LABORATORY ADEQUACY AND ITS EFFECT ON PERFORMANCE IN CHEMISTRYIN SECONDARY SCHOOLS IN KESSES SUB-COUNTY, UASIN GISHU COUNTY KENYA.

BY

KOSGEI CAROLINE

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DECLARATION

This thesis is my original work and has not been presented for any other award in any other university. No part of this work should be reproduced without prior permission from the author and /or University of Eldoret.

KOSGEI CAROLINE

______________________________ ______________________

EDU/PGSE/018/14 **Date**

This Thesis has been submitted with our permission as university supervisors.

______________________________ ______________________

Dr. P.WASWA **Date**

University of Eldoret

______________________________ ______________________

PROF. J.K. LUSWETI **Date**

University of Eldoret

DEDICATION

This research thesis is dedicated to my dear mum, Esther Koskei for her tireless and unending support throughout the exercise. May Almighty Lord grant her His mercies and blessing.

ABSTRACT

It has been observed that the general poor performance in science subjects is due to inadequate laboratory resources. An expository study designed to investigate laboratory adequacy and performance in secondary school Chemistry in Kesses Sub-County has been undertaken. The aim of the study was to; determine the frequency of students' interaction with laboratory resources in the teaching and learning of chemistry, assess the utilization of laboratory resources in the teaching and learning of chemistry and evaluate the effect of laboratory adequacy on chemistry performance in Kenya Certificate of Secondary Education (K.C.S.E) examination. The main research question was; how laboratory adequacy affects chemistry performance. The hypothesis that guided the study was; the utilization of chemistry laboratory in the teaching and learning of chemistry and influence laboratory adequacy on students' performance in Chemistry. The study assumed that the K.C.S.E performance that was received from the research sample was a true reflection of the effect of laboratory adequacy in chemistry. This study was guided by constructivist theory attributed to Jean Piaget which postulates that learners learn by experimentations, and not by being told what will happen, and are left to make their own inferences, discoveries and conclusions. A sample of 30 percent (1590) of the target population was used to conduct the study. The students and Chemistry teacher were involved through administration of questionnaires. An inventory checklist for laboratory apparatus and reagents was filled by laboratory assistant/Chemistry teacher. The Director of Studies also filled a form to capture the scores, grades and school means for K.C.S.E chemistry performance for three consecutive years: 2014, 2015 and 2016. All these enabled the establishment of laboratory adequacy. After gathering data, analysis was done using the descriptive statistics. A relationship was drawn to show the correlation between laboratory adequacy and performance of chemistry using Pearson Product Moment Coefficient which gave an index of +0.973. A t-independent test for two sample means was used to test the hypotheses. The study established that there is need to maximize utilization of laboratory resources in teaching and learning of chemistry. This would provide the learner with a chance to handle and develop correct scientific skills that can be implemented not only in their exams but also in their real life situations. It was also revealed that most of the schools in Kesses Sub-County had general laboratories, few of them had no laboratories at all and yet some of the few schools with specific and sufficiently equipped modern laboratories underutilized them and did not score as expected. Therefore the study recommends that; practical examination should not be limited to Forms Three and Four, instead be introduced in Form One. Such an approach will ensure learners interact with laboratory resources in an examination set up more regularly. The ministry of Education should set up minimum laboratory resource requirements for any school to be allowed to offer pure chemistry at K.C.S.E level. Teachers' Service Commission should also consider employing laboratory assistants because most of the schools visited did not have them. Implementing this recommendation would go a long way in helping teachers in planning and organizing for regular practicals. The study findings will be of importance to Chemistry teachers, the school Board of management as well as curriculum developers.

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LIST OF ABBREVIATIONS AND ACRONYMS

A – Agree

B.O.M: Board of Management

C.B.S: Central Beareu Standards.

D – Disagree

D.O.S: Director of Studies

G.O.K: government of Kenya

H.P: High Performers

K.C.S.E: Kenya Certificate of Secondary Examination

L.P: Low Performers

NECO: National Examination Council

SA – Strongly Agree

SD – Strongly Disagree

U – Undecided

UNESCO: United Nations Education, Social and Cultural Organizations.

WAEC: West African Examination Council

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter presents the background of the study, the statement of the problem and the purpose of the study. The chapter will also present objectives of the study, research questions, hypotheses, significance and justification of the study. The scope of the study will be addressed together with limitations of the study, assumptions, theoretical framework and the operational definitions of terms used.

1.2Background Information

The primary purpose of education is to bring about a desirable change in behaviour through acquisition of skills, attitudes, competencies, critical and creative thinking. In this respect, it is true to say that teaching is a complex and demanding task that requires highly specialized skills, knowledge and resources to impact it significantly on student learning. Students' learning outcome is influenced by appropriate utilization of the school resources. It is further explained that investing school resources is key to ensuring that schools become institutions where students work together, learn from each other and benefit from a supportive environment, and consequently maximize learning so that all can achieve their full potential (United Nations Education, Social and Cultural Organizations (UNESCO), 2007).

Avaa, (2007), adds that education in particular science and technical education is the 'factory' for the production of the needed technologists, technicians and craftsmen as well as skilled artisans who are required to turn the nation's economy around and usher in the desired technological advancement which is very much required for the elevation of a given nation so as it moves from a ‘consumer nation’ to a producer nation’ and from a ‘developing nation’ to a ‘developed nation’.

According to Adesoji (2008), chemistry teaching is supposed to be result oriented and student centered. It is further explained that this can only be achieved when students are willing and the teachers are favourably disposed of, thus suggested that appropriate methods and resources in the teaching of the students be employed. Students by nature are curious, they need to be actively involved in learning process in which they are continuously equipping, testing, speculating and building their own personal construct and knowledge. This study argues that it is by personalizing such knowledge that it becomes valid, meaningful and useful to them. Hence, students need to actively construct their own awareness and meaning in Chemistry.

Abayomi and Olukayode (2006), further add that resources like laboratory in schools are important in education because learning takes place best through discovery, exploration and interaction with environments. As a result the emphasis in education is to shift from teacher centered approach to a more learner centered approach. This involves actually putting the learner’s needs at the centre of the activities. This study observes that to achieve this goal teachers need to use a wide variety of resources, which can enrich the learning environment. The study therefore concurs with what had been observed that adequacy of the physical resources and teaching materials as well as their effective utilization has been a matter of serious concern to the educators.

In line with this presentation, Okorie (2001) says the utilization of the resources in education brings about fruitful learning outcomes. Lyons (2012), further adds that learning is a complex activity that involves interplay of student's motivation, physical condition, teaching resources, skills of teaching and the curriculum. As a result these play a vital role in a student's development. It is further concluded that there is explicit relationship between a school's physical facilities and educational outcomes. This study thus agrees with what had been observed in that good maintenance, modern systems and flexible designs are important because the physical structure can limit the learning experience. As a result school facilities should be flexible enough to accommodate changing learning patterns and methods.

1.3Statement of the Problem

Abdul-Kareem (1989), observes in his study that, availability and utilization of the school laboratory resources determine the efficiency of the school in the teaching and learning of chemistry. Thus in order to ensure students' success, Chemistry teachers requires quality and adequate laboratory resources to enable them perform well in the subject.

This research therefore assessed the adequacy of the chemistry laboratory in terms of availability of the basic apparatus and reagents, space in relation to the population of the students. It also assessed the accessibility of students to practical lessons either through classroom experiment or teacher demonstration during the teaching and learning process.

The study then compared the student's performance in chemistry examination for individual schools in relation to laboratory adequacy.

1.4 Purpose of the Study

This study intended to investigate the adequacy of the chemistry laboratory and its impact on student's performance in chemistry in Kesses Sub-county secondary schools in Uasin Gishu County.

1.5Objectives of the Study

This study was guided by the following objectives;

1.5.1 General Objective

To find out the relationship between laboratory adequacy and student's performance in Kenya Certificate Secondary Examination Chemistry**.**

1.5.2 Specific Objectives

i. To determine the frequency of students interaction with laboratory resources in the teaching and learning of chemistry.
ii. To assess the utilization of laboratory resources in the teaching and learning of chemistry.
iii. To evaluate the effect of laboratory adequacy on chemistry performance in K.C.S.E. examination.

1.6 Research Questions

i. How often do students interact with laboratory resources in the teaching and learning of chemistry?
ii. How are the laboratory resources utilized in the teaching and learning of chemistry?

iii. How does laboratory adequacy affect the performance of chemistry in K.C.S.E examination?

1.7 Null Hypothesis

H_{O1}. The frequency of student interaction with laboratory resources has no significant influence on teaching and learning of chemistry.

H_{O2}. Utilization of laboratory resources has no significant influence on the teaching and learning of chemistry.

H_{O3}. Laboratory adequacy has no significant influence on chemistry performance in examination.

1.8 Justification and Rationale of the Study

Performance in chemistry at K.C.S.E in Kesses Sub-County has consistently been dismal. As the old Chinese adage advises "when you hear, you forget, when you see, you remember, and when you do, you understand". Consequently the observed performance could be related to laboratory adequacy. Therefore understanding the effect of laboratory adequacy on student's performance in chemistry is important.

This study sought to find out the impact chemistry laboratory has on the performance in chemistry examination. This is because in the examination the practical paper forms a critical proportion in score aggregate.

1.9 Significance of the Study

The findings of the study have significant implications for the future of the secondary schools in Kesses Sub-County and in the country as a whole. The findings would enlighten the B.O.M of schools on the need to equip their laboratories with basic resources.

The results of this study would enlighten the chemistry teachers on the appropriate laboratory use and accessibility and adequate utilization in ensuring good performance in chemistry.

It would also enable the curriculum developers set minimum laboratory requirements needed for effective teaching and learning of chemistry.

1.10 Scope of the Study

The study focused on adequacy of the chemistry laboratory in teaching and learning of chemistry. It also examined the extent of utilization of the laboratory resources and availability of the resources and finally assessed the influence of laboratory adequacy on the student's performance in chemistry.

1.11 Limitations of the Study

Students' responses were not adequately precise as to the level of laboratory endowment. Therefore the researcher overcame this by providing a checklist of laboratory equipments was provided which was filled by the chemistry teacher/ laboratory assistant.

The likert scale questionnaire could not provide adequate explanation or description on nature of laboratory adequacy. Consequently a questionnaire was developed for chemistry teachers to shade more light on the responses received from students.

1.12 Assumption of the Study

The assumption of the study included;

The K.C.S.E academic performance received from the research sample represented a true reflection of the effects of laboratory adequacy in chemistry.

Statistical test used would give reliable results and teachers had required competencies to handle the teaching and learning of Chemistry.

1.13 Theoretical Framework of the Study

This study was guided by constructivist theory attributed to Jean Piaget, a Swiss psychologist who articulated mechanisms by which knowledge is internalized by learners (Miller, 2011). Piaget suggests that through the process of accommodation and assimilation, individuals assimilate, incorporate the new experience into already existing framework without changing that framework. Piaget adds that this may occur as a failure to change a faulty understanding. According to the theory, accommodation is a process of reframing ones mental representation of the external world to fit new experiences.

Floden (1994) also describes constructivism basing on observation and scientific study about how people learn. He says, people construct their own understanding and knowledge of the world, through experiences. Hence in the class room, constructivist view of learning can point towards a number of different teaching practices, which include encouraging students to use active techniques (experiments, real world problem solving) to create more knowledge and then reflect on and talk about what they are doing and how their understanding is changing. The teacher makes sure he/she understands the student persisting conceptions and guides the activity to address them, and then build on them. This is in agreement with Garner (1994) who says that being a major tenet of Piagetian Constructivism, it assumes that the learners are exposed to a variety of hands-on- experiences where they understand what they do and are able to construct new level of understanding.

It demands active involvement of learners to reflect on their learning, make inferences and to experience conflict. When this happens, learners become aware of their own cognitive process a situation which Garner (1994) refers to meta-cognition.

Various approaches in teaching and learning derive from constructivist theory. They usually suggest that learning is accomplished best using a hands-on approach. Learners learn by experimentations, and not by being told what will happen, and are left to make their own inferences, discoveries and conclusions.

Prawat and Floden (1994), add that constructivists agree with this and emphasize that individuals make meanings through the interactions with each other and with environment they live in. Knowledge is a product of human’s interaction with environment (Ernest, 1998).

MacMahon (1997) agrees that learning process is greatly enhanced by improving the environment; a poor deprived environment attenuates learning while a rich environment with adequate resources stimulates learning.

1.14 Conceptual frame work

According to this study, realization of good performance in chemistry is depended upon a web of three inter-dependent variables as follows:

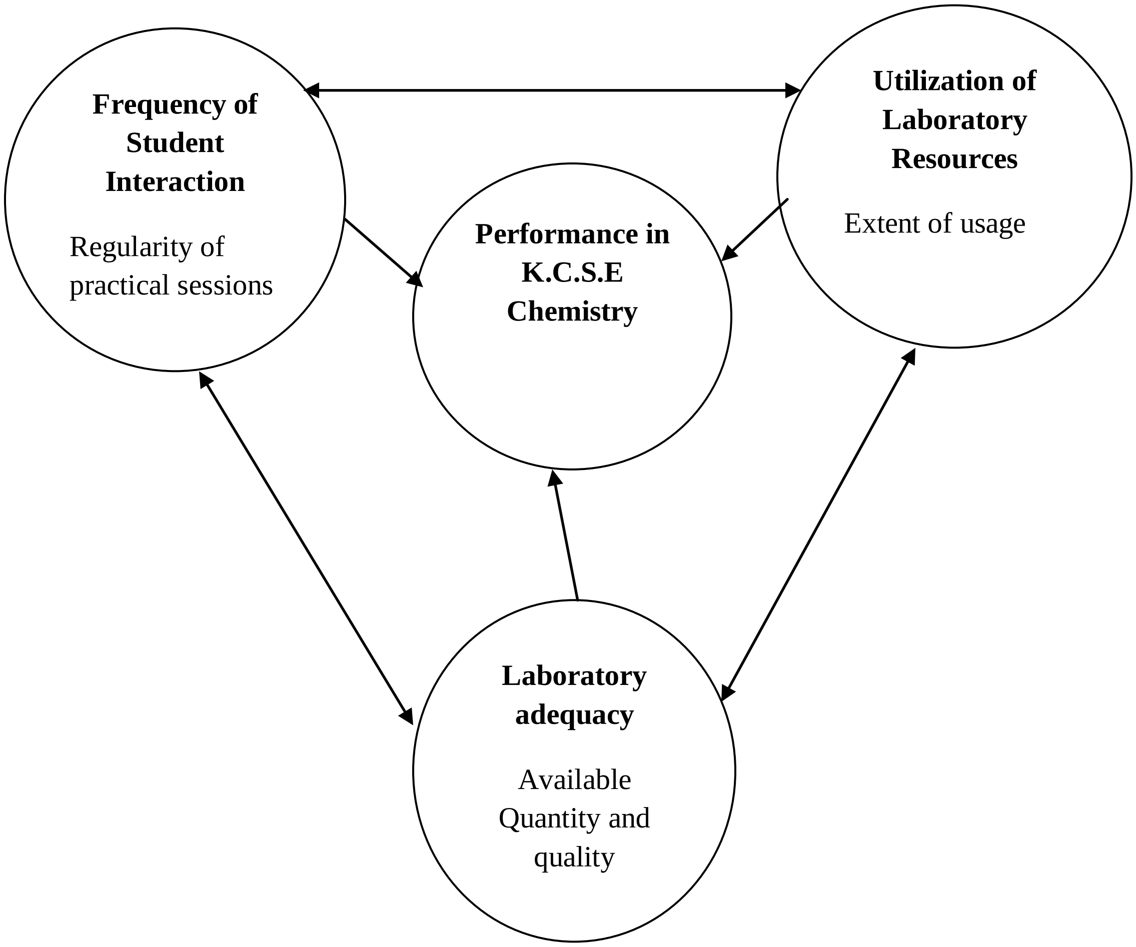

Figure 2.1: Relationship between study variables-frequency of student interaction, utilization of laboratory resources and adequacy of laboratory resources in the teaching and learning of chemistry.

i. Frequency of student interaction with laboratory resources in the teaching and learning of Chemistry -this refers to the number of times learners go to the laboratory for practicals. Thus learners should be provided to the opportunity perform chemistry practicals regularly.

ii. Utilization of laboratory resources – refers to extend of usage of laboratory resources during the learning of chemistry. Thus, learners should be allowed to manipulate the laboratory resources during chemistry practicals. Indeed, learners should be allowed to engage the resources not only during Chemistry lessons but also in their own individual or group practice.

iii. Laboratory Adequacy – refers to the quality and quantity of available laboratory apparatus and reagents. Thus, students' engagement should not be hindered by inadequate resources.

