

**EFFECT OF CHEMISTRY PRACTICALS ON STUDENTS' PERFORMANCE IN
CHEMISTRY IN PUBLIC SECONDARY SCHOOLS OF MACHAKOS AND NAIROBI
COUNTIES IN KENYA**

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DECLARATION

This research thesis is my original work and has not been presented for any academic award at any other university.

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DEDICATION

To my late wife Agnes Muthoni and our children Njoki, Wahura and Wambui.

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LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|-----------------|---|
| A N O V A | Analysis of Variance |
| ANCOVA | Analysis of Covariance |
| C C E | Cooperative Class Experiment |
| C E M A S T E A | Centre of Mathematics, Science and Technology Education in Africa |
| C S E C | Caribbean School Examination Council |
| G o K | Government of Kenya |
| I C T | Information and Communication Technology |
| K C S E | Kenya Certificate of Secondary Education |
| K I C D | Kenya Institute of Curriculum Development |
| K N E C | Kenya National Examination Council |
| M o E | Ministry of Education |
| NACOS TI | National Commission for Science, Technology and Innovation |
| N E S T A | National Endowment for Science, Technology and the Arts |
| P E N C I L | Permanent European resource Centre for Informal Learning |
| P O E | Predict Observe Explain |
| S A T | Student Achievement Test |
| S M A S S E | Strengthening of Mathematics and Science in Secondary Education |
| S P S S | Statistical Package for Social Sciences |
| S T I | Science, Technology and Innovation |
| T S C | Teachers Service Commission |
| U K | United Kingdom |
| U S A | United States of America |
| W A E C | West African Examinations Council |

ABSTRACT

The purpose of this study was to investigate the effect of chemistry practicals on students' performance in chemistry in Machakos and Nairobi counties' public secondary schools. The main objective of the study was to establish if there is any significant difference in academic achievement in chemistry between students exposed to chemistry practicals and those not so exposed. This was against the backdrop of the need to find out the appropriate role played and the reality of what is actually achieved by chemistry practicals especially with continued decline in academic performance in secondary school chemistry. The specific objectives of the study were to: evaluate the effect of the nature of chemistry practicals, examine the effect of quality of chemistry practicals and the effect of frequency of chemistry practicals on students' performance in secondary school chemistry. Other areas investigated were the relationship of chemistry practicals and performance in chemistry between students of mixed gender schools and those of single gender schools. Learners' performance in chemistry was determined by scores obtained by students in Students Achievement Tests (SAT) done just before and immediately after exposure to the topic under investigation. Data relating to teachers' and students' views on the use or non use of chemistry practicals and its effects on performance in chemistry were collected using questionnaires. The computer package SPSS (Statistical package for social scientists) was used to analyze the data. Descriptive statistics such as frequency, mean, percentages, and standard deviation was used to discuss the research findings. The study also used inferential statistics such as ANOVA, ANCOVA, independent T-test and multiple regression to test the statistical significance in the four null hypotheses generated for the study. It was found that the use of chemistry practicals in teaching and learning of chemistry at secondary school level, improved performance in the subject. There was a difference between the mean scores in the post test of the students of both groups. The mean score for experimental group was (15.73) whereas it was (14.18) for the control group. The t-test value was (4.47) at $p = 0.00$, that is, a significant level at $p < 0.05$ which indicated that there was a significant difference in performance of the experimental and the control group. That is, the students exposed to chemistry practicals scored significantly higher in the achievement test than those not exposed. The ANOVA results ($F = 74.2$, $p = 0.00$), a significance level at $p < 0.05$ and ($F = 132.7$, $P = 0.00$), that is a significance level at $p < 0.05$ showed that a strong relationship existed between performance in chemistry and nature, and frequency respectively, of chemistry practicals used in the teaching and learning of chemistry. It was further found that a majority of students (68.8% and 76.6%) respectively agreed that the use of chemistry practicals makes learning to be enjoyable to students and increases their understanding of concepts. In addition, it was observed that pressure to cover the syllabus is not an obstacle to using of chemistry practicals as a teaching and learning method. The study recommended that students be given an opportunity to engage in 'deep learning' during chemistry practicals and that there should be further study on the curriculum and learning standards for chemistry practicals in secondary school Chemistry and that due consideration should be paid to improving school conditions and teachers' capacity, for effective implementation of chemistry curriculum. The researcher further recommends that information and communication technology (ICT) should be integrated in the teaching and learning of chemistry, especially in chemistry practicals since the computer and its Internet access have a lot of potential of improving chemistry performance.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Chemistry is the branch of science that deals with the study of the composition and properties of matter, changes in matter, the laws and the principles that govern these changes (Ebbing, 1996). Chemistry is one of the subjects that is offered in the Kenyan secondary school curriculum (KIE, 2002). It is an important part of what is called science and an active and continually growing science that has vital importance to our world in both the realm of nature and realm of society (Anaso, 2010). According to Kauffman and Szmant (1987), chemistry is characterized as the most utilitarian of all the experimental sciences. For example, in Kenya, a good secondary school education pass grade in chemistry is a prerequisite for joining medical and agricultural professional courses. Poor performance in the subject means fewer students are able to join such professions, therefore lack of enough professionals leading to low health care provision and food insecurity in the country.

