmark \\
 &= \frac{6262.09}{100} = 62.62 \checkmark
 \end{aligned}$$

7. Give the uses of the following laboratory apparatus.

Teat pipette - *measure small amounts of liquid drop wise.* ✓

Volumetric flask- *measure accurate volume of liquid substances* ✓

Burette – *measure small accurate and exact volume of liquids.* ✓

Conical flask- *for general laboratory experiments.* ✓

8. Fill the table below:

Indicator	Colour in acid	Colour in base
Methyl orange	<i>Pink</i> ✓	<i>Orange/ yellow</i> ✓
Phenolphthalein	<i>Colourless</i> ✓	<i>Pink</i> ✓
Litmus	<i>Red</i> ✓	<i>Blue</i> ✓

9. 1.60g of an oxide of Magnesium contains 0.84g by mass of magnesium. Determine its empirical formula.

$$\text{Mass of oxygen: } 1.60\text{g} - 0.84\text{g} = 0.76\text{g}$$

	Magnesium	Oxygen
Mass in grams	0.84	0.76
R. A. M	24	16
Moles	$0.84/24=0.035$	$0.76/16=0.0475$
Mole ratio	$0.035/0.035=1$	$0.0475/0.035=1.4$

Empirical formula:  $\text{MgO}_{1.4}$

10. When a hydrated sample of calcium sulphate  $\text{CaSO}_4 \cdot x\text{H}_2\text{O}$  was heated until all the water was lost, the following data recorded;

$$\text{Mass of crucible} = 30.296 \text{ g}$$

$$\text{Mass of crucible + hydrated salt} = 33.111 \text{ g}$$

$$\text{Mass of crucible + anhydrous salt} = 32.781 \text{ g}$$

Determine the empirical formula of the hydrated salt (Relative formula mass of  $\text{CaSO}_4 = 136$ ,  $\text{H}_2\text{O} = 18$ ).

$$\text{Mass of hydrated salt} = (33.111 - 30.296) = 2.815\text{g}$$

$$\text{Mass of anhydrous salt} = (32.781 - 30.296) = 2.485\text{g}$$

$$\text{Mass of water} = (2.815 - 2.485) = 0.330\text{g}$$

	$\text{CaSO}_4$	$x \text{H}_2\text{O}$
Mass	2.485	0.320
Moles	$2.485/136 = 0.0183$	$0.330/18 = 0.0183$
Mole ratio	$0.0183/0.0183 = 1$	$0.0183/0.0183 = 1$

*Empirical formula:*  $\text{CaSO}_4 \cdot \text{H}_2\text{O}$



**Appendix IV: Post-test**

Time: 2hr

1.  $10\text{cm}^3$  of concentrated sulphuric (VI) acid was diluted to  $100\text{cm}^3$ .  $10\text{cm}^3$  of the resulting solution was neutralized by  $36\text{cm}^3$  of  $0.1\text{M}$  sodium hydroxide solution. Determine the mass of sulphuric (VI) acid that was in the concentrated acid ( $s = 32.0$ ;  $\text{H} = 1.0$ ;  $\text{O} = 16.0$ ). (3marks)

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

2. Calculate the concentration of Sulphuric acid in moles per litre if  $15\text{cm}^3$  of the acid is completely neutralized by  $20\text{cm}^3$  of one molar potassium hydroxide. (2marks)

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

3.  $22.2\text{cm}^3$  of sodium hydroxide solution, containing  $4.0\text{g}$  per litre of sodium hydroxide were required for complete neutralization  $0.1\text{g}$  of a dibasic acid. Calculate the relative formula mass of the dibasic acid ( $\text{Na} = 23$ ,  $\text{O} = 16.0$ ,  $\text{H} = 1.0$ ). (3 marks)

.....  
.....

- .....
- .....
4. When 34.8g of hydrated sodium carbonate ( $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ ) were heated to a constant mass. 15.9g of anhydrous sodium carbonate were obtained. Calculate the value of x in the hydrated carbonate. (Na=23.0, O=16.0, C=12.0, H=1.0). (3 marks)

.....

.....

.....

.....

5. The table below shows the volumes of nitrogen dioxide gas **produced** when different volume of 1M nitric acid were each reacted with 2.07 g of lead at room temperature.