The study affirms that if the conditions above are adequately satisfied, good results are likely to be realized in K.C.S.E.

1.15 Operational Definition of Terms

The terms below are defined as they were used in the study.

Chemistry performance– scores of test/examinations obtained by learners who have been subjected to lessons in chemistry- theory and practical -based on secondary school chemistry curriculum.

Laboratory resources –these are apparatus, reagents and personnel needed to facilitate performance of chemistry experiments in the laboratory.

Laboratory adequacy –refers to laboratory sufficiency or insufficiency in terms of frequency of use, accessibility and extent of utilization.

Utilization – it is the extent to which the laboratory resources are used in teaching and learning of chemistry, that is, the degree to which learners are engaged in manipulating laboratory resources in Chemistry practicals.

Frequency of interaction – the number of times learner access laboratory resources and manipulates them during chemistry practicals.

1.16Chapter Summary

In general, chapter one introduces the study problem which is laboratory adequacy and students performance in chemistry in Kesses sub-county, Eldoret South, Uasin-Gishu County.

The aim of the research was to find out how an adequate laboratory in terms of the resources can be co-related with student's performance. Thus research questions were generated so as to guide the research during the study.

The chapter also gives an overview, justification and significance of the study. Moreover, apart from enabling the researcher achieve an academic award, the findings of the study will help various organs such as schools and curriculum developers to integrate laboratory resources in the learning and teaching of chemistry.

The chapter also enlightens on the assumptions, limitations as well as the scope of the study. Definitions of terms are also given so that those who read this work may understand fully what is to be conveyed.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter contains a review of related scholarly work. It mainly focuses on the laboratory adequacy, utilization and availability of laboratory resources and effects of laboratory adequacy on chemistry performance in secondary schools.

2.2 Related Studies

Chemistry has been identified as a very important science subject and indeed its importance in the scientific and technological development of any nation has been widely reported. It was as a result of recognition given to chemistry in the development of the individual and the nation that it was made a core subject among the sciences in Kenya (Adesoji, 2008).

In chemistry, students need to actively construct their own awareness and meaning. This is evidently seen in Usman's (2006), argument that the brain is not a passive consumer of information, and to learn with understanding, learners need to actively construct meaning of what is to be learned. Usman adds that Chemistry performance is still low in general with major contributors as laboratory adequacy among other factors like attitude, class size, environment, non-coverage of syllabus.

Edomwonyi-Otu and Avaa (2011), echo that the aim of chemistry in schools is to give students the opportunity to gain full learning, acquire appropriate skills and attitudes that enable them live and contribute to the development of the society.

2.3 Main Review

This part mainly looks at the scholarly work on various areas related to laboratory adequacy, student's performance and the role of laboratory in the teaching and learning of science.

2.3.1 Laboratory Adequacy

Jones (1990) examined the teacher provision in the sciences in many countries and found that 4.5% of the schools surveyed indicated insufficient laboratories. This finding agrees with Barrow's (1991) in Saudi Arabia whose findings indicated inadequacy in the provision of the laboratory facilities in schools. The findings were also consistent with those of Black, Atwara-Okello, Kiwanuka, Serlwadda, Birabi, Mahiga, Biumigishu and Rodd (1998), who found in Uganda that science education is faced with the problem of lack of resources with half schools having real laboratory.

In addition, Eshiet (1996), holds that the adequacy of laboratory facilities makes teaching of chemistry concrete and stimulating and better student's academic performance in secondary schools. Lagoke (1997) adds that science education needs to be build on the knowledge and skills acquired by the learner so that students can understand the scientific principles, laws and theories. As a result the adequacy of the laboratory facilities used during science instruction helps to develop values and skills that assist the learner make decision.

Hoftenin and Ginetta (1998), on the other hand argue that the laboratory has been a distinctive feature in science teaching and learning because students learn efficiently when the teacher ensures that adequate laboratory facilities for science are procured.

This is in line with Faroumbi (1998), who found out that students tend to understand and recall what they see and hear as a result of using laboratories in teaching of sciences, but most schools lacked functional laboratories.

Moreover, Abuseji (2007) recommends practicals as an integral part of the subject. This is because with inadequate laboratory infrastructures, the students will be taken into existing depilation if any. As a result effective science teaching is the gate way to attainment of scientific and technological greatness and this can be achieved through integrating theory with practical work. The study further recommends that there is need to have well-equipped laboratories with essential amenities like water and electricity. Sam (2009)concluded that infrastructure is often stressed as a result of insufficient or incomplete laboratory equipments in most of the public secondary schools both in urban and rural areas.

In Israel, Hofstein and Mamlok-Naaman (2007), in their research found out that although the science laboratory has been given a distinctive role in science education, research has failed to show simple relationships between experiences in the laboratory and students learning. Therefore they suggested that meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment and materials in order to construct their knowledge of phenomena and related scientific concepts.

Chemistry is a subject that involves a lot of demonstrations and can only be effectively taught in the laboratory for easy access to instructional materials. However, most schools in Nigeria lacked the essential facility(Edomwonyi-Out &Avaa, 2011).Moreover Ngure (2013), observed that despite the teaching learning resources being available in most schools and being properly utilized, laboratories are inadequate therefore recommends for allocation of more funds to equip the laboratories. This is because utilization of resources in education brings fruitful learning outcomes. Certainly, resources such as the laboratory stimulate students learning as well as motivating them.

Ikechukwu and Akeem (2015), says that a lot of concern has been shown, about the inadequacy of science laboratories in South Africa. As a result laboratories have been given a central and distinct role in science education. Science educationalists have suggested that rich benefits in learning accumulate from using laboratory activities. They further add that to achieve the desired objectives of effective teaching in secondary schools, operational chemistry laboratory equipments have to be provided. However it is important to note that most of the schools do not have functional laboratories.

2.3.2 The Role of Science Laboratory

Farombi (1998), argues that seeing is believing, as a strategy of using the laboratory in the teaching of science related disciplines as students tend to understand and recall what they see more than what they hear. Hence the laboratory is a very essential tool in the teaching of science and success of any science course which is much dependent on the provision made for it.

Laboratory is an ideal environment for both active and cooperative learning (Hass, 2000). Hass explains that active engagement in laboratory exercise promotes understanding of the concepts described in lectures. Moreover, a further enhancement of the laboratory can be gained by encouraging students to interact with each other during the practical activity process. Hass adds that experiments in the laboratory help students understand concepts and also increase their ability to solve problems.

Furthermore, Raw (2003) says that appropriate utilization of resources in schools controls dropout rates, maintains student discipline and makes students remain motivated for a longer period. School resources including laboratories, classrooms, desks, chairs, computers, textbooks, teachers, principals, school operating expenses and other instructional equipment/materials are critical in making teaching-learning more effective. They help improve access and educational outcomes since students are less likely to be absent from schools that provide interesting, meaningful and relevant experiences to them. Indeed according to Raw, these resources should be provided in quality and quantity in schools for effective teaching-learning process.

According to Hofstein (2004), School laboratory activities have special potential as a media for learning that can promote important science learning outcomes for students. Moreover, laboratory activities provide unique environment that differs from the learning environment that exists in classrooms where other instructional techniques are used. Hofstein further found out that students involved in laboratory learning environment were more open-ended and more integrated with conceptual framework and the gap between the actual and preferred learning environment smaller.

Lunetta and Hofstein (2004) on the other hand observed that laboratory practicals are by their very definition and operation active and interactive ways to teach and learn; and considered as valuable tools in maximizing the learning experiences of both students and staff. Moreover, combination of classroom based theory and the application of these theories in the laboratory are considered by many not only essential components for modern, successful Chemistry graduates and future research chemist but are also important in promoting and development of indispensable, generic skills needed for non-chemistry related career sector.

Laboratory experiences shoulder a distinctive importance for assisting learners/ students to think through chemical concepts and enlightenments (Bond-Robinson, 2005). In addition, Festus (2007),explains that problem based solving techniques like use of laboratory in teaching and learning of chemistry is capable of developing students' communicative and collaborative working skills and their skills on accessing information and utilizing it. Bond-Robinson therefore recommends the adoption of the method as one of the basic methods of teaching chemistry in secondary schools.

Omiko (2007) listed five groups of educational objectives that may be achieved through the use of the laboratory in science teaching and these are:

i. Skills: manipulative skills, inquiry skills, investigative skills, organizational skills and communicative skills.
ii. Concept of mastery: for example, hypothesis, theoretical model, taxonomic category.
iii. Development of cognitive abilities: critical thinking, problem solving, application, analysis, synthesis.
iv. Understanding the nature of science – scientific enterprises, scientists and how they work, existence of a multiplicity of scientific methods, inter-relationships between science and technology and among the various disciplines of science.

v. Development of scientific attitudes: For example, curiosity, interest, risk taking, objectivity, precision, confidence, perseverance, satisfaction, responsibility, consensus, collaboration, and liking science.

Omiko further gives eight (8) aspects of scientific attitudes that exist and can be nurtured in the science laboratory in the school. They include; curiosity, open mindedness, objectivity, intellectual honesty, rationality, willingness to suspend judgment, humility and reverence for life.

Laboratory applications aim at developing students scientific processing skills, problem solving skills, draw their attention and develop positive attitude towards scientific approaches according to objectives of fundamental science education (Hofstein & Mamlok-Naaman, 2007). In addition, Queens University (2008), an internet website on good practice (laboratory-based learning) states that science educators believe that the laboratory is an important means of instruction in science since late 19th century.

Yara (2011) adds that important ingredients for effective science teaching are appropriate items, laboratory equipments and materials. This observation is in agreement with Owoeye (2011) and Nwoye (2012), who echo that integrating theory with practical work stimulates learners' interest as they are made to personally engage in useful scientific activities and experimentation. They further add that it is needed as a means of verifying scientific principle, law or a theory. Also knowledge obtained through laboratory work promotes long term memory.

Aina (2012), reports that laboratory has been given a central and a distinct role in science education. Science educationalists have suggested that rich benefits in learning accumulate from using laboratory activities as science laboratory setting in students who can work in small groups to investigate scientific occurrences.

Bello (2012), recommends a high priority be placed on good management and techniques of the science laboratories in order to appraise the technology of science laboratories so as to appraise the technology of science instruction in the schools which enable to develop within the limits of human and material resources, a system that enhances understanding, thinking, production and problem solving.

According to Ojimba (2013), students learn more from scientific lessons when they are given opportunity to learn through doing work themselves than when they are simply allowed to watch.

Omike (2015) and Ufondu (2009) concur in their observation that laboratory teaching is sometimes used in conjunction with large lecture courses so that students may acquire technical skills and apply concepts and theories presented in the lecture. In addition they observed that the use of the laboratory in science teaching has the following benefits:

(a) Laboratory teaching makes the students/learners to learn about the nature of science and technology in order to foster the knowledge of human enterprise of science and this enhances the aesthetic and intellectual understanding of the child.

(b) Learning scientific inquiry skills that can be transferred to other spheres of problem solving that are acquisition of problem solving skills.

(c) Students learning to appreciate and in fact, emulate the role of the scientist through acquisition of manipulative skills.

(d) Developing interests, attitudes and values by considering what science entails, it is clear that a field experience has the best potential for stimulating a life time interest in science in the students when accorded the chance for personal experience by handling the real thing. This further increases students' interest in science as they yearn to investigate and explore more about their environment.

Omike further adds that laboratory instruction is considered essential because it provides training in observation, supplies detailed information, and arouses pupil's interest. Omike goes further to say that developing and teaching in an effective laboratory requires as much skill, creativity, and hard work as proposing and executing a first-rate research project.

Omike (2015)also listed the following number of possible goals that can be achieved through a developed laboratory programme:

(a) Develop intuition and deepen understanding of concepts

(b) Apply concept learned in class to new situations

(c) Experience basic phenomena

(d) Develop experimental and data analysis skills

(e) Learn to use scientific apparatus

(f) Learn to estimate statistical error and recognize systematic errors

(g) Develop reporting skills (written and oral).

Omike further states that hands-on experience encourages students to develop a spirit of inquiry and allows them to acquire scientific skills and the right attitude to handle scientific tools and materials. In addition, the science laboratory provides students with the richest experiences which they will transfer to the society and their various places of work and explains that this helps in providing the students with the opportunities to practice science as the scientists do. Consequently, in order for the laboratory to be effective, students need to understand not only how to do the experiments, but also why the experiment is worth doing, and what purpose it serves for better understanding of a concept, relation, or process.

2.3.3 Laboratory Adequacy and Student's Performance

Dan-Azuma (cited in Donelly,1998), laments on students poor performance in chemistry, stating that one of the most repeatedly mentioned problem causing poor performance in the subject is lack of resources like equipments and materials to conduct practicals. This is in line with the position held by Donelly (1998), who echoes that, the place of laboratory in science is not a neglected issue. Indeed, researchers like Nwosu (1994) and Abbas (2007) reported in their work the presence of inadequate resource materials in science teaching.

Demircioglus and Norman (1999), in their study in Turkey found out that there was a significant relationship between chemistry achievements, for instance mean of chemistry II grades was higher than that of curriculum laboratory school students. However, the curriculum laboratory school chemistry mean was higher than the chemistry I grades due to chemistry background of students as well as the variety of facilities and instructional methods provided for both school students.

Okafor (2000) found out that the adequacy of laboratory facilities had a significant effect on student's academic performance in Chemistry. In this regard Nwadiani (2000), measured output from secondary school in terms of the number of school learners weighted by the number of passes. According to Nwadiani the quality of output is equated with student's examination performance. These views were supported by Adeyemi (2008), who remarked that the best measure of output from schools is the number of school leavers.

Similarly, according to Festus and Ekpete (2012), in order to solve chemistry problems in an acceptable manner, the problem solver must have conceptual, scientific and procedural knowledge. However, many studies show that students frequently do not use conceptual understanding in solving chemistry problems. They further recommend that chemistry teachers in various secondary schools have to embrace problem based solving technique in order to solve the problem of students withdrawing from the study of chemistry and performing poorly in examinations.

Again, Jimoh(2002) points out that the use of laboratory activities outweighs other methods of teaching science. This is to mean that the efficacy of frequency of practical teaching to unravel the mystery behind perception of chemistry concepts is not in doubt. Jimoh further adds that the frequency of practical classes is also an important school factor since scientific process skills such as observation and prediction involves 'doing' and doing means practical activity. As a result it is assumed that frequent use of laboratory for practical lessons by the teacher can translate chemical knowledge to the understanding of scientific facts, laws and theories. Students' acquisition of practical skills with reasonable accuracy in laboratory based teaching is in heart of experimental subjects like chemistry.