Since chemistry is the science that has the most direct and dramatic impact on our lives, and the science that shapes the world we will live in tomorrow, the performance of students in the subject is a major concern to any developing country (Khan, Hussain, Ali, Majoka, and Ramzan, 2011). The uniqueness of chemistry and the central role that it stands to play in the development of any nation when considered, are however, not evident in the performance of students. The students' performance in chemistry in Nigeria has been poor and unimpressive (Anaso, 2010).

In their study, Edomwonyi-Out & Aava (2011) made an attempt to ascertain the remote causes for the poor performances reported in Nigeria in chemistry at the secondary level of

education. Teacher variables, student variables and environment-related variables were investigated and the findings showed that these all contribute greatly to the poor performances of students in science subjects and chemistry in particular.

According to Inyega and Thomson (2002), the poor performance in chemistry in the national examinations by many candidates has been a subject of debate since the inception of 8-4-4 system of education in Kenya. This is an indication that the teaching and learning of this subject in secondary schools has not been well. The Strengthening of Mathematics and Science in Secondary Education (SMASSE) project (Kenya) was introduced when the consistently poor performance in Mathematics and Science became a matter of serious concern (Nui & Wahome, 2006). Despite the intervention by SMASSE, the many Kenya National Examination Council (KNEC) annual KCSE reports of the years between 2006 and 2011 indicate that Kenya secondary school students continue to perform poorly in chemistry as shown in Table 1.1, a situation that has caused great concern to teachers, educators and government policy makers.

Table 1.1

Overall Performance and candidature in Chemistry in the years 2006 – 2011

| <u>Year</u> | <u>Candidature</u> | <u>Performance (% Mean Score)</u> |
|-------------|--------------------|-----------------------------------|
| 2006 | 236,831 | 24.91 |
| 2007 | 267,719 | 25.39 |
| 2008 | 296,937 | 22.74 |
| 2009 | 329,730 | 19.12 |
| 2010 | 347,364 | 24.90 |
| 2011 | 403,070 | 23.66 |

Source: KNEC annual KCSE reports for the years 2006, 2007, 2008, 2009, 2010 and 2011.

Table 1.1 shows that the overall students' performance in chemistry has over the years been poor, consistently at a mean score of less than 26%. The poor performance of students in the subject has reached unacceptable levels especially when the number of students taking chemistry has constantly risen over the years and the performance sometimes going lower.

Improvement in learners' performance in chemistry will greatly help in the achievement of the "Kenya Vision 2030" which proposes intensified application of science, technology and innovation (STI) to raise productivity and efficiency levels in Kenya (GoK, 2008). Millar (2004) argues that the school science curriculum in most countries has a distinct purpose of supplying new recruits to jobs requiring more detailed scientific knowledge and expertise. The learning of school chemistry, a science, provides the foundations for more advanced study leading to such jobs. In Kenya, many efforts such as provision of trained chemistry teachers, construction and equipping of chemistry laboratories, provision of the necessary teaching and learning resources and initiating projects like SMASSE have been made to improve the performance in chemistry. Despite all these efforts, students' performance in the subject has been poor and unimpressive.

Students' academic performance and achievement in science in the United States of America (USA), have shown a decline over the years. These results pushed the national (USA) focus and urgency to school reform efforts for science education (Mupanduki, 2009). Hofstein (2004) reports that we are operating in a new era of reform in science education where both the content and pedagogy of science are being scrutinized, and new standards intended to shape meaningful science education are emerging. In chemistry, one area that requires urgent reforms are the chemistry practicals, where it is important to rethink the role and place of chemistry practicals in the learning and teaching of chemistry.

Over the years, many have argued that science cannot be meaningful to students without worthwhile practical experiences or practicals in the school laboratory (Hofstein and Mamlok-Naaman, 2007). Typically, the term practicals means experiences in school settings where students interact with materials to observe and understand the natural world. Practicals are designed and conducted to engage students individually or in small groups, a method referred to as class experiment or in large-group demonstration settings, which is known as teacher demonstration method.