Volume of 1 M nitric acid ( $\text{cm}^3$ )	Volume of nitrogen dioxide gas ( $\text{cm}^3$ )
5	60
15	180
25	300
35	420
45	480
55	480

On the grid provided below, plot a graph of the volume of the gas produced (Vertical axis) against volume of acid. (3 marks)

Using the graph, determine the volume of:

- i) Nitrogen dioxide produced when 30cm<sup>3</sup> of 1 M nitric acid were reacted with 2.07 g of lead

(1mark)

.....  
.....

- ii) 1M nitric acid which would react completely with 2.07g of lead. (1mark)

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

Using the answer in d(i) above, determine:

- i) The volume of 1M nitric acid that would react completely with one mole of lead  
(Pb=207) (2marks)

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

- ii) The volume of nitrogen dioxide gas produced when one mole of lead reacts with excess 1 M nitric room temperature. (1mark)

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

Calculate the number of moles of:

- i) 1M nitric acid that reacted with one mole of lead (1mark)

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

- ii) Nitrogen dioxide produced when one mole of lead were reacted with excess nitric

acid. (Molar gas volume of  $2400\text{cm}^3$ ) (1mark)

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

iii) Using the answers obtained in f (i) and (ii) above, write the equation for the reaction between lead and nitric acid given that one mole of lead nitrate and two moles of water were also produced. (1mark)

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

6. The table below shows results obtained from a titration of 4.9g/l of  $\text{H}_2\text{SO}_4$  solution C against aqueous sodium hydroxide (NaOH) solution D in the presence of phenolphthalein indicator.

Titration	I	II	III
Final burette reading ( $\text{cm}^3$ )	25.1		
Initial burette reading ( $\text{cm}^3$ )	0.0	20.0	
Volume of solution C ( $\text{cm}^3$ )			25.0

Complete the table. (4 marks)

- (a) Calculate the average volume of solution C. (1 mark)

.....  
 .....

- (b) Calculate the concentration of the dibasic acid, solution C in mol/litre (S=32,O=16,H=1). (1 mark)

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

- (c) Calculate the number of moles solution C used. (1 mark)

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

(d) Calculate the number of moles of solution D in the above experiment that were present in 25cm<sup>3</sup>. (1 mark)

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

(e) Calculate the concentration of solution D in moles per litre. (1 mark)

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

II) Table 2 below shows results obtained from the titration of solution B (prepared by diluting 10cm<sup>3</sup> of HCl to 250cm<sup>3</sup>) against solution D from part I above. Fill the table above.

Titration	I	II	III
Final burette reading (cm <sup>3</sup> )	12.4		12.6
Initial burette reading (cm <sup>3</sup> )	0.0	12.5	
Volume of solution B (cm <sup>3</sup> )			

Complete the table above. (4 marks)

(a) Calculate the average volume of solution B used in  $\text{cm}^3$ . (1 mark)

.....  
.....

(b) i. calculates the number of moles of sodium hydroxide, in solution D used. (1 mark)

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

(ii) Calculate the number of moles of the diluted acid that reacted completely with  $25\text{cm}^3$  of sodium hydroxide. (1 mark)

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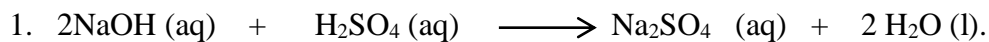
(c) Calculate the number of moles of the diluted acid in  $100\text{cm}^3$  of the solution. (1 mark)

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.....  
.....

(d) Calculate the concentration of the original hydrochloric acid, solution A in moles per litre. (1 mark)

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.....  
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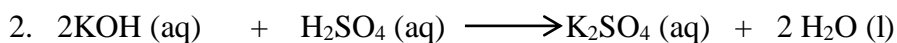
### Appendix V: Marking Scheme for the Post Test



Moles of NaOH =  $0.1 \times 36/1000 = 0.0036$  moles. ✓

Moles of H<sub>2</sub>SO<sub>4</sub> =  $0.0036/2 = 0.0018$  moles. ✓

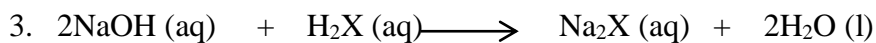
mass of H<sub>2</sub>SO<sub>4</sub> =  $0.0018 \times 98 = 0.18$  g ✓