Raimi (2000) theorizes that an environmental factor that has a negative students' performance in chemistry is laboratory inadequacy. This agrees with Onipede (2003) who found out that many schools do not have required laboratory facilities. Thus, students fail to acquire science laboratory skills because their teachers were unable to conduct practicals as they would like to and this had inevitable consequences for students learning. On the same breadth, Aburime (2004) also investigated the influence of adequacy of laboratory facilities and academic performance in chemistry and found adequacy had significant influence on students' academic performance in secondary school chemistry.

Abbas (2007), states that where there are little resources at all, they are not usually in good condition while the few ones that are in good condition are not enough to go round to those who need them. As a result then this poses a great challenge to government on the need to raise the funding needs of schools where science subjects such as chemistry are being offered. This observation is in agreement with Okafor (2000), who support the view that where materials are not available in large quantities to meet demand, effective teaching and learning science especially Chemistry which is the Queen of science becomes very difficult.

Adeyemi (2008) says that a laboratory is a critical variable in determining the quality of output from secondary schools. As a result schools with laboratories perform better in examinations. Adeyemi further adds that shortage of laboratory facilities could have serious implication on the quality of schools output. Therefore inadequate provision of science laboratory and equipment in secondary schools has significant relationship with quality of output.

As a matter of fact, laboratory activities appeal as a way to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science (Prades & Espinar, 2010). They also observed that laboratory practicals and experiences are central to science education goals: that science cannot be meaningful to students and the achievements of scientific prophecy cannot be obtained without practical experience. Thus the need for and importance of laboratory practical in chemistry should not be undervalued.

Prades and Espinar, further say practical skills are not only essential for successful chemistry graduate, they are also central to practice of research scientists as they provide experience with equipment, organisms and chemicals, promote important creative and critical generic skills such as report writing, data handling, interpretation skills and ability to evaluate evidence.

Edomwonyi-Otu and Avaa, (2011), in Nigeria report in their study; one of the students said that he was to be a science student but had no laboratory in their school and added that the only experiment done before writing final examination was a simple pendulum in physics, this made him fail chemistry. More so in the same school some students denied having a laboratory saying that it is still under construction thus has never done any practical since science was offered. Teachers in the same school said that a temporary laboratory which is not well equipped was available. This therefore made the place not conducive resulting in students not concentrating during practical lessons. As a result most students really felt that they would have performed better if exposed to practical lessons in good time.

In addition, Bello (2012) emphasizes that the laboratory is a critical variable in determining the quality of output from secondary schools. This was evidenced in his findings that showed that science laboratory had significant relationship with quality of output from secondary schools. He further recommends that secondary schools be provided with standard laboratories where improvised and other concrete materials such as models and specimens can be stored for the purpose of science teaching.

Aderonke, Awobodu, Saibu and Victoria (2013), also recommended that, students need to be exposed to more laboratory applications and activities so as to recognize laboratory materials and equipment. They further add that practical activities be taught by techniques that will generate interest in student's interest. This is because students who do not show significant interest in Chemistry are not able to internalize concepts learnt in the subject and may consequently not be able to apply them in life experience. This is in agreement with Effiong-Edem (2001), argues that to avoid the prospect of a possible negative background, there should be provision of adequate laboratory equipment.

Similarly, Neji, Ukwetang and Nja (2014), found out that academic performance depicts the level of educational attainment of an individual. Indeed it differentiates one with high knowledge content from the other with low and less competency in performance.

Mucai (2013), on the other hand, also found out that most schools in Mbeere South, Embu County, Kenya fall short of some features like rooms for demonstration or preparation room, store, tables with gas taps, water taps and sinks, fume chamber as well as safety devices. As a result this hindered effective utilization of the laboratory hence dismal performance in chemistry subject.

In addition, Omike, (2015) points out that, based on the roles of the science laboratory in science teaching and learning, it implies that schools without laboratories, where students can carry out biology, chemistry and physics practicals would end up producing or graduating students who will have no knowledge of science practicals required by the West African Examination Council (WAEC) and the National Examination Council (NECO) to pass the senior school certificate examination. Consequently, such students would lack the requisite requirement qualification for courses like medicine, engineering, agricultural science and any of the science related careers.

In a related study carried out in Imenti North Kenya by Kaimenyi (2013), established a relationship between laboratory adequacy and performance at K.C.S.E. According to the study, 98% of the participants who rated their school performance as above average also reported adequate laboratory resources in their laboratories. On the other hand, the study found out that 66.7% of the respondent who said that their school performance also pointed out that their school performance was below average. Based on these findings, and agreeable to the present study, the extent of laboratory adequacy is reflected in K.C.S.E performance.

Similarly Kiswili (2016), found out that most students in Masinga Sub-County Kenya lacked important physical facilities. This was evident by the 53.9% representation of the schools under the study that had adequate laboratories and as a result had adverse effect on the overall performance of students in K.C.S.E.

Finally, Neji and Nuoha (2015), report in their research in Nigeria that laboratory based mode of presentation of concept, has been consistently found to be an important strategy in Chemistry teaching and learning in secondary schools. This is because there was a continuous record of student's low performance in final Chemistry Examination, a serious indication that all was not well in education system, most especially at the secondary school level.

2.4 Study Variables

2.4.1 Independent Variables

i. Laboratory
ii. Laboratory resources
iii. Adequacy
iv. Chemistry

2.4.2 Dependent Variables

i. Utilization and availability of laboratory resources
ii. Influence of adequate laboratory on students performance in chemistry.

The independent variable; laboratory and laboratory adequacy, laboratory resources are likely to influence the student's performance (dependent variable). However, finances are extraneous variables that may also impact on the education outcome.

2.5 Chapter Summary

Chapter two reflects on the work that other scholars have researched on laboratory adequacy and student's performance. From all the reviews, it is clear that despite the prime position chemistry occupies in our education system and the efforts made by researchers to enhance performance, students' performance in chemistry and science in general is still low. The reasons being: laboratory adequacy, examination malpractices, non-coverage of syllabus, class size, non-professionalism and environment among other factors.

Laboratory work has been found to be the scientist workshop where practical activities are conducted to enhance a meaningful learning of science concepts and theories (Seweje, 2000). Jeske (1990) adds that, laboratory facilities have also been found to be the primary vehicle for promoting formal reasoning skills and student understanding thereby enhancing desired learning outcomes by students.

It has also been revealed that there is no real picture of the recent situation on the effect of laboratory adequacy because some scholars concluded that there was no significant relationship between students' performance and laboratory adequacy (Okeke, 1995). On the other hand, Aburime (2004) found that, laboratory adequacy had a significant influence on student's academic performance in secondary school chemistry.

As a result, the research work done shows that chemistry generally is low in performance hence the wish to find out the effect of laboratory adequacy in the students' performance because it is mentioned as a major contributor to low performance in chemistry. The current study purposes to fill this knowledge gap.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter presents the background of the study area, study design and sampling procedures. It also looks at data collection procedures, data analysis and ethical considerations.

3.2 Location of the Study

The study area was Kesses Sub-County, Uasin Gishu County, Kenya. The region shares common boundaries with Eldoret North to the North, Eldoret East to the East, Nandi County to the West and Kericho County to the South. (Appendices 10a and 10b)It has a total area of 750km^2.

Table 3.1: Summary of area, Locations and Sub-locations in Kesses Sub County

Constituency	Area (sq. km)	Locations	Sub locations
Kesses	299.0	4	15
Kapseret	451.0	5	26
TOTAL	**750**	**9**	**41**

Source: (G.O.K C.B.S 2008-2012)

3.2.1 Education Indicators

The sub county has several secondary schools and primary schools as well as tertiary level colleges and universities. Higher level of institutions of learning in Kesses include: Moi University, Catholic University of East Africa, Eldoret polytechnic, among others. The table below gives a summary of schools in the region.

Table 3.2: The Number of Learning Institutions in Kesses

Primary schools	Secondary schools	Tertiary colleges	Universities
150	53	5	2

3.2.2 Accessibility

The sub county is easily accessible. Several main roads go through the sub county; they include Eldoret –Nakuru highway, Eldoret –Kisumu highway, Nabkoi-Kapsabet highway and Cheptiret- Moi university road. There are also other several all weather murram roads. It was therefore easy to access the study participants with ease.

3.3 Study Design

Bryman & Bell (2015) describe a research design as a framework for the collection and analysis of data. They point out that a choice of design reflects about the priority being given to a range of dimensions of the research process. Maree (2008) further describes research design as the plan on how to proceed with a research study. Consequently the study design adopted is quantitative research designs which comprise of descriptive and correlation approaches.

3.3.1 Descriptive Approach

Polit & Hungler (1999) defines descriptive approach as a method that depicts the participants in an accurate and objective way. Mugenda & Mugenda (2004) on the other hand highlighted the purpose of the descriptive approach as an attempt to describe things such as behaviour, attitude, values and characteristics. They gave five steps to be followed in descriptive approach as follows:

a) Formulating the objectives of the study
b) Designing the methods of data collection; using questionnaires, interviews or through observation.
c) Selecting the sample; sampling procedure.
d) Data collection
e) Analyzing the results.

The study therefore employed the approach to quantify the frequency of student's interaction with laboratory resources in the teaching and learning of chemistry and assess the extent of utilization of laboratory resources in the teaching and learning of chemistry.

3.3.2 Correlation Study

Mugenda & Mugenda (2004) defines correlation study as degree to which variables are related. They add that the approach aims at exploring relationships between variables and predict a subject's score on one variable given his or her score on another variable. They further highlighted steps to be followed in the correlation research approach as follows:

a) Statement of the problem.
b) Selection of the subjects who provide relevant data.
c) Data collection such as questionnaires, interviews and observation.
d) Data analysis by use of correlation coefficient to determine the strength of the relationship between variables.

The study also adopted the approach in order to evaluate the effect of laboratory adequacy on performance in K.C.S.E Chemistry examination by computing Correlation coefficient using the Pearson Product Moment formula.

3.4 Target Population

The target population comprised of all the form three's and form four's students in both public and private secondary schools in Kesses Sub County. This is because they have stayed long in school hence having appropriate and adequate information required for the study. Furthermore their content involves more practical work than the lower classes.

3.5 Sampling Procedure

The study used stratified random sampling to identify the schools from the various categories. The categories included; boys secondary schools, girls secondary schools and mixed secondary schools. Simple random sampling was then used to pick the schools from the various categories. Simple random sampling was again used to sample population.

Once the schools had been identified, the students were assembled, then folded papers marked 'yes' or' no' were picked by the students. The papers marked 'yes' consisted of the number required for the sample.

3.6 Sample Size of the Study

Kothari (2003) says a sample of 30% is appropriate and can produce generalizable findings. The study therefore derived a 30% of each of the categories of the target population as shown in the table below:

Table 3.3: **Showing the Target and Sample Population**

School Category	Number of schools	Target Population	Sample population
Boys Sec. Schools	4	332	100
Girls Sec. Schools	4	608	182
Mixed Sec. Schools	45	4361	1310
Total	**53**	**5301**	**1590**

3.7 Data Collection Tools

The set of collection instruments that were used included; questionnaires for students, supplementary questionnaires for chemistry teacher, a Chemistry laboratory checklist and K.C.S.E Chemistry results capture form.

3.7.1Questionnaires

The researcher developed and used two questionnaires.

3.7.1.1 Students Questionnaire

The first questionnaire was administered to the students. This research instrument was in two parts; section A, which solicited the bio data of the respondent; the section sought to capture class level and school type of the respondent while section B comprised of 30 items. These items were presented in a structured Likert scale based on the objectives of the study. The questionnaire was in three parts each containing 10 items (Appendix 1).

Respondent chose responses from a five point Likert scale of Strongly Agree (SA), Agree (A), Undecided (U), Disagree (DA) and Strongly Disagree (SD).

These items were adapted from three sources as follows: Mohammed, (2017); Ngozi and Halima, (2015) and Najdi, (2012).

3.7.1.2 Supplementary Questionnaire

The second questionnaire had six items whose responses were used to supplement responses by the students; this questionnaire was administered to Chemistry teachers only. The questionnaire focused on getting the information on frequency of use of laboratory resources, availability and utilization as well the level of maintenance (Appendix II).

3.7.2 Chemistry Laboratory Inventory Checklist

An inventory checklist was developed to capture data on available basic apparatus and reagents for chemistry laboratory in each school sampled. The data obtained on the checklist were used to establish whether the laboratory under the study was adequately equipped in terms of resources. This in turn allowed the researcher to draw a relationship between laboratory adequacy and students performance in chemistry. This was used to supplement data received from the students (Appendix III).

3.7.3 K.C.S.E Chemistry Results Capture Form `

A form was designed to capture the mean scores and grades of each school sampled for K.C.S.E Chemistry performance for three consecutive years: 2014, 2015 and 2016. The form was filled by the Director of Studies for each respective school sampled. These scores were used to categorize the sampled schools into high performing and low performing for the purpose of correlation between laboratory adequacy and Chemistry performance (Appendix IV).

3.8 Validity and Reliability of Research Tools

In order to ensure that the identified data collection tools yielded results that would accurately answer the research questions, then validity and reliability of data collected had to be maximized by ensuring correctness and relevance of data collected.

3.8.1 Validity of the Tools

According to Kothari (2003), validity is the extent to which an instrument is to be a good example of behaviour, skill and knowledge that it purports to measure.

In-depth study was carried out on available relevant questionnaires on the area of study. Items elicited from the review were adapted and refined in consultation with research supervisors from the University of Eldoret who are more conversant with research instrumentation.

3.8.2 Reliability of the Tools

Mugenda and Mugenda (2003), define reliability as a measure of consistency in which the instrument will measure. This study concurs with what has been done and adopts test -retest method to ascertain the capacity of the research instrument to produce consistent results. Hence during piloting the following procedure was followed:

i. The developed questionnaire was administered to three schools, not included in the research sample but with same characteristics with target population: Boys boarding, Girls boarding and Mixed Secondary Schools.
ii. The responses were manually scored.
iii. The same questionnaire was administered to same participants after two weeks.
iv. The responses once more were scored manually

v. Computation of the correlation coefficient was done between the 1st and 2nd result.

vi. A Correlation Coefficient yielded an index of $\geq$ 0.7and this implied a strong relationship between the first and second administration.

Consequently the instrument had a capacity to produce consistent and reliable results.

3.9 Data Collection Procedure

A questionnaire was developed for students and chemistry teacher, a K.C.S.E Chemistry Results capture form and Chemistry laboratory checklist, then administered them to the respective respondents in the sampled schools.

The sampled schools were visited, permission from the school administration was sought to administer data collection tools as well as sampling of the students for the study.

Questionnaires were administered to the sampled students, instructions on how to respond to the questions were given, and the students were allowed adequate time to fill the Questionnaire. They took an average of 40 minutes to fill the Questionnaire. The filled questionnaires were collected and they were appreciated for their participation.

The chemistry teacher was consulted, explained to them the purpose of the research and gave them teacher’s questionnaire. The respective Director of Studies (D.O.S) were also consulted, it was explained to them too the purpose of study and requested them to fill the K.C.S.E Chemistry results capture form. Finally the laboratory assistant/ chemistry teacher were consulted and again the purpose of the study explained and requested them to fill the chemistry laboratory checklist. The respective respondents were thanked for their cooperation.

3.10 Data Analysis

After the data had been collected, completeness of the questionnaires was checked, and analysis commenced.

The structured Likert scale questionnaires from the selected schools were scored according to the points. The items were categorized in to two broad groups; negatively stated and positively stated items. The negatively stated items were assigned points as follows: strongly agree 1, agree 2, undecided 3, strongly disagree 4, and disagree 5.The positive statements were assigned points as follows; strongly agree 5, agree 4, undecided 3, strongly disagree 2, and disagree 1.