Since chemistry is a practical science, teaching and learning of chemistry should involve chemistry practicals. Chemistry practicals are an essential part of effective science education and science educators have suggested that there are rich benefits in learning from using laboratory activities (Millar, 2009). Anaso (2010) reports that researchers had observed that lack of chemistry practicals by Chemistry students' results in poor communication as well as observational skills; this gives rise to students' poor performance. Also, good quality chemistry practicals helps in developing students' understanding of scientific processes and concepts (Dillon, 2008), hence the heavy investment made in the provision and equipping of chemistry laboratories in secondary schools.

Chemistry practicals is an essential feature of secondary science education (Abrahams and Millar, 2008), hence high proportion of chemistry lesson time in secondary schools is given to chemistry practicals with assumption that it leads to distinctive attainments in students. Although Abrahams & Millar report that questions have been raised by some science educators about their effectiveness as a teaching and learning strategy, this is yet to be thoroughly studied in Kenya. Whilst such an approach is generally effective in getting students to do things with objects and

materials, it is seen as relatively ineffective in developing their conceptual understanding of the associated scientific ideas and concepts.

In countries with a tradition of chemistry practicals in school chemistry teaching (such as the UK), chemistry practicals are often seen by teachers and others (particularly scientists) as central to the appeal and effectiveness of chemistry learning (Abrahams & Millar, 2008). Although many science teachers believe that student chemistry practicals lead to better learning and indeed better performance – because we all understand and remember things better if we have done them ourselves, many educators have expressed concern about their effectiveness in promoting learning (Millar, 2009). For example, Abimbola's (1994) research on appraisal of the role of laboratory chemistry practicals concludes that, continuing to accord a central role to laboratory work in science teaching does not seem reasonable and feasible any more in the developing countries. Due to arguments such as these and taking into consideration of the relatively high demand for resources and time, then the effectiveness and usefulness of chemistry practicals as a teaching and learning strategy has to be addressed.

Although chemistry courses at all levels have included chemistry practicals where students follow procedures directing them to mix chemicals, make measurements, analyze data, and draw conclusions, Shakhshiri, (2009) argues that the chemistry practicals often consists of what is generally described as “cook-book” exercises and is often dull and routine, rather than engaging or inspiring. According to Abimbola (1994) science teachers do not usually find it convenient to make chemistry practicals the centre of their instruction. They usually complain of lack of materials and equipment to carry out chemistry practicals and at the same time, it is possible that some of these materials and equipment may be locked up in the school laboratory store without teachers being aware of their existence.

Although the importance of chemistry practicals in school science is widely accepted, it is also important that the nature of chemistry practicals be supportive to learning (Dillon, 2008). For many students, what goes on in the laboratory in form of chemistry practicals is said to contribute little to their learning of chemistry or to their learning about chemistry and its methods (Millar, 2009). According to Abimbola's (1994) research findings, a verbal, non-practical approach might be best for some teachers and students. Some students may find practical activity a sheer waste of their time. These concerns have led to calls for more 'authentic' practical experiences, or to re-think, re-evaluate, and perhaps reduce, the amount of chemistry practicals, to leave more room for other learning activities. Abrahams and Millar (2008) maintain that it is time for a reappraisal of the nature, quality, quantity and role of chemistry practicals in the teaching and learning of chemistry. "I think they learn so much more by actually doing it than by just being told or even watching me do it" or "I think I believe strongly that by doing things you're more likely to remember it" [Abrahams,2011:11, 82]. Indeed science practicals are quite efficient in creating new images of a particular subject. However, the thing that does cause concern is the quality of the images.

The House of Commons Science and Technology Committee (UK, 2002), report argued that science practicals are a vital part of science education. They help students to develop their understanding of science, appreciate that science is based on evidence and acquire hands-on skills that are essential if students are to improve in science performance and progress in science. Students should be given the opportunity to do exciting and varied experimental and investigative work. The (UK, 2002) report highlights the quality of school science practicals and laboratories as key concerns. The report argues that science practicals are a vital part of students' learning experiences and should play an important role in improving students' performance in

science. Some sections of the science community, industry and business have expressed concerns that schools in general are not doing enough practical work and that its quality is uneven (Abrahams and Millar, 2008).