Moles of KOH =  $1 \times 20/1000 = 0.02$  moles. ✓

Moles of H<sub>2</sub>SO<sub>4</sub> =  $0.02/2 = 0.01$  moles. ✓

Molarity of H<sub>2</sub>SO<sub>4</sub> =  $1000 \times 0.01/15 = 0.67$  M ✓



Moles of NaOH =  $0.1 \times 22.2/1000 = 0.00222$  moles. ✓

Moles of H<sub>2</sub>X =  $0.00222/2 = 0.00111$  moles. RFM of H<sub>2</sub>X =  $0.1/0.00111 = 90.09$  ✓



x = 7

5. Graph-scale ✓

-plotting ✓

- line ✓



## 6. Table1

CT..... 1 mark

D.P..... 1 mark

C.....1 mark

Average volume =  $25.1 + 25.2 + 25.0/3 = 25.1\text{cm}^3$  ✓Molarity of solution C =  $4.9/98 = 0.05\text{M}$  ✓Moles of solution C =  $0.05 \times 25.1/1000 = 0.001255\text{moles}$  ✓Moles of solution D =  $0.001255/2 = 0.0006275$  moles ✓Molarity of solution D =  $0.0006275 \times 1000/25 = 0.0251\text{M}$  ✓

Table 2.

CT..... 1 mark

D.P..... 1 mark

C..... 1 mark

Average volume of solution B =  $12.4 + 12.5 + 12.6/3 = 12.5\text{cm}^3$  ✓Moles of NaOH =  $0.0251 \times 25/1000 = 0.0006275\text{moles}$  ✓Moles of HCl =  $0.0006275$  moles. ✓Moles of HCl in  $100\text{cm}^3 = 100 \times 0.0006275/12.5 = 0.00502\text{moles}$ . ✓Molarity of HCl =  $1000 \times 0.00502/100 = 0.05\text{M}$ . ✓

### Appendix VI: Observation checklist for skills acquisition

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

Topic		Not able	To a small extent	perfectly
Science process skills	Observing			
	Measuring			
	Recording			
	Classifying			
Experimental achievement skills	Setting up apparatus			
	Reading scales on apparatus			
	Manipulation of experimental data			

Comments

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.....

.....

## Appendix VII: Research permit

<p style="text-align: center;"><b>CONDITIONS</b></p> <ol style="list-style-type: none"> <li>1. The License is valid for the proposed research, research site specified period.</li> <li>2. Both the Licence and any rights thereunder are non-transferable.</li> <li>3. Upon request of the Commission, the Licensee shall submit a progress report.</li> <li>4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research.</li> <li>5. Excavation, filming and collection of specimens are subject to further permissions from relevant Government agencies.</li> <li>6. This Licence does not give authority to transfer research materials.</li> <li>7. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.</li> <li>8. The Commission reserves the right to modify the conditions of this Licence including its cancellation without prior notice.</li> </ol>	 <p><b>REPUBLIC OF KENYA</b></p> <hr/>  <p><b>National Commission for Science, Technology and Innovation</b></p> <p><b>RESEARCH CLEARANCE PERMIT</b></p> <p><b>Serial No.A 20251</b></p> <p><b>CONDITIONS: see back page</b></p>
---	--

<p><b>THIS IS TO CERTIFY THAT:</b>  <b>MR. RAYMOND LUKE ELUKET</b>  <b>of UNIVERSITY OF ELDORET, 0-50400</b>  <b>BUSIA, has been permitted to conduct</b>  <b>research in Busia County</b></p> <p><b>on the topic: EFFECTS OF</b>  <b>EXPERIMENTAL APPROACH ON</b>  <b>KNOWLEDGE MASTERY AND PROCESS</b>  <b>SKILLS ACQUISITION IN CHEMISTRY IN</b>  <b>SECONDARY SCHOOLS IN TESO SOUTH</b>  <b>SUB-COUNTY, KENYA</b></p> <p><b>for the period ending:</b>  <b>17th August, 2019</b></p> <p>  <b>Applicant's Signature</b></p>	<p><b>Permit No : NACOSTI/P/18/92655/24621</b>  <b>Date Of Issue : 18th August, 2018</b>  <b>Fee Received :Ksh 1000</b></p>  <p>  <b>Director General</b>  <b>National Commission for Science, Technology &amp; Innovation</b></p>
---	--

## Appendix VIII: Letter from County Commissioner

REPUBLIC OF KENYA



THE PRESIDENCY  
MINISTRY OF INTERIOR AND CO-ORDINATION OF NATIONAL  
GOVERNMENT

Email: ccbusia@gmail.com  
Telephone: 055 - 22598  
Fax No: 055 - 22231  
When replying please quote  
REF No. ADM 15/4/VOL.IV/23