Average means were computed from the sum total of the points obtained based on each objective and divided with total number of sampled students in each school under study. Hypothesis testing was then computed using independent samples t-test for two sample means. According to Kothari (2003), t-tests are used when samples used happen to be small and population variances not known but assumed to be equal.

The distribution of the responses from the five point likert questionnaire was also used to compute percentages for each hypothesis.

3.11 Ethical Considerations

3.11.1 Research Authorization

The university of Eldoret gave consent to conduct study through letter Ref: UOE/B/CTE/PGC/033/Vol. 1, the research permit was sought from the National commission for science Technology and Innovations and received permit ref: NACOSTI/P/17/46OO2/18325. Reporting was done to the County Commissioner and

County Director of education, Uasin Gishu County before embarking on research project. At the schools involved in the study permission was also sought to administer the research instrument from the principals of the respective schools and relevant heads of departments.

3.11.2 Confidentiality

The sampled schools were visited with the permit, permission from the school administration was sought to administer questionnaires to the students and chemistry teacher, administer chemistry laboratory inventory checklist to chemistry teacher/laboratory assistant, as well as filling of K.C.S.E Chemistry results capture form from the D.O.S office.

The participants were then informed of the objectives of the study before responding to the items in the research instrument.

Since questionnaires did not require the identity of the respondent as well as the name school confidentiality of the response was assured, and again verbally by keeping the information private and was to be used only for the purpose of the study.

3.12 Chapter Summary

Study area was secondary schools in Kesses Sub-County in Uasin Gishu County. The study targeted form three and form four students in the sub county and because of the various categories of schools, stratified random sampling was used to categorize the schools in to boys sec. school, girls school and Mixed secondary schools.

Simple random sampling was then used to sample the schools from each category that were to be used for the study. Students who participated in the study were also chosen using simple random sampling which involved picking papers marked ‘yes’ and ‘no’. The paper marked ‘yes’ had the required sample population.

The sampled students were issued with questionnaires to respond. Supplementary questionnaire for chemistry teachers and chemistry laboratory checklist were also issued to be filled as well as the K.C.S.E. Chemistry results capture form issued to the D.O.S to fill the chemistry performance for three consecutive years:2014, 2015and 2016.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, INTERPRETATION AND DISCUSSIONS

4.1 Introduction

This chapter presents data obtained from the field in form of tables, analyzed data and interpretation, discussions and summary of the chapter.

4.2 Data presentation

The participants were provided with a likert scale questionnaire and their responses scored accordingly. Table 4.1 presents the means of each objective response as scored on the questionnaire by the students in the study. The results obtained as per the objectives of the study are presented as follows.

Table 4.1: Means of Score of Responses from the Sampled Schools

School	Objective 1	Objective 2	Objective 3
A	37.68	35.51	39.2
B	35.23	33.15	38.41
C	29.83	31.24	40.17
D	37.19	36.16	39.22
E	36.37	36.63	40.37
V	32.84	29.69	40.76
W	34.51	33.72	40.98
X	29.43	29.88	38.98
Y	30.65	28.69	32.98
Z	31.12	31.79	34.23

The means were obtained by totaling up the points of each filled questionnaires from each school and dividing by the number of students who participated in the study from their respective schools; that is, $\sum X / N$.

In analyzing the data, the participating schools were categorized in two groups; high performers and low performers based on the school's previous scores in the Kenya Certificate of Secondary Education (K.C.S.E). The K.C.S.E scores are also critical in analyzing and comparing the student's responses vis-à-vis the objectives of the study. The school K.C.S.E scores were considered valid and reliable indices of performance. Table 4.2 gives the mean score obtained by the various sampled schools in three consecutive years (2014-2016) and their average means.

Table 4.2: Summary of Chemistry K.C.S.E Performance Mean and Average Mean

School	2014	2015	2016	Average mean
A	8.5	9.3	8.1	8.63 (B)
B	6.4	6.8	4.8	6.00 (C)
C	4.6	4.7	5.0	4.75 (C-)
D	3.7	6.0	3.5	4.42 (D+)
E	4.2	4.0	3.3	3.83 (D+)
V	3.9	3.9	2.2	3.38 (D)
W	2.9	4.2	2.3	3.13 (D)
X	2.7	2.1	1.8	2.2 (D-)
Y	___	2.2	1.35	1.19 (E)
Z	___	___	1.29	1.29 (E)

The table reveals that the highest average mean was 8.63 equivalent to mean grade of B in school A while the lowest scored mean was 1.19 equal to grade E by school Y; a school that did KCSE for the first time in the year 2015.

This study considered schools that had an average mean of 3.8 (D+) in the K.C.S.E chemistry examination and above as high performing; that is schools, A, B, C, D and E while those that scored an average mean of D to E as low performers; schools V, W, X, Y and Z.

4.3 Data Analysis and Interpretation

The results of Table 4.1 were analyzed and data obtained presented in the table 4.3 below;

Table 4.3: Summary of Data Analyzed

Category 1 schools	$\mathbf{H_{01}}$	$\mathbf{H_{02}}$	$\mathbf{H_{03}}$
Mean (X_1)	35.995	35.035	39.64
Standard deviation (S_1)	1.22	1.37	0.92
Category 2 schools	$\mathbf{H_{01}}$	$\mathbf{H_{02}}$	$\mathbf{H_{03}}$
Mean (X_2)	30.772	30.035	37.312
Standard deviation (S_2)	1.19	1.12	2.84
Test values	$\mathbf{t_1}$	$\mathbf{t_2}$	$\mathbf{t_3}$
	+6.845	+6.056	+3.396

Table 4.3 shows the average means of the two categories: category 1 comprised of high performers while category 2 was for low performers. From the computed means, standard deviations were also derived.

The means together with standard deviations were then used to calculate the t- values for the two independent samples. Variance was assumed unequal and $\alpha = 0.05$ used as level of significance. Furthermore, distribution of responses obtained from the five point likert scale questionnaire was also analyzed based on their percentages for each hypothesis.

4.3.1 Hypothesis Testing; H_{01}

The first null hypothesis stated that the frequency of student's interaction with laboratory resources had no significance influence on teaching and learning of chemistry.

The means of the objective 1 from Table 4.1 were used to obtain the average means; X_1 and X_2 from category one schools and category two schools, respectively. The two sets of data together with their standard deviations were used to test the null hypothesis 1, $H0_1$ of the study as illustrated below.

Step 1: $H_{0:}\mu_1 = \mu_2$ [the claim]

$H_1 : \mu_1 \neq \mu_2$

Step 2: Degree of freedom (Df) = (N-1)

N=10

Df= 10-1

=9

Df of 9 gave a critical value (Cv) of $\pm$ 2.262 from the table.

Step 3: Test value (t_1)

$t_1=(X_1 - X_2) \div (\sqrt{(S^2_1/N_1+S^2_2/N_2)})$

$= (35.995-30.772) \div (\sqrt{\frac{1.488}{5}+\frac{1.424}{5}})$

$= 5.223 \div 0.763$

$= +6.845$

Step 4:

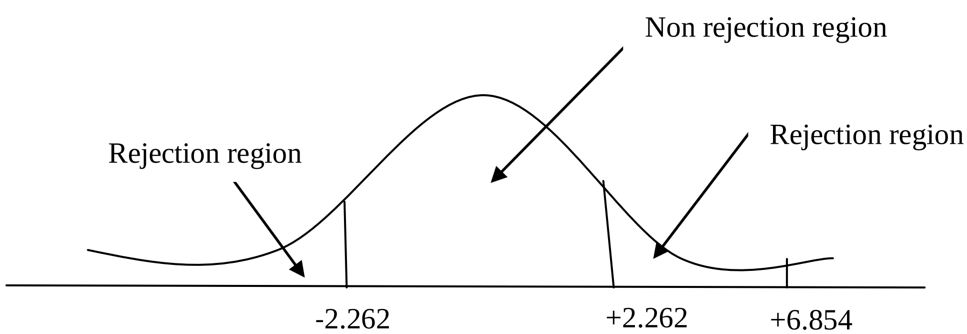

Figure 4.1: Normal distribution curve

Step 5: Decision: Reject the null hypothesis

There is enough evidence to support the claim that the frequency of student's interaction with laboratory had a significant influence on teaching and learning of chemistry.

A comparison of the two values;t_1 (+6.845) and critical value ($\pm$2.262) implies rejection of the null hypothesis. This is because the t value computed (+6.845) exceeds the statistical to accept the null hypothesis hence reject claim in the null hypothesis one that the frequency of students' interaction with laboratory resources had no significant influence on teaching and learning of chemistry.

Table 4.4 shows distribution of responses generated from a five point likert scale questionnaire and their percentages for the first hypothesis as presented in appendix 1(I).

The distribution of the responses derived from the five point likert scale questionnaire and their percentages for the first hypothesis were presented in Table 4.4that sought to interrogate the relevance of the frequency of students' interaction with laboratory resources in the teaching and learning of chemistry.

The first item sought to assess the frequency at which chemistry practical sessions were carried out in the learning institutions sampled for the study. Thus the statement stated, 'We carry out chemistry practicals often'. The responses from the high performing (H.P) schools varied greatly from those of the respondents from low performing (L.P) schools. From the high performing schools, 78% of the respondents strongly agreed (SA) while 11% agreed (A). Only 2% of the respondents were undecided (U) and a total of 9% disagreed (D) with the statement.

On the other hand, from the low performing schools, only 8% of the respondents strongly agreed with the statement while 4%agreed, and 7% were undecided. However,atotal of 81% of the respondents disagreed with the statement. Consequently, it is apparent that the frequency of chemistry practical sessions influences the performance of the learners at K.C.S.E level.

Table 4.4: Distribution of Subject Responses Based on Questions for $H0_1$

Code	SA	A	U	D	SD
1 H.P	620(78%)	87(11%)	16(2%)	48(6%)	24(3%)
L.P	64(8%)	32(4%)	56(7%)	111(14%)	534(67%)
2 H.P	80(10%)	40(5%)	111(14%)	72(9%)	493(62%)
L.P	461(58%)	40(5%)	119(15%)	64(8%)	111(14%)
3 H.P	16(2%)	48(6%)	0(0%)	64(8%)	668(84%)
L.P	64(8%)	127(16%)	56(7%)	286(36%)	254(32%)
4 H.P	374(47%)	72(9%)	40(5%)	167(21%)	143(18%)
L.P	223(28%)	127(16%)	72(9%)	223(28%)	151(19%)
5 H.P	572(72%)	72(9%)	40(5%)	56(7%)	56(7%)
L.P	135(17%)	87(11%)	40(5%)	64(8%)	469(59%)
6 H.P	302(38%)	103(13%)	56(7%)	87(11%)	254(32%)
L.P	246(31%)	127(16%)	24(3%)	103(13%)	294(37%)
7 H.P	390(49%)	350(44%)	32(4%)	16(2%)	8(1%)
L.P	326(41%)	286(36%)	111(14%)	48(6%)	24(3%)
8 H.P	0(0%)	0(0%)	0(0%)	16(2%)	779(98%)
L.P	8(1%)	0(0%)	24(3%)	16(2%)	747(94%)
9 H.P	24(3%)	32(4%)	56(7%)	72(9%)	612(77%)
L.P	318(40%)	6(7%)	56(7%)	24(3%)	342(43%)
10 H.P	0(0%)	8(1%)	0(0%)	24(3%)	763(96%)
L.P	24(3%)	8(1%)	0(0%)	16(2%)	747(94%)

H.P – High Performing, L.P – Low Performing, **n** = 795,**SA** – Strongly Agree, **A** – Agree, **U** – Undecided, **D** – Disagree, **SD** – Strongly Disagree

Further, to determine learner participation in the organization and performance of the practical lessons, there was an assertion, ‘Our teacher organizes practical lessons for our class regularly’. Based on this statement, 68% of the respondents from low performing schools agreed with the statement compared to 15% of the respondents from thehigh performing schools. On the statement, 71% of the respondents from high performing schools disagreed while only 25% disagreed with the statement from the low performing schools.

An interesting contradiction was, however, observed where a significant number of the respondents from low performing schools thought ‘Performing chemistry practicals is a waste of time’. A total of 24% from low performing schools agreed with the statement and another 7% remained undecided while 8% from the high performing schools agreed with the statement and none remained undecided. Generally, however, 92% and 68% of the high performing and low performing respectively disagreed with the statement.

Similarly, to determine learner perception on the need for chemistry practical sessions, the statement ‘I need to do more chemistry practicals’ was provided. A simple majority of the students from the two categories agreed with the statement. A total of 56% of the students from the H.P either strongly agreed or agreed, while 44% of the students from the L.P category also agreed. However, a significant number of students from the two categories disagreed with the statement, where 47% disagreed and another 9% remained undecided from the low performing category. From the H.P category 39% disagreed with the statement and 5%were undecided.

It is thus deduced that learner participation is critical to good performance. This compares well with the responses to the statement, ‘We get involved in many chemistry practicals where 81% of the respondents from H.P schools agreed with the statement compared to only 28% from the L.P schools. Indeed 67% of the respondents from H.P schools disagreed as compared with a mere 14% from the H.P. schools. It is, however, important to note that the respondents from the two categories of schools; H.P and L.P schools were unanimous on the need to enhance practical sessions if good grades are to be attained.

Furthermore, to determine the frequency of the student interaction with laboratory resources, the statement ‘We don’t use the chemistry laboratory until we are in Form 3 and Form 4’ was given. From this statement mixed responses were observed where 51% and 47% from H.P and L.P categories, respectively agreed with the statement, yet 43% and 50% from H.P and L.P categories, respectively disagreed with the statement. Only 7% and 3% from H.P and L.P categories respectively remained undecided.

Again the respondents from both categories were almost unanimous in agreeing with statement that ‘Regular Chemistry practicals play a role in developing my thinking’. Indeed, 93% from high performing category and 77% from the L.P category agreed with the statement. A slight variation was, however, observed where 7% from the H.P category and 23% from the H.P category were either undecided or disagreed with the statement. The study attributes this to uncertainty on the role of practicals on the overall grading of chemistry scores at K.C.S.E level.

A high degree of concurrence was observed on student response to the statement ‘I can pass my chemistry examinations even with few or no chemistry practicals’. Indeed, 100%

and 96% of the respondents from H.P and LP schools respectively disagreed with the statement. No respondent entertained the notion that they could pass chemistry exams without performing chemistry practicals.

From the study, it is apparent that more students from the H.P category perform their own group practicals compared to those from the L.P category as suggested by their responses to the statement 'We have never organized our own group for Chemistry practicals in the laboratory'. A total of 86% of the students from the H.P schools disagreed with the statement; with 77% indicating "strongly disagree" as compared with 46% of the students from the L.P category disagreeing with statement, with only 43% indicating "strongly disagree". However, 7% of the students from both categories remained undecided, 7% from H.P category agreeing with the statement compared to 47% from the L.P schools.

Students from both categories agreed with the need for more practical sessions. To determine this, a statement, 'Many chemistry practicals make me confuse concepts' was given. To this statement 99% of the students from the H.P category disagreed with the statement while amere1% agreed. From the low performing category 96% of the respondents disagreed with the statement while only4% agreed with the statement. None of the respondents in the study was undecided.

4.3.2 Hypothesis Testing; Ho2

The second null hypothesis stated that utilization of laboratory resources had no significant influence on the teaching and learning of chemistry.

Computation similar to that of hypothesis one was done to obtain t_2 whose value of +6.056 was realized and is presented in Table 4.3. When compared to the same critical value of $\pm$ 2.262, t_2 (+6.056) occurred on the rejection region of a normal distribution curve and thus the null hypothesis 2 was rejected. Therefore there was sufficient evidence to support the claim that the nature of utilization of laboratory resources had significant influence on the teaching and learning of chemistry.

Table 4.5 shows distribution of responses derived from a five point likert scale questionnaire and their percentages for the second hypothesis as presented in appendix 1(II).The table shows tabulated distribution of the responses from a five point likert scale questionnaire and their percentages for the second hypothesis.

The first statement sought to investigate the appropriateness of the apparatus and reagents used in the school laboratories. Respondents were given to the assertion, ‘Laboratory equipments are inappropriate’. A majority of the respondents from the two categories, high performing (H.P) and low performing (L.P) schools disagreed with the statement. A total of 66% of the respondents from the H.P category strongly disagreed while 30% disagreed. Only 2% were none committal while another 2% agreed with the statement. This compares favourably with data from the L.P category where 57%strongly disagreed, 31% disagreed, 7% undecided, 4% agreed while only 1% disagreed.

Again, to assess the extent of utilization of laboratory resources, the following statement was provided, ‘I always look for chemistry practical experiments from the revision papers’. The responses provided by the respondents in the two categories showed a high

Table 4.5: Distribution of Subject Responses Based on Questions for $H0_2$

Code	SA	A	U	D	SD
1 H.P	0(0%)	16(2%)	16(2%)	239(30%)	525(66%)
L.P	8(1%)	32(4%)	56(7%)	246(31%)	453(57%)
2 H.P	342(43%)	159(20%)	40(5%)	8(1%)	246(31%)
L.P	223(28%)	183(23%)	151(19%)	48(6%)	191(24%)
3 H.P	72(9%)	56(7%)	111(14%)	231(29%)	326(41%)
L.P	215(27%)	167(21%)	151(19%)	111(14%)	151(19%)
4 H.P	215(27%)	175(22%)	72(9%)	111(14%)	223(28%)
L.P	72(9%)	143(18%)	127(16%)	199(25%)	254(32%)
5 H.P	620(78%)	103(13%)	8(1%)	8(1%)	48(6%)
L.P	334(42%)	159(20%)	254(32%)	56(7%)	0(0%)
6 H.P	477(60%)	231(29%)	16(2%)	32(4%)	40(5%)
L.P	72(9%)	103(13%)	95(12%)	167(27%)	358(45%)
7 H.P	215(27%)	119(15%)	111(14%)	103(13%)	246(31%)
L.P	374(47%)	199(25%)	87(11%)	56(7%)	80(10%)
8 H.P	692(87%)	87(11%)	0(0%)	8(1%)	8(1%)
L.P	127(16%)	167(21%)	48(6%)	95(12%)	358(45%)
9 H.P	95(12%)	127(16%)	16(2%)	183(23%)	374(47%)
L.P	382(48%)	111(14%)	80(10%)	151(19%)	72(9%)
10 H.P	445(56%)	334(42%)	8(1%)	8(1%)	0(0%)
L.P	40(5%)	64(8%)	294(37%)	286(36%)	111(14%)

H.P – high performing **L.P** – low performing **n** = 795

SA – Strongly Agree, **A** – Agree, **U** – Undecided, **D** – Disagree, **SD** – Strongly Disagree degree of similarity. For instance, 63% of the respondents from the H.P category agreed with the statement compared to 51% from the L.P category.

Amajor variation was observed from those who were non-committal where only 5% of the respondents from the H.P category were undecided compared to 19% from the L.P category. Again, minimal variation was observed for those who disagreed, where 32% from the H.P category disagreed compared to 30% from the L.P category.

In addition, the third statement, 'Chemistry is a difficult subject because I do not see the application of things we study' was provided to determine the learners' degree of appreciation on the role and relevance of chemistry practicals. Students' responses to this statement indicated major variation between learners in the two categories. For instance a total of 48% of learners from the L.P category agreed with the statement compared to only16% from the H.P category, while a total of 70% of the learners from the H.P category disagreed with the statement compared to 33% from the L.P category. However, 14% of the learners from the H.P category remained undecided compared to 19% from the L.P category.

On the other hand, mixed reactions were also observed when respondents were provided with the 4^{th}statement, 'I often plan individual chemistry practicals and do them in the laboratory'. To this statement, 49% of the students from high performing category agreed while 42% disagreed and 9% were non-committal. On the contrary, 27% from the L.P category agreed with the statement, 57% disagreed and 16% remained non-committal.

Again a major variation in response was observed when students were given the statement, 'I'm able to carry out individual chemistry practicals in the laboratory'. From the H.P category, 91% agreed with the statement against 62% from the L.P category, while 7% each from the two categories disagreed with the statement. On the contrary, only 1% of the learners from the H.P category were undecided compared to32% from the L.P category.

Similarly, a major variation in student responses was observed to the statement, ‘We often organize our own group for chemistry practicals in the laboratory’. A total of 89% of the respondents from the H.P category agreed with the statement compared to only22% from the low performing category, 2% and 12% from the H.P and L.P categories respectively remained undecided while 72% of the respondents from the L.P category disagreed with the statement compared to only 9% from the H.P category.

The study also revealed that inadequate facilities resulted in limited access and utilization of the laboratory equipment, particularly by the learners from L.P schools. For instance, concerning the statement, ‘I have never organized individual chemistry practicals in the laboratory’, 72% of the respondents from the L.P schools agreed with the statement compared with only 42% from the H.P category. From the H.P category, 14% remained undecided compared to 11% from the L.P category. On the contrary only 17% of the respondents from the L.P category disagreed with the statement compared to 44% from the H.P category.

To ascertain availability of laboratories in the schools involved in the study, the statement, ‘We have a laboratory in our school’ was provided, where the responses were as follows; H.P schools, 87% strongly agreed, 11% agreed, 2% disagreed while 1%, while responses from students from the L.P category was as follows: 37% agreed, 57%

disagreed and 6% were undecided. These findings correlate well with K.C.S.E performance (Table4.2) for the schools involved in the study.

Teacher demonstrations were necessitated by inadequate apparatus. Consequently, despite the appropriateness of the laboratory equipment, the apparatus were noted to be inadequate in the low performing schools compared to those of the high performing schools as attested by the respondents. The statement, ‘Only our chemistry teacher performs demonstrations during chemistry practicals’ was provided. The responses were as follows: H.P schools, 12% strongly agreed, 16% agreed, 2% undecided, 23% disagreed while 47% strongly disagreed. From low performing schools; 48% strongly agreed, 14% agreed, 10% undecided, 19% disagreed while 9% strongly disagreed.

In terms of learner confidence in handling laboratory apparatus, a significant variation was observed between responses from the H.P category and L.P category as attested by responses to the statement, ‘I can perform any chemistry practical with ease’. Respondents from the H.P category gave the following responses; H.P schools, 56% strongly agreed, 42% agreed, 1% undecided, 1% disagreed while 0% strongly disagreed. On contrary, learners from L.P schools gave the following responses; 5% strongly agreed, 8% agreed, 37% undecided, 36% disagreed while 14% strongly disagreed.

The same patterns and variation in utilization of laboratory resources were reflected in the statements provided by students. Laboratory utilization is thus an important feature to be considered for attainment of good academic grades. This concurs with the second hypothesis of the study.

4.3.3 Hypothesis Testing; Ho3

The third null hypothesis stated that laboratory adequacy had no significant influence on chemistry performance in K.C.S.E.

In computing a correlation of scores from responses of high performing against low performing schools, a t-test for independent two samples where variance was assumed unequal was used. The computation realized a t_3 –value of +3.3958 which was compared against a critical value of $\pm$ 2.262. Since +3.3958 occurred on the rejection region of a normal distribution curve, the null hypothesis was rejected. The level of significance for the computation stood at $\propto$=0.05. Hence there was sufficient evidence to support the claim in the third hypothesis that laboratory adequacy has a significant influence on chemistry performance in K.C.S.E examination.

The claim in third hypothesis is also supported by the tabulated data in Table 4.6 that gave the distribution of responses from five point likert scale questionnaire as presented in appendix 1 (III) with their respective percentages. Thus, the efficacy of laboratory on learners understanding of the concept in chemistry needed to be ascertained. Ten items were provided to the respondents where they were to choose one aspect that captured their perception of the claim.

Table 4.6: Distribution of Subject Responses Based on Questions for $H0_3$

Code	SA	A	U	D	SD
1H.P	382(48%)	191(24%)	56(7%)	103(13%)	64(8%)
L.P	254(32%)	151(19%)	40(5%)	215(27%)	135(17%)
2H.P	56(7%)	87(11%)	16(2%)	246(31%)	390(49%)
L.P	40(5%)	87(11%)	72(9%)	310(39%)	302(38%)
3H.P	382(48%)	246(31%)	135(17%)	32(4%)	0(0%)
L.P	342(43%)	223(28%)	167(21%)	40(5%)	24(3%)
4 H.P	119(15%)	191(24%)	103(13%)	167(21%)	215(27%)
L.P	143(18%)	95(12%)	159(20%)	191(24%)	207(26%)
5 H.P	87(11%)	191(24%)	151(19%)	215(27%)	151(19%)
L.P	48(6%)	151(19%)	207(26%)	223(28%)	167(21%)
6 H.P	453(57%)	239(30%	0(0%)	72(9%)	32 (4%)
L.P	366(46%)	278(35%)	48(6%)	40(5%)	64(8%)
7 H.P	167(21%)	334(42%)	87(11%)	135(17%)	72(9%)
L.P	48(6%)	143(18%)	95(12%)	246(31%)	262(33%)
8 H.P	87(11%)	95(12%)	183(23%)	262(33%)	167(21%)
L.P	588(74%)	32(4%)	32(4%)	87(11%)	56(7%)
9H.P	0(0%)	32(4%)	64(8%)	294(37%)	405(51%)
L.P	191(24%)	135(17%)	111(14%)	215(27%)	143(18%)
10 H.P	389(49%)	294(37%)	24(3%)	56(7%)	32(4%)
L.P	326(41%)	223(28%)	80(10%)	111(14%)	56(7%)

H.P – high performing **L.P** – low performing **n** = 795

SA – Strongly Agree, **A** – Agree, **U** – Undecided, **D** – Disagree, **SD** – Strongly Disagree

The first statement stated, ‘Chemistry practicals play an important role in my understanding of chemistry’. To this statement, 48% of the respondents from the H.P category strongly agreed with, another 24% agreed, and 7% were undecided while 21% disagreed. This fairly contrasts with the respondents from the H.P category where 32% strongly agreed with the statement, while 19% agreed. Five percent were non-committal while a significant percentage, 44% disagreed with the statement. The study attributes this to the latter scenario, that is, inadequate laboratory equipment has made the learners uncertain on the role of practicals in chemistry performance

The second statement, ‘Chemistry practicals make chemistry a difficult subject’, contrasted the first statement. The responses to this statement reaffirm those of the earlier statement. Indeed, an average of 78.5% of the entire sample population (high performing and low performing schools) disagreed with the statement while17% agreed and only 5.5% were undecided. To the study, these responses serve to reinforce the study hypothesis.

Further, many respondents from the two categories agreed with the 3rdstatement that ‘Chemistry practicals make learning of Chemistry enjoyable’. In fact, atotal of 79%of respondents from H.P category agreed which compares well to 71% from the L.P category, while 4% from H.P disagreed with statement against 5% from the L.P schools. However, a significant number of the respondents remained none committal with 17% and 21% from the H.P schools and L.P schools respectively remaining undecided.

On the application of the knowledge acquired from chemistry practicals, the 4thstatement, ‘Chemistry practicals help me understand many natural phenomena associated with chemistry' was provided. On this statement, an average of 30% of the total sample, from H.P schools and L.P schools, agreed with the statement while 47.5%disagreed with the statement. A significant number, 22.5%,of the total sample from H.P schools and L.P schools, also remained undecided. From these responses, it is apparent that the learners could not be able to adequately link chemistry practicals to the real life situations. Marginal differences were however observed between the responses from the H.P and L.P categories.

Similarly to determine the efficacy of laboratory adequacy on students' performance, the 5th statement was provided, 'Chemistry practicals equip me with better skills in answering chemistry questions'. Mixed responses were observed with only 35 % of the respondents from the H.P category agreeing against 25% from the L.P category. However, a significant number of the respondents from the two categories remained non-committal where 19% and 26% from the H.P and L.P categories respectively remaining undecided. From the H.P category, 46% disagreed with the statement, while 49% from L.P category also disagreed.

Moreover, a large number of the respondents from both categories agreed with the 6thstatement that, 'Chemistry practicals enable me understand concepts clearly'. A total of 87% of respondents from the H.P category agreed with the statement against 81% from the L.P category, while 13% of the respondents from each of the two categories disagreed with the statement. None of the respondents from the H.P category was undecided while 6% of the respondents from the L.P category were undecided.

A big variation was observed between the two groups (HP and LP categories) on the responses to the 7th statement, 'We always have sufficient laboratory equipment for our chemistry practicals' where majority of the respondents, 63%, from the H.P category agreed with the statement compared to only 24% from the L.P category. On the other hand, only 26% of the respondents from the H.P category disagreed compared to their counterparts from the L.P category where 64% disagreed.

The data from the 7th statement correlated well with those of the 8th statement linking laboratory adequacy to performance, 'Lack of sufficient laboratory resources in our school affects my performance in chemistry negatively'. To this, 78% of the respondents from the L.P category concurred with the statement, compared to only 23% from the H.P category. It is also important to note that 23% of the respondents from the H.P schools were undecided while 54% disagreed with the statement.

Again, a significant variation in responses from students in the H.P and L.P categories was observed when given the 9th statement, 'Lack of chemistry practical lessons does not affect my performance in Chemistry'. A total of 88% of the students from H.P category disagreed with the statement against 45% from the L.P category. Only 4% of the students from the H.P category agreed with the statement compared to 41% from L.P category. Similarly, only 8% of the students from H.P category remained undecided compared to 14% from the L.P category.

Lastly, indeed, equipping chemistry laboratories in schools is paramount if learners are to perform well. This is supported by the data received from the statement, 'I can only perform well in chemistry if I do many chemistry practicals'. To this statement, 86% of respondents from the H.P category agreed while 69% from the L.P category also agreed. Consequently, laboratories should be sufficiently equipped and the resources prudently used for good grades to be realized in chemistry examinations.

4.4.3 Relationship Between Laboratory Adequacy and Performance

The study also purposed to ascertain existing correlation between laboratory adequacy and academic performance based on K.C.S.E scores. To establish laboratory adequacy, several factors were considered: type of chemistry laboratory in the sampled schools, presence or absence of a laboratory assistant and basic requirements necessary for optimal chemistry performance in secondary school. In regard, a total of 42 basic laboratory apparatus were identified. A checklist of laboratory apparatus was provided to the schools where laboratory assistant/ chemistry teachers indicated the available apparatus and their quantities.

In order to compute the correlation between laboratory adequacy and performance, the following criteria were used to assign scores for the laboratory adequacy:

i. a) Availability of a specific laboratory in the school – 10 points

   b) Availability of a science laboratory in the school – 5 points

   c) Lack of laboratory in the school – 0 points

ii. a) Presence of a laboratory assistant in the school – 6 points

   b) Lack of a laboratory assistant in the school – 0 points

iii. laboratory adequacy;

   a) availability of at least 10 items of the identified basic apparatus; a maximum of 2 points each for 42 items = 84 points

b) below 10 items of the identified basic apparatus = 1 points

c) Lack of the identified basic apparatus = 0 points.