COUNTY COMMISSIONER'S OFFICE  
BUSIA COUNTY  
P.O. BOX 14-50400  
BUSIA (K)

27<sup>th</sup> November, 2018

Deputy County Commissioner  
Teso South Sub-County  
AMUKURA

**RE: RESEARCH AUTHORIZATION**

Following research authorization vide letter Ref.No.NACOSTI/P/18/92655/24621, dated 18<sup>th</sup> August, 2018, by the National Commission for Science, Technology and Innovation on "*Effects of experimental approach on knowledge mastery and process skills acquisition in chemistry in secondary schools in Teso South Sub-County, Kenya*". This is to inform you that **Raymond Luke Eluket** has been authorized to carry out research in Teso South Sub-County in Busia County for the period ending 17<sup>th</sup> August, 2019.

Kindly accord him the due co -operation.

  
Samuel Kimani  
For: County Commissioner  
BUSIA COUNTY

**Copy to:**  
Raymond Luke Eluket  
University of Eldoret  
P.O.Box 1125-30100  
**ELDORET**

## Appendix IX: Letter from County Director of Education



**REPUBLIC OF KENYA  
MINISTRY OF EDUCATION  
STATE DEPARTMENT OF EARLY LEARNING AND BASIC EDUCATION**

**Telephone: 055-22152**  
**Fax: 055-22152**  
**When replying please quote**  
Email: cdebusia@gmail.com

COUNTY DIRECTOR OF EDUCATION  
BUSIA COUNTY  
P.O. BOX 15 - 50400  
BUSIA (K)

**26<sup>th</sup> November, 2018**

**Ref No. BSA/CDE/ED/9/6/(344)**

Sub-County Directors of Education  
**BUSIA COUNTY**

**RE: RESEARCH AUTHORIZATION**

This office is in receipt of letters from National Commission for Science, Technology and Innovation dated 18<sup>th</sup> November, 2018 authorizing research on ***“Effects of experimental approach on knowledge mastery and process skills acquisition in Chemistry in Secondary Schools in Teso South Su-County, Kenya”*** in Busia County. The research period is expected to end on 17<sup>th</sup> November, 2019.

This is to inform you that **Raymond Luke Eluket** has been authorized to conduct the research. Kindly accord him necessary assistance.

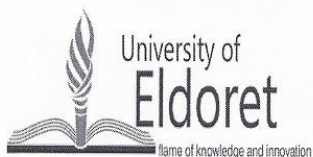
  
**PAMELLA A. AKELLO**  
COUNTY DIRECTOR OF EDUCATION  
**BUSIA COUNTY**

**C.C.**

The Director-General/CEO  
Kenya National Commission for UNESCO  
**NAIROBI**

**Raymond Luke Eluket**

## Appendix X: Introductory Letter



P.O. Box 1125-30100, ELDORET, Kenya  
 Tel: 053-2063111 Ext. 242  
 Fax No. 20-2141257  
 Email: soe@uoeld.co.ke  
 www.uoeld.ac.ke

UNIVERSITY OF ELDORET

SCHOOL OF EDUCATION  
 CENTRE FOR TEACHER EDUCATION

Ref: UOE/B/CTE/PGS/033/Vol.1  
 Date: July, 18, 2018

The Executive Secretary,  
 National Council for Science Technology & Innovation  
 P.O Box 30623- 00100  
 Nairobi.  
 Dear Sir /Madam

**SUBJECT: RESEARCH PERMIT FOR: ELUKET LUKE RAYMOND- EDU/S/PGSE/004/15**

This is to confirm that the above named Post Graduate Student has completed course work and has successfully defended his thesis proposal.

He is currently preparing for a Field Research work on his thesis entitled: *Effects of Experimental Approach on Knowledge Mastery and Process Skills Acquisition in Chemistry in Secondary Schools in Teso South Sub -County*

Any assistance accorded to him to facilitate successful conduct of the research and the publication will be highly appreciated.

Yours Faithfully,

DR. P. WASWA

HEAD, CENTRE FOR TEACHER EDUCATION



Cc Permanent Secretary  
 Ministry of Higher Education, Science & Technology,  
 P. O Box 9583-00200,  
 Nairobi  
 Post Graduate Coordinator  
 University of Eldoret

University of Eldoret is ISO 9001: 2008 Certified



## Appendix XI: Similarity Report

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EDU/S/PGSE/004/15 By Eluket L. Raymond



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