A well endowed school based on the above criteria would score a maximum of 100 points. On the other hand, a school that did not possess any factor considered a prerequisite for laboratory adequacy scored zero points. The scores received from the schools based on these criteria were correlated against average scores received from the schools K.C.S.E in the past three consecutive years. For ease of computation, the average scores were converted into percentages using the formula $\frac{x}{12} \times 100$ where x is the average mean (Table 4.2) for each school while 12 equal the maximum score. The data obtained are represented in table 4.7 together with subsequent computation of correlation coefficient using Pearson product moment correlation coefficient formula:

$$\gamma xy = \frac{n\sum xy - \sum x \sum y}{\sqrt{\left[n\sum x^2 - \left(\sum x\right)^2\right]\left[n\sum y^2 - \left(\sum y\right)^2\right]}}$$

Table 4.7: Correlation of Laboratory Adequacy and Performance Scores

Schools	x	y	xy	x^2	y^2
A	100	72	7200	10000	5184
B	74	50	3700	5476	2500
C	46	40	1840	2116	1600
D	40	37	1480	1600	1369
E	25	32	800	625	1024
V	24	28	672	576	784
W	23	26	598	529	676
X	19	18	342	361	324
Y	10	10	100	100	100
Z	10	11	110	100	121
n=10	$\sum$ **371**	$\sum$ 324	$\sum$ **16842**	$\sum$ **21483**	$\sum$ **13682**

Computation of data:

$$\gamma xy = \frac{(10 \times 16842) - (371 \times 324)}{\sqrt{[(10 \times 21483) - (371)^2][(10 \times 13682) - (324)^2]}}$$

$$= \frac{48216}{49578.29}$$

$$= 0.973$$

From the computation, it is evident that there is a very strong positive relationship of 0.973 between laboratory adequacy and performance. Consequently, laboratory adequacy is a prerequisite to good performance in chemistry at K.C.S.E level.

4.4 Discussion

4.4.1 Student's Interaction with Laboratory Resources

The frequency of the students' interaction with laboratory resources in the teaching and learning of the chemistry is critical if good performance is to be realized in K.C.S.E. In affirmation of this claim, learners from high performing category unanimously agreed (89%) with first assertion that they carried out chemistry practicals often (Table 4.4). On the contrary only 12% from the low performing category agreed with the statement compared to 81% who disagreed. This correlates well with the performance index obtained from K.C.S.E results (Table 4.1) and may help explain the variation in performance between the two categories. The study therefore finds frequent and regular exposure of students to chemistry practicals critical for good results.

The need to expose learners to hands on participation during chemistry practicals was also tested in the 2nd statement. Significant differences in responses were observed with 81% of the learners from the H.P category compared to 35% from the L.P category agreeing to the statement that 'Our teacher organizes practical lessons for our class regularly.' Indeed, 68%of learners from L.P category disagreed with the statement. To this study, this again accounts for the variation in performance at K.C.S.E. Consequently, teachers need to expose learners to regular practical sessions.

The third statement, 'Performing chemistry practicals is a waste of my time', sought to investigate student perceptions on the usefulness of chemistry practical sessions in their learning. Though a big majority of the students disagreed with the statement, a major difference was noticeable in the quality of their responses. For instance, 84% of learners from the H.P category strongly disagreed with the statement compared to 32% from the L.P category. However, 36% of the respondents from the low performing category only disagreed. Thus, the learners from the H.P category attached more value to the practicals and this as reflected in the K.C.S.E performance. Learners' attitude towards the practical sessions is therefore an important factor in the performance.

Again, mixed reactions were observed in students' response to the statement 'I need to do more chemistry practicals.' From the H.P category, 56% of the respondents agreed with the statement, while 39% disagreed with the statement. Thus, although the students did not think doing chemistry practicals was a waste of time, a significant number was not certain if they needed more practical sessions than they already had. It is likely that they thought what they already have been adequate; nevertheless, a significant majority thought they needed more practicals from the H.P category. On the other hand, only 44% of the students from the L.P category agreed with the statement while another 47% disagreed with the statement and 9% were undecided. Consequently, 56% of the students from the L.P category did not see the need the need for more practicals.

To this study, this may imply that due to inadequate exposure of the learners from the L.P category to practicals. As a result, the learners were disillusioned and were not clear on the role of practicals in their conceptualization of learning content in chemistry. It is thus the contention of this study that adequate exposure of learners to chemistry practicals prompts their realization of the role of practicals in understanding and performance in K.C.S.E.

Further, to this study, student involvement in practical sessions was considered critical. Consequently, to get student opinion, the 5th statement 'We get involved in many chemistry practicals' was provided. Again, 81% of learners from the H.P category agreed with the statement compared to 34% from the L.P category. Interestingly, 67% of the students from the L.P category disagreed. Subsequently, the need for greater involvement of learners in practical sessions cannot be over emphasized. This is reflected in the examination performance of learners from the two categories (Table 4.2).

To ascertain the frequency of learners' interaction with the laboratory resources, the 6th statement, 'We don't use chemistry laboratory until we are in Form 3 and Form 4,'was given. From this statement, mixed reactions were observed from students from the two categories. For instance, from the L.P category 51% of students agreed with the statement compared to 43% who disagreed with the statement from the same category. It is therefore apparent that a significant number of teachers intensify the use of practical resources in Form 3 and Form 4 as students approach their final examination. To this study, this explains the general poor performance in science subjects compared to the Arts based courses at K.C.S.E level. This study thus proposes the need to intensify the use of chemistry practical sessions in teaching chemistry right from Form 1 in order to equip students with appropriate skills and attitudes in necessary to enhance their performance in their final examination.

In addition, the study findings also revealed that 93% of the respondents from the H.P category saw the need for regular chemistry practicals as a strategy of enhancing their learning and thinking skills (Statement 7). This observation is in agreement with the findings of Aderonke, Awobodu, Saibu and Alaka (2013) that the frequency of practical classes is an important factor because of its scientific process similar to observation and prediction which involves doing which equals chemistry session. They observed that teachers translate chemical knowledge to understanding of scientific facts, laws and theories.

Though it is generally accepted that learner participation in chemistry practicals is critical to learner mastery of content, 47% of students from the L.P category agreed with 9^{th} statement, ‘We have never organized our own group for chemistry practicals in the laboratory.’ Apart from explaining the poor results for the L.P category, this scenario is an indicator that many learners only depend on teacher organized practical unlike their counterparts from the H.P category where 86% disagreed with the statement. Learners should therefore be encouraged to organize their own practical sessions if good results are to be realized in K.C.S.E.

Furthermore the findings of the study(Table 4.4) reveal that an average of 86% from both categories (H.P and L.P) of the respondents disagreed with the claim that many chemistry practicals made them confuse concepts (8^{th} statement) while another average of 97.5% also disagreed with the notion that they could pass chemistry examinations with few or no chemistry practicals. Deriving from these findings, the study proposes that exposing learners to frequent chemistry practicals is critical in promoting learners' conceptualization of concepts in chemistry.

In addition, in one of the best performing schools included in the study, a chemistry teacher was observed to be overtly passionate about the teaching of chemistry particularly the practical aspect of the subject. The teacher explained that many chemistry practical lessons were organized during the weekends thus increasing the frequency of learners' interaction with laboratory resources to enhance their competencies, which resulted in extremely good grades in the subject; an average mean of 8.63 equivalent to grade B (Table 4.2).

In another well performing school, the chemistry teacher was found organizing a practical session after school hours in a day school. Consequently, it became apparent that the official scheduled practical lessons may not be sufficient for learners to attain quality grades in chemistry. Thus the study suggests that more chemistry practical sessions are a prerequisite to good performance. From the research, the study disclosed that no low performing school reported extra practical lessons for chemistry.

On the other hand, Holbrook (2005) argues agreeably that the current chemistry curricula approaches are not providing the impetus to promote the popularization of chemistry that is expected. Holbrook goes on to say that the current curricula over emphasize the development of conceptual understanding, forgetting the appreciation of the way scientists do things, which make chemistry irrelevant to student's life. Indeed, this limitation was observed in the low performing schools. It is important to re-emphasize that teachers in the high performing schools went out of the scheduled time for teaching of chemistry and indulged in carrying out chemistry practicals outside the stipulated hours.

The teachers also employed creative and innovative ways of teaching chemistry which included intra and inter- group learning in school. The chemistry teacher in the best performing school also organized several inter-school chemistry practical competitions which endeared students to chemistry as a subject thereby dramatically changing their attitudes towards the subject. This resulted in excellent performance.

According to Danmole (2012) such innovative approaches to teaching chemistry encourage knowledge and information sharing and promote the acquisition of social skills which can enhance retention of knowledge. Nevertheless, it is important to point out that chemistry teachers in the high performing schools have significant advantage over their counterparts in low performing schools in terms of resources endowment and co-operative school managers since finances are involved in organizing the various inter and intra school competitions. They also have laboratory assistants to help them organize the practical sessions.

4.4.2 Availability and Utilization of Laboratory Resources

A summary of the data collected for this section are presented in table 4.5. From this data, the study revealed that an average of 92% of the study participants from both categories disagreed with the assertion in the first statement that laboratory equipments were inappropriate. On the contrary, 48% of respondents from the L.P category thought chemistry was a difficult subject. This findings correlates well with 48% of the study sample from the low performing category who agreed that they did not see the applications of things they study in chemistry. The study attributes this to inadequate exposure to chemistry practicals mainly in the low performing schools. It is therefore evident that students need to fully interact with laboratory resources during the teaching and learning of chemistry.

This study also aimed at evaluating the extent of utilization of laboratory resources in the teaching and learning of chemistry. Based on the study, majority of the respondents agreed with the statement, ‘I always look for chemistry practical experiments on revision papers.’ A total of 63% and 51% from H.P and L.P categories respectively agreed with the statement. The implication of this is that extra effort is required to expose students to practicals if good results are to be achieved. This concurs with study findings obtained from the very high performing schools where practical sessions were conducted outside the school time-table, mainly in the evenings and during weekends. This not only ensured adequate utilization of the laboratory facilities but also increased learner interaction with the resources.

This is supported by data from the 4th statement which asserted that ‘I often plan individual chemistry practicals and do them in the laboratory.’ A total of 49% of students from the H.P category agreed with the statement. This suggests that a significant proportion of learners from the H.P category indulge in preparing individual practicals in the laboratory. This kind of self-driven motivation is destined to produce better grades at K.C.S.E level. Chemistry teachers therefore need to encourage their students towards this end.

Indeed apart from the frequency of student interaction with laboratory resources, the study also sought to ascertain the quality or extent of use of these resources by the students. This study argues that the quality of use, appropriateness of laboratory resources and the level of learner interaction with laboratory resources would translate into student's skills and competency in carrying out individual or group chemistry practicals more so during examination time.

To test this critical feature-learner competency in handling laboratory equipment- of learning in chemistry several statements were provided to the respondents. Such statements include: 'I'm able to carry out individual chemistry practicals in the laboratory' and 'I can perform any chemistry practical with ease'. Indeed 78% of respondents from high performing schools strongly agreed while 19% agreed. Only one percent was undecided and another one percent disagreed. This was thought to explain the good grades. On the contrary, only 42% of the students from low performing schools strongly agreed while 20% agreed with the statements. On the other hand, 32% of the respondents were undecided while 7% disagreed.

This above scenario indicates that learners from low performing schools either lacked confidence in manipulating laboratory resources during their practicals or did not have adequate experience or quality training in utilization of laboratory services. In fact some schools did not have a laboratory at all. To the study, this too explains the poor grades attained in the K.C.S.E.

Consequently, learners require adequate exposure in order to develop sufficient confidence to carry out chemistry practicals which result in favourable results. In this case for instance, 37% of learners from low performing schools doubted if they had the capacity to carry out chemistry practicals while 50% said they did not have the capacity to carry out the practicals. The study attributes this to lack of, or inadequate laboratory facilities (Appendix V a).

Consequently, based on these findings, the present study advocates facilitating closer interaction between the learners and laboratory resources in order to enhance their competencies in chemistry. Greater students' involvement was clearly observed in the high performing schools while abundance of chemistry resources was evident from laboratory resources checklist (Appendix II) provided by the teachers and/ or laboratory technicians of the respective schools.

Again in close relation to the 4^{th} statement, students were provided with another assertion, stating: 'I have never organized individual chemistry practical in the laboratory.' Based on this assertion, only 42% of the students from the H.P category agreed with the statements compared with 72% from the L.P category. It is therefore true that more students from the H.P category are motivated enough to carry out individual chemistry practicals compared to those of L.P category of schools. To this study, the observed motivation may explain the good grades attained by students.

Furthermore these findings are corroborated by Tatli and Ayas (2011) who observed that maximizing interactivity, laboratory practical applications render students active thinkers instead of passive observers and thereby construct effective and meaningful learning process.

The present study also concurs with Omiko (2015) and Ofundu (2009) who found out that the use of laboratory in science teaching benefits learners by enabling them learn about the nature of science and technology. They add that this is necessary in the enhancement of human knowledge as well as developing interests, attitude and values by considering what science entails. From the statistics, the frequency of students' interaction with laboratory resources is important in the teaching and learning of chemistry which agrees with the hypothesis of the study.

Again more respondents from low performing schools agreed with the statement that 'Only our chemistry teacher performs demonstration during chemistry practicals' compared to high performing schools. In addition, more students from low performing schools perceived chemistry as a difficult subject and rarely looked for chemistry practical experiments in revision papers.

On the contrary more students from high performing schools disagreed with the claim that 'chemistry is a difficult subject' but agreed with the statements that they often sought chemistry practical experiments in revision papers and used them in the laboratory to sharpen their skills in management of laboratory resources. Subsequently, though most schools indicated that they possessed sufficient basic facilities for chemistry practicals, the study revealed a significant variation in the quality of utilization of laboratory resources.

Further, the findings of this study were supported by the fact that all the high performing schools categorized as sampled 1 were well endowed in terms of laboratory resources. For instance the school coded A with a specific chemistry laboratory ascertained the claim that laboratory adequacy is a critical factor in performance. The school attained an average mean of 8.6 equivalent to grade B for the last three consecutive years compared to least performing school which attained a mean of 1.19 equivalent to grade E.

Most schools have general laboratories where practicals for all the science subjects are held. The findings revealed limited laboratory resources in the low performing schools categorized as sample 2. This study assumed that the inadequate laboratory resources culminated in poor grades ranging from 3.14 (grade D) to 1.19 (grade E). Indeed two schools with a mean of E had no laboratory at all. The schools had make shift rooms (appendices V a, V b, V c) that were used to store apparatus and reagents.

Chemistry practicals in these schools were held in the classrooms mainly as teacher demonstrations. Individual learners had a limited chance of manipulating the equipment. From the data collected many students from these schools remained undecided while responding to such statements ‘chemistry practicals help me understand many natural phenomena associated with chemistry’.

These findings are supported by Etiuben (2010) who carried out a study on utilization of chemistry facilities and academic performance in chemistry. This study concluded that adequate laboratory equipments must be provided if academic performance of students taking chemistry in schools is to be enhanced.

Similarly, this study agrees with Festus and Ekpete (2012), who say that a purpose of chemistry practical is to make students active, free and self learning individuals through problem solving and to enhance their thinking skills rather than being passive recipients of knowledge so as to perform better in the learning of chemistry.

As observed from the performance of the best performing schools, this study consequently advocates for acceptable methods of teaching chemistry mainly comprising of learner centered instruction. The study argues that methods that engage students in more practical sessions are capable of changing their performance and attitudes towards chemistry. Certainly, most students from low performing schools perceived chemistry as a difficult subject with little or no relevance to their daily lives.

Subsequently, this study agrees with Danmole (2012) who argues that it would be difficult for chemistry teachers to teach and explain the form and function of various chemistry apparatus and reagents without employing them in practical sessions. Students thus should be provided with the opportunity to interact with laboratory apparatus in order to develop conceptual insights.

Consequently, it is logical for this study to propose the need to improve the quality and quantity of practical work as a prerequisite for quality grades in chemistry. Thus, there has to be priority shift towards procedures that would expose students to many and varied activities during the conduct of practical work in chemistry.

It is, however, important to note that most of the schools visited possess elaborate laboratory structure constructed courtesy of Constituency Development Fund (CDF). On the contrary, the structures are ill equipped and do not possess the minimal apparatus and reagents to enable students perform chemistry practicals. Most of the structures did not have laboratory tables, sinks, water and gas systems (Appendix5c). Indeed, one of the structures had only one clamp stand primarily used for teacher demonstration (Appendix 5b). It would thus be prudent for management teams to request CDF to take a further step of equipping the laboratories so as to make them functional in the provision of the envisaged goal of offering practical laboratory services to the learners.

This study also concurs with the findings of Omiko (2015) who reports that the use of chemistry laboratory helps students to master scientific methods for science learning. Based on findings, this study agrees further with Eze (2006) who argues that humans get involved in science teaching so as to develop creative thinking, reflective and critical thinking skills necessary for good performance in Chemistry. Moreover, the present study also concurs with the findings of Yara (2011) that appropriate laboratory equipments and materials are important ingredients for effective science teaching.

Finally, 98% of students from the H.P category agreed with the assertion, ‘We have a laboratory in our school.’ On the contrary, a mere 37% of the students agreed with the statement. In conclusion, a laboratory and a well equipped laboratory for that matter, is a prerequisite to attainment of good chemistry results in the Kenya Certificate of Secondary Education.

4.4.3 Laboratory Adequacy and Students Performance in K.C.S.E

The study also sought to evaluate the effect of laboratory adequacy on chemistry performance in K.C.S.E examination. The data obtained are presented in table 4.6. To investigate the nature of influence that chemistry practicals posses on learner conceptualization of chemistry content, the 1st statement, 'Chemistry practicals play an important role in my understanding of chemistry' was given. From the data obtained 72% of the students from the H.P category agreed with the statement, 21% disagreed and 7% were undecided, compared to those from L.P category where 51 % agreed with the statement, 44% disagreed and 5% were undecided. Thus, on average, the statement received a 61% approval rating from the entire sample. Though a significant number of (32%) did not agree with the statement, the study concluded that practicals play an important role in enhancing learner's understanding in chemistry. The divergent views could be a result of the learner's disillusionments considering the fact that many L.P school were inadequately equipped particularly in the laboratory resource (Appendices V a, V b, V c).

Again, to assess the efficacy of chemistry practicals, the statement, 'Chemistry practicals make chemistry a difficult subject.' Respondents from the two categories were almost unanimous in disagreeing with the statement. An average of 77.5% of the study sample disagreed with the statement.

To corroborate this finding, a contradictory statement was provided to the respondents. Statement three claimed, 'Chemistry practicals make learning of chemistry enjoyable.' An average of 75% agreed with the statement which compares well with 77.5% that disagreed with previous negated claim. From this data, therefore, the effectiveness of chemistry practicals and making learning enjoyable is validated.

To evaluate learner's ability to apply knowledge gained from chemistry practicals, the statement, 'A chemistry practicals helps me understand many natural phenomena associated with chemistry.' To this 4thstatement, mixed reactions were elicited with a significant portion of respondents in the sample (average 16.5) remaining undecided. A total of 39% from the H.P category agreed with the statement while a total of 48% disagreed with the statement. From the L.P category, only 30% agreed with the statement, while 50% disagreed. This study thus observes that most students do not clearly see the applicability of chemistry practicals outside the laboratory environment. This study therefore appeals to teachers of chemistry to demystify their practical sessions so as to allow their learners to link ideas generated from their practicals to day to day living. This would enable the learners to clearly see the usefulness of chemistry in their daily lives which would lead to increased interest and understanding.

Further, this study sought to assess the role of chemistry practicals in equipping learners with relevant skills and knowledge that would enable them attend to questions in chemistry more competently. To ascertain this, the 5th statement, 'Chemistry practicals equip me with better skills in answering chemistry questions' was provided. It is worth noting that an average of 70% of respondents from the entire sample were either undecided or disagreed with the statement. Only 30% of the respondents in the sample thought chemistry practicals equipped them with better skills in answering chemistry questions. To the study, this implies that proficiency in carrying out chemistry practicals does not automatically translate to better skills in answering other chemistry questions that were not related to the practicals.

This fairly correlates with the data obtained from the previous (4^{th}) statement where 65.5% of the study sample thought chemistry practicals did not help them understand many natural phenomena associated with chemistry. This study therefore postulates that there is need for new approaches in teaching and carrying out practicals so that the knowledge gained can be translated to suit other concepts in chemistry and be applied outside the laboratory.

On contrary, an average of 86% of the respondents agreed with the 6^{th} statement ‘Chemistry practicals enables me understand concepts clearly.’ Thus, whereas chemistry practicals enhance the understanding of concepts taught within its domain, the study respondent’s did not think practicals enabled them understand other chemistry concepts outside the practical domain. Subsequently, better grades would be realized if the teaching of chemistry practicals is adequately linked to the learning of other chemistry topics in general. Chemistry practicals would thus provide the synergy for better performance in chemistry at K.C.S.E.

To assess level of laboratory resource endowment, the 7^{th} statement, ‘We always have sufficient laboratory equipment for our chemistry practicals’ was provided. To this statement a major variation was observed between the responses from the H.P and L.P categories. For instance, 63% of respondents from then H.P category agreed with the statement compared to a mere 24% from the L.P category. On the other hand, 64% of respondents from the H.P category disagreed with the statement compared to 26% from the L.P category.

Further a negative form of this statement was provided to enhance the findings obtained from the former statement. The statement, 'Lack of sufficient laboratory resources in our school affects my performance in chemistry negatively.' From this statement only 23% of students from the H.P category agreed compared to 78% from the L.P category. Students from schools with limited laboratory resources feel disadvantaged and they think their performance is affected by inadequate laboratory resources.

From this data, it is clear that laboratory endowment is a critical factor in the teaching of chemistry and has an influence in performance at K.C.S.E. Thus to improve examination performance in chemistry, schools should strive to provide adequate laboratory equipments and reagents.

Furthermore, to evaluate learner perception on the role of chemistry practicals on their academic performance, the following statement was provided, 'Lack of chemistry practical lessons does not affect my performance in chemistry examination.' To this statement 88% of the students from the H.P category disagreed, only 4% agreed while 8% remained undecided. On the contrary, only 45% of the learners from L.P category disagreed with the statement, 14% were undecided while 41% agreed. From this data, it is apparent that learners from the H.P category had adequate practical lessons and did not feel their learning was undermined by lack of practicals.

However, from the L.P category, a significant number of students (45%) felt that lack of chemistry practicals undermined their performance while 14% were undecided.

Consequently, 59% of the learners from the L.P category lacked confidence to perform well due to insufficient laboratory resources. Yet, 88% of learners from the H.P category were confident that they could perform well because they did not lack practicals. Chemistry practicals thus play a role in boosting learning confidence which result in better performance.

Again, the statement, ‘I can only perform well in chemistry if I do many chemistry practicals’, was purposefully set to further corroborate student perception on the role of chemistry in their performance in chemistry examinations. A majority of students from two categories agreed with the statement. A total of 86% of students from the H.P category agreed with the statement compared to 88% who displayed confidence of passing chemistry due to adequate practicals in the former statements.

In addition, from the L.P category, 69% of students also saw practicals as a prerequisite for passing chemistry. In conclusion therefore laboratory adequacy has a significant influence on students’ chemistry performance in K.C.S.E examination. Consequently, no effort should be spared in equipping chemistry laboratories particularly in the young and upcoming schools.

The checklist of laboratory resources (appendix III) provided by the various schools involved in the study indeed gives credence to the claim that abundance of laboratory resources correlates positively with learner’s performance in the subject. Again it is prudent to reiterate that the chemistry teacher in the best performing school said that to increase the frequency of laboratory interaction for the learners, the school organized intra and inter school expository contests to sharpen learner's skills in management of chemistry education.

It is also deduced from the findings that a majority of the respondents strongly disagreed with the statement that 'chemistry practicals made chemistry a difficult subject'. Most of them also disagreed with the statement 'Lack of chemistry practicals did not affect their performance in chemistry'. However, they all agreed that sufficient laboratory resources would enhance their performance. Indeed, to a majority of the respondents from the two categories, laboratory adequacy boosted their understanding of chemistry concepts.

The present study also concur with Adeyemi (2008), Cythia and Megan (2008) and Ado (2009) who in their various reports assert that there is a significant relationship between available laboratory facilities and performance of students in the examination.

Certainly, laboratory adequacy influences performance in chemistry performance as demonstrated by Tai, Sadler and Loehr (2005), whose findings indicated that students reporting more instances of repeating laboratory to enhance their understanding earned higher chemistry grades as opposed to their peers who reported few or no instances of repeating the laboratory practicals for understanding. They concluded that laboratory work holds a greater promise in helping to prepare students for higher level studies.

This study also revealed that in most of the low performing schools, Chemistry is basically taught as general science with very limited exposure of learners to practical lessons. Yet, the critical aim of teaching chemistry in secondary schools is to prepare students for practical courses in higher education such as Medicine, Bio-chemistry, Chemical Engineering, Analytical Chemistry, Industrial Chemistry, among others. Indeed, according to Danmole (2012 p.70) the aim of practical education includes:

- To acquire power of observation
- To develop the ability to relate observation by illustration
- To develop the ability to recognize general characteristics of phenomena.
- To be able to interpret and illustrate the knowledge of chemistry principles and to develop the ability to perform simple experiments and make inferences from the results established.

On the other hand, the study observed that most of the low performing schools had make-shift rooms that served as laboratory (Appendix V c.). Indeed most of the schools with low performance in the K.C.S.E had no laboratories and had limited apparatus and reagents. Only the chemistry teacher performed the practicals as the students watched passively. Some of their apparatus were stored on the floor and temporary shelves. This made teaching and learning of chemistry difficult which is commensurate with learners' observation that 'chemistry is a difficult subject with little relevance to their lives'. It is not therefore surprising that such a school had a mean score of 1.19, equivalent to grade E, a fail (Table 4.2).

The findings of this study concur with Keister (1992) who argues that poor performance in chemistry examination is due to poor acquisition of science process skills by students. Keister further argues that this is because their teachers were unable to conduct practical lessons as they would like to. Dike (2011) adds that teachers and students are struggling to teach and learn with inadequate and antiquated facilities. The findings from the learner responses concur with computation of correlation coefficient of 0.973 derived from the laboratory checklist compared to performance attained in K.C.S.E. (Table 4.7).

Ironically, due to the general crave for science oriented courses, all the schools in the study sample choose to offer pure sciences despite the limited resources. Yet, the ministry of Education curricula for secondary schools give room for students to take general sciences (Alternative B) for the poorly endowed schools. However, the study wonders why the ministry of Education in Kenya is watching helplessly as schools make decisions to offer pure sciences even when they have inadequate equipments.

Citing a recent World Bank report on '*Education, Jobs and Social protection for a Sustainable Reduction of poverty in sub-Saharan Africa'*, Kigotho, (2017), in an article entitled 'forget the Universities, Secondary is where the future lies' p.24, asks, 'As to what kind of secondary schools do we want now and in the future if secondary education was to become an entry point, not just for the individual's career option, but for Kenya's overall development agenda?'

Indeed to this study, this is the question the government seems not to have thought out, taking into account that according to the report 70% of the students are enrolled in bottom-tier secondary schools that are poor in implementing curriculum in Physical Sciences and Mathematics (Kigotho, 2017). These are key subjects necessary in developing a competent workforce with 21^{st} century skills. The current situation in Kenya is that there is robust strategic plan that encourages students especially those in lower-tier schools to perform well in sciences and Mathematics. Most schools lack science laboratory (Appendix V c) and other essential facilities that would improve learning.

Consequently, in Kenya there should be an effort to transform the sub-county schools and other low cost secondary schools from being the ugly face of secondary education to institutions that could become the starting point of quality science education in the country. Only then will schools become institutions of developing a competent workforce.

According to the World Bank report, Kenya's under development is embedded in lack of qualified workforce basically because the current secondary education has failed to inculcate the students in science subjects and culture of lifelong learning. In this case, the first step towards the right direction is to provide quality secondary education that could be the basis of having cutting edge skills in the country. We must rethink how we dispense our science education in secondary schools.

4.5 Chapter summary

Chapter four presents mainly the data as collected from the sample population. The population was from the average mean points scored per school sampled on completely filled questionnaire.

The various means for each objective were in turn used to compute for t-test value for two sample means variance assumed unequal and level of significance $\propto = 0.05$. Degree of freedom (Df) of 9 was used and gave a critical value of $\pm$ 2.262.The computed t-test values obtained were +6.845, +6.056 and +3.3958 for null hypotheses 1, 2 and 3, respectively. Comparison was done using a normal distribution curve for decision to be arrived

The findings supported the claims in each hypothesis as students under study agreed with the need for an increased frequency of interaction with laboratory resources, and the need for greater access to utilization of chemistry resources through individual chemistry practicals to enhance their skills in answering chemistry questions. They also agreed with the need for adequate resources in the laboratory.

According to the students involved in the study, satisfying these conditions would enable them improve and perform better in their K.C.S.E examination.

CHAPTER FIVE

CONCLUSIONS, SUMMARYAND RECOMMENDATIONS OF THE STUDY

5.1Introduction

This chapter presents conclusions, summary and recommendations of the study.

5.2 Conclusions of the study

The conclusions of the study were based on the themes derived from the study objectives.

5.2.1 Frequency of students' interaction with laboratory resources

The study established that the frequency of student's interaction with laboratory resources had significant influence on the teaching and learning of chemistry.

This study found out that regular chemistry practical lessons cultivate critical scientific processes such as observations which enable the learner to draw inferences based on the understanding of scientific facts, laws and theories. Further, the study revealed that many chemistry practicals help clarify concepts which make them develop creative, reflective and critical thinking. These skills are prerequisites to good performance in chemistry.

This is given credence by one of the best performing schools, under study with mean score of 8.63 which is equal to grade B. The school organized intra and inter school chemistry practical contests so as to encourage learner participation and to sharpen learners' skills in management of chemistry questions.

On the contrary, most of the low performing schools in the study performed few chemistry practicals. Indeed most of the practical lessons in these schools were teacher demonstration. Consequently the students were rendered passive learners who ended up perceiving chemistry as hard subject resulting in low performance.

The study therefore concluded that more varied and regular chemistry practicals be performed to cultivate scientific skills in learners, make them active and self driven individuals in the learning process. The study revealed that such an approach would help change learners' attitude and performance as well as cultivate knowledge and information sharing.

5.2.2 Utilization of laboratory resources in teaching and learning chemistry

The study findings show that lack of laboratories or use of make shift structures as laboratories (Appendix V b) denied learners the opportunity to perform chemistry practicals. Such students developed poor attitudes towards chemistry and subsequently lacked confidence in manipulating laboratory resources during their practicals. The study deduced that this explained the poor grades in chemistry examinations.

In addition, in the low performing schools, the study revealed that students lack the opportunity to utilize the available laboratory resources in the school, mainly because most of the schools had no laboratory assistant. This meant limited utilization of laboratory resources since only the chemistry teacher was to organize the practical session and also be present whenever the students wanted to perform practicals.

Subsequently, the teacher is over worked since the teaching load does not consider practical preparation time and in most instances, the chemistry teacher has more teaching lessons than desired. This denies learners extra chemistry practical sessions whenever they are free and wish to sharpen their scientific skills in the laboratory.

Certainly, teachers in low performing schools with no laboratory assistants are left with no option but to employ the teacher demonstration approach in teaching chemistry practicals. This is because a teacher demonstration not only requires little preparation time but is nonetheless easy to carry. Consequently, the method denies students a chance to interact with laboratory resources resulting in negative attitudes towards chemistry, hence poor grades.

This study concludes, therefore, that there is need to maximize utilization of laboratory resources in teaching and learning of chemistry so as to provide the learner with a chance to manipulate laboratory equipment. This would help develop correct scientific skills that can be implemented not only in their examinations but also in their real life situations. This can only be achieved if the teacher's teaching workload is reduced to realistic levels and laboratory assistants be employed in all schools.

5.2.3 Effects of Laboratory on Chemistry Performance in K.C.S.E Examination

The findings of the study clearly established that laboratory adequacy has significant influence on the performance of chemistry in K.C.S.E examination. The claim is supported by the high performing schools (under category 1) that were sufficiently equipped with modern and up to date laboratory resources.

The best performing school coded as A ascertained that laboratory adequacy is a critical factor in performance of chemistry. Because of this realization, the schools provided their learners with extra chemistry practical sessions through intra and inter school chemistry contests and competitions. As a result the school always scored highly in the chemistry K.C.S.E examination and their students reported that chemistry was not only interesting but also relevant to their day to day activities.

The low performing schools (categorized as sample 2), had limited resources and consequently limited exposure of learners to practicals. In fact the school coded Z had a small store (Appendix V a), where the few laboratory resources were stored implying that the chemistry practicals were teacher demonstrated and only performed in the classroom. It therefore meant that learners had little or no chance of manipulating the resources, resulting in lack of confidence during the examination time when they were now expected to perform the practicals on their own. The learners in this category perceived chemistry not only as a difficult subject but also saw it to lack relevance in their lives.

Nevertheless, majority of the students reported that sufficient laboratory resources, regular and varied chemistry practicals would enhance their performance. They agreed that more instances of repeated laboratory practicals enhanced their understanding and prepared them well to handle the practical examinations in K.C.S.E.

This study therefore revealed that most of the schools in Kesses Sub-County had general laboratories. Indeed few schools have no laboratory at all. Yet some of the few schools with specific and sufficiently equipped modern laboratories (Appendix 6), underutilized them thus did not score as high as expected due to high workload that resulted from high enrolment of students in the school, thus teachers lacked enough time to prepare for a practical lesson instead used lecture method.

This accounted for the difference in the K.C.S.E performance between schools coded B which scored a mean grade of C in chemistry at K.C.S.E and the school coded A which scored a mean score of B, yet both schools were well endowed in terms of laboratory establishment.

The study therefore argues that for better performance, schools need to sufficiently equip their laboratories with the basic, modern and up to date resources. As a matter of policy, the schools should give sufficient opportunities to every student to perform the practicals themselves, by employing innovative teaching methods. More importantly, schools should employ laboratory assistants.

5.3 Summary

This study was guided by the Constructivist theory as postulated by Jean Piaget. Agreeable to this study, Piagetian Constructivism argues that learner should be exposed to a variety of hands-on-experience which consequently enables them to construct new levels of understanding (Miller, 2011).

The study thus advocates for hands-on-experience through enhanced chemistry practicals. Indeed, the constructivist theory postulates that students learn best through experimentations and not by being told what will happen. The findings of the study concur with these theoretical assumptions.

Subsequently this study proposes that there is need as a matter of policy to ensure all students who take Chemistry at K.C.S.E level are subjected to an adequate level of laboratory utilization, access chemistry practical session and sufficient frequency in performance in order to inculcate competency. The Ministry of Education should also ensure that the school laboratories are adequately equipped with the basic secondary school laboratory facilities. This would ensure that all learners are exposed to a level playing ground so that K.C.S.E can test learner mastery of concepts they were adequately exposed to and therefore the grades attained would reflect the true ability of the learner.

This is important not only to the learner but also to the Country since K.C.S.E is a point of transition of the learners to their respective career choices. Conclusively, appropriate identification of the learner's ability and correct career placement would give the country a more productive workforce.

5.4 Recommendations

Based on the findings and conclusions, the following recommendations were made:

5.4.1 Frequency of students' interaction with laboratory resources

- Practical examination should not be limited to Form three and Form four, instead be introduced in Form one to ensure that learners interacts with laboratory resources in an examination set up more regularly.
- Chemistry lessons per week for lower classes (Form one and Form two) be increased to five to enable the learners have frequent and varied practicals.

5.4.2 Utilization of laboratory resources in teaching and learning chemistry

- Teachers' Service Commission should consider employing laboratory assistants. This is because most of the schools visited did not have laboratory assistants, yet they would go a long way in helping teachers in planning and organizing regular practicals.
- Teachers' Service Commission also needs to employ more Science teachers to reduce the workload of the current workforce.
- At school level the Science teachers need to be assigned few lessons so as to have time to plan and carry out practical lessons if the objectives of teaching the sciences are to be fully realized.

5.4.3 Effects of laboratory on chemistry performance in K.C.S.E examination

- Laboratory resources play an important part in the learner's chemistry performance in K.C.S.E. The study recommends that the Ministry of Education sets up the minimum laboratory resource requirements for any school to be allowed to offer Chemistry at K.C.S.E level.
- Schools that do not meet the minimum laboratory requirement should only be mandated by the Ministry of Education to offer general sciences (option B) where practicals are not a major requirement.
- The Ministry of Education should carry out a nationwide inspection of schools to ascertain that schools meet the minimum requirement for the teaching of the science subjects, particularly chemistry.

5.5 Suggestions for Further Research

From the study findings, various issues emerged that seems to also influence performance of Chemistry in general hence the researcher suggests the following areas for further research:

1. How Teacher's level of motivation influences performance of chemistry in K.C.S.E examination.
2. The minimum levels of learners' exposure to chemistry practicals to enable learners acquire sufficient competencies that would allow learners achieve better grades.
3. Ways of demystifying the notion held by most students that chemistry is a difficult subject.

4. Investigate the appropriate number of lessons and other duties that would allow the science teachers maximize the use of laboratory resources.

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APPENDICES

Appendix I: Questionnaire

QUESTIONNAIRE FOR LABORATORY ADEQUACY AND STUDENTS' PERFOMANCE ON CHEMISTRY

I'm a master of Education (Chemistry) student at the University of Eldoret and currently pursuing my field of study. I therefore appeal to you to assist me achieve this goal by providing honest responses. All information received shall be used for the stated purpose only. Confidentiality is assured. Do not write your name anywhere in this questionnaire.

Section A: BIO DATA

Type of the School: Boys boarding [ ] Girls boarding [ ] Mixed day [ ]

Class/ Form**:** [ ]

Section B

INSTRUCTIONS

This section contains 30 items. Select your most appropriate response from the following options: strongly agree (SA), agree (A), undecided (U), disagree (D) and strongly disagree (SD). Put a tick on the space provided after each question.

I. Questions on frequency of students' interaction with laboratory resources in the teaching and learning of chemistry.

1	We carry out Chemistry practicals often.	SA	A	U	D	SD
2	Our teacher organizes practical lessons for our class regularly	SA	A	U	D	SD

3	Performing chemistry practicals is a waste of my time	SA	A	U	D	SD
4	I need to do more chemistry practicals	SA	A	U	D	SD
5	We get involved in many chemistry practicals	SA	A	U	D	SD
6	We don't use the chemistry laboratory until we are in form 3 and form 4	SA	A	U	D	SD
7	Regular chemistry practical play a role in developing my thinking	SA	A	U	D	SD
8	I can pass my chemistry exams even with few or no chemistry practicals	SA	A	U	D	SD
9	We have never organized our own group for chemistry practicals in the laboratory	SA	A	U	D	SD
10	Many chemistry practicals makes me confused concepts	SA	A	U	D	SD

II. Questionnaire on the utilization of laboratory resources in the teaching and learning of chemistry.

1	Laboratory equipments are inappropriate	SA	A	U	D	SD
2	I always look for the chemistry practical experiments on the revision papers	SA	A	U	D	SD
3	Chemistry is a difficult subject because we do not see the applications of things we study	SA	A	U	D	SD
4	I often plan individual chemistry practicals and do them	SA	A	U	D	SD

	in the laboratory					
5	I am able to carry out individual Chemistry practicals in the laboratory	SA	A	U	D	SD
6	We often organize our own group for Chemistry practical in the laboratory	SA	A	U	D	SD
7	I have never organized individual chemistry practical in the laboratory	SA	A	U	D	SD
8	We have a laboratory in our school	SA	A	U	D	SD
9	Only our chemistry teacher performs demonstration during chemistry practicals	SA	A	U	D	SD
10	I can perform any chemistry practical lesson with ease.	SA	A	U	D	SD

III. Questionnaire on the effect of laboratory adequacy on chemistry performance in K.C.S.E. examination.

1	Chemistry practicals play an important role in my understanding of chemistry	SA	A	U	D	SD
2	Chemistry practicals make chemistry a difficult subject	SA	A	U	D	SD
3	Chemistry practicals make learning of chemistry enjoyable	SA	A	U	D	SD

4	Chemistry practicals helps me understand many natural phenomena associated with chemistry	SA	A	U	D	SD
5	Chemistry practicals equips me with better skills in answering chemistry question	SA	A	U	D	SD
6	Chemistry practicals enables me understand concepts clearly	SA	A	U	D	SD
7	We always have sufficient laboratory equipment for our chemistry practicals	SA	A	U	D	SD
8	Lack of sufficient laboratory resources in our school affects my performance in chemistry negatively.	SA	A	U	D	SD
9	Lack of chemistry practical lessons does not affect my performance in chemistry exams	SA	A	U	D	SD
10	I can only perform well in chemistry if I do many chemistry practicals	SA	A	U	D	SD

Appendix II: Questionnaire for Chemistry Teacher

I'm a master of Education (Chemistry) student at the University of Eldoret and currently pursuing my field of study. I therefore appeal to you to assist me achieve this goal by providing honest responses. All information received shall be used for the stated purpose only. Confidentiality is assured. Do not write your name anywhere in this questionnaire.

INSTRUCTIONS: Put a tick within the brackets provided besides your appropriate choice and then give a brief explanation on the space provided.

1. Are there adequate laboratory facilities for teaching of chemistry in your school?

Adequate [] fairly adequate [] inadequate [ ]

____

____

2. Are the available facilities adequately utilized in the teaching of chemistry in your school?

Adequately used [ ] Fairly used [ ] Not used [ ]

____

____

3. Are the available facilities regularly maintained by the teacher/ lab technician in your school?

Well maintained [ ] fairly maintained [ ]Not maintained [ ]

____

____

4. What type of chemistry laboratory is available in your school?

General [ ] Special [ ] No lab [ ]

5. Do you have a laboratory assistant in this school?

Yes [ ] No [ ]

6. How many chemistry practical lessons do you perform per class per week?

Form 3 ____________ Form four ____________

Appendix III: Chemistry Laboratory Equipments Checklist Inventory

APPARATUS/ REAGENTS	QUANTITY
Source of heat	
Test tubes	
Beakers	
Burettes	
Pipettes	
Clamp stands	
Thermometers	
Measuring cylinders	
Volumetric flasks	
Spatulas	
Test tube holders	
Red litmus papers	
Blue litmus papers	
Funnels	
Filter papers	
Wash bottles	
Boiling tubes	
Weighing balance	
Wooden splints	
Test tube rack	
Indicators	
Cobalt chloride paper	
Sodium hydroxide	
Hydrochloride acid	
Sulphuric acid	
Nitric acid	
Ammonia solution	
Sodium hydrogen carbonate	
Sodium chloride	
Copper(II) Sulphate	
Lead nitrate	
Barium nitrate	
Ethanol	
pH charts	
Mortar and pestle	
Droppers	
Evaporating dish	
Crocodile clips	
Bulbs	
Copper wires	
Distilled water	
Stirring rods	

Appendix IV: K.C.S.E Chemistry Results Capture Form

I'm a master of Education (Chemistry) student at the University of Eldoret and currently pursuing my field work. I therefore appeal to you to assist me achieve this goal by providing honest responses. All information received shall be used for the stated purpose only. Confidentiality is assured. Do not write your name anywhere in this questionnaire.

Instructions: Provide KCSE scores for chemistry in your school for indicated years.

YEAR	MEAN SCORE	MEAN GRADE
2014		
2015		
2016		

Appendix V a: Laboratory Resources Storage in School X

Source: Author

Appendix V b: Laboratory Resources Storage in School Z

Source: Author

Appendix V c: Make Shift Structures Used as Laboratories in schools Y and Z

Source: Author

Appendix VI: Modern Laboratory School D

Source: Author

Appendix VII a: Research Authorization

University of Eldoret
flame of knowledge and innovation

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/PGC/033/Vol.1

Date: 22nd June, 2017

The Executive Secretary,
National Council for Science Technology & Innovation
P.O. Box 30623-00100,
NAIROBI.

Dear Sir/Madam

RE: RESEARCH PERMIT FOR:
KOSGEI CAROLINE REG. NO.: PGSE/EDU/018/14

This is to confirm that the above named Post Graduate Student has completed Course Work and has successfully defended her thesis proposal.

She is currently preparing for a Field Research Work on her thesis entitled: ***Laboratory Adequacy and Chemistry Performance in Wareng Sub-county Secondary Schools, Uasin-Gishu County, Kenya.***

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

Yours faithfully,

HEAD
Centre for Teacher Education
UNIVERSITY OF ELDORET
TOWN CAMPUS

Dr. Peter Waswa
HEAD, CENTRE FOR TEACHER EDUCATION

c.c. 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 VII b: Research Authorization

NATIONAL COMMISSION FORSCIENCE, TECHNOLOGY ANDINNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax: +254-20-318245,318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/17/46002/18325**

Date: **25th July, 2017**

Caroline Chepchumba Kosgei
University of Eldoret
P.O. Box 1125-30100
ELDORET.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Laboratory adequacy and chemistry performance in Wareng Sub County Secondary Schools, Uasin Gishu County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Uasin Gishu County** for the period ending **24th July, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Uasin Gishu County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GKalerwa.
GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Uasin Gishu County.

The County Director of Education
Uasin Gishu County.

Appendix VII C: Research Permit

CONDITIONS

1. The License is valid for the proposed research, research site specified period.
2. Both the Licence and any rights thereunder are non-transferable.
3. Upon request of the Commission, the Licensee shall submit a progress report.
4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research.
5. Excavation, filming and collection of specimens are subject to further permissions from relevant Government agencies.
6. This Licence does not give authority to transfer research materials.
7. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.
8. The Commission reserves the right to modify the conditions of this Licence including its cancellation without prior notice.

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No.A 15091

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MISS. CAROLINE CHEPCHUMBA KOSGEI
of UNIVERSITY OF ELDORET, 86-30102 BURNT FOREST,has been permitted to conduct research in *Uasin-Gishu County*

on the topic: *LABORATORY ADEQUACY AND CHEMISTRY PERFORMANCE IN WARENG SUB COUNTY SECONDARY SCHOOLS, UASIN GISHU COUNTY, KENYA*

for the period ending:
24th July,2018

Permit No : NACOSTI/P/17/46002/18325
Date Of Issue : 25th July,2017
Fee Recieved :Ksh 1000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

Appendix VIII a: Map of Counties of Kenya

The area shaded red is Uasin Gishu County which houses Kesses Sub-County.

Source: (G.O.K C.B.S 2008-2012)

Appendix VIII b: Map of Uasin Gishu County.

The area shaded white represent Uasin-Gishu County which houses Kesses sub-County that houses two Constituencies: Kesses and Kapseret.

Source: (G.O.K C.B.S 2008-2012)