In a review of research on chemistry practicals in school science, Dillon (2008) reports that despite curriculum reform in UK aimed at improving the quality of chemistry practicals, students spent too much time following 'recipes' and consequently, practising lower level skills. Strategies to improve the quality of chemistry practicals have been identified by many authors. For example, Millar, (2004) pointed out that, effective tasks are those where students are not only 'hands on' but also 'minds on' so that they can make the most of this learning experience. In Millar's opinion, improving the quality of practical activities would be to help teachers become much clearer about the learning objectives of the practical tasks they use. Good quality chemistry practical work promotes the engagement and interest of students as well as developing a range of skills, science knowledge and conceptual understanding. In reviewing research on chemistry practicals, Dillon (2008) found out that the amount and quality of chemistry practicals carried out in schools have both suffered as a result of the impacts of national tests in science. For example, according to Dillon the assessment regime in England and Wales has had a major impact on the amount and variety of chemistry practicals that teachers carry out.

Literature on school chemistry practicals indicates that there is no clear consensus about the relative merits of chemistry practicals and why we devote so much of our time and limited resources to it (Barton, 2004). Similarly, Abimbola (1994) reports that reviews of research in this area concluded that science education researchers failed to provide conclusive evidence to support the view that using the laboratory method of teaching science is superior to other methods, at least, as measured by paper and pencil achievement tests. Hofstein (2004) asserts

that research has failed to show a simplistic relationship between experiences provided to the students in the laboratory and learning science.

Knowledge of how teaching methods affect students' learning may help educators to select methods that improve the teaching and learning quality and effectiveness. An appraisal of the role of chemistry practicals as an approach or method in the learning and teaching of chemistry is necessary. This can be done by conducting related classroom-based relevant research on central issues like the effectiveness of the method, which can shape and improve chemistry learning consequently improving performance. Hence, the study intended to find out the effects of chemistry practicals on learners' performance in chemistry in Kenyan secondary schools.

While chemistry practicals are assumed to be necessary for all learners, some studies (Gardner, 1975) show that boys and girls differ in the reception of the practical approach. Although learners benefit through engagement with concepts in chemistry practicals through interactions, hands-on activities and application in science, Gardner (1975) shows that sex may determine students' attitude towards science. A study in Israel (Trumper, 2006) showed that boys and girls of the same age tend to have different attitudes to similar teaching styles. On the other hand, a study by Kibirige and Tsamago (2013) shows that the attitudes of boys and girls towards science are not different when using similar methods. Due to differing views, this study also sought to find out if there was gender differences in performance when learners were taught chemistry using methods incorporating practicals.

1.2 Statement of the Problem

Chemistry has a crucial role in the rapid developments in science and technology. Since the Kenya 'Vision 2030' emphasizes the role of science, technology and innovation (STI) in a

modern economy, then, good performance in the subject and other sciences is crucial. The school science curriculum in most countries has a distinct purpose of supplying new recruits to jobs requiring more detailed scientific knowledge and expertise than learning of school chemistry, a science, provides the foundation for more advanced study leading to such jobs. Poor performance of students in chemistry is a major concern to teachers, policy makers and curriculum developers who are all geared towards achieving the 'Kenya Vision 2030'.

In Kenya, chemistry practicals are given a central and distinctive place in the teaching and learning of chemistry at the secondary school level. Although chemistry teaching and learning essentially involves chemistry practicals and has a long tradition of student experimental work in schools, questions have been raised about the appropriate role and the reality of what is actually achieved by the chemistry practicals especially with continued decline in performance in the subject. Despite the widespread use of chemistry practicals as a teaching and learning strategy in school chemistry, and the view that increasing its amount would improve chemistry learning, some science educators have raised questions about its effectiveness. Although chemistry practicals often occupy a massive share of curriculum time and resources, doubts have been raised about their effectiveness or their real educational value, as students continue to perform poorly in the subject. Therefore, this study sought to find out the effect of chemistry practicals on students' performance in chemistry in Kenyan secondary schools in a bid to improve the academic achievement in the subject.

1.3 Purpose of the Study

The purpose of this study was to investigate the effect of chemistry practicals on performance in chemistry among public secondary school students of Machakos and Nairobi counties in Kenya.

1.4 Research Objectives

The study aimed at achieving the following objectives. These were to:

- i Establish whether students learning chemistry using chemistry practicals perform better than those learning without.
- ii Find out the effect of nature of chemistry practicals on students' performance in secondary school chemistry.
- iii Examine the effect of quality of chemistry chemistry practicals on students' performance in secondary school chemistry.
- iv Determine the effect of frequency of chemistry practicals on students' performance in secondary school chemistry.
- v Find out whether boys and girls exposed and those not exposed to chemistry practicals differ significantly in their average score.

1.5 Research Hypotheses

The following research hypotheses were generated for the study and tested at significance alpha level of 0.05.

H₀1: There is no significant difference between the post-test mean score in chemistry of students exposed to chemistry practicals and those not exposed.

H₀2: There is no significant difference in performance in chemistry of students exposed to various types of chemistry practicals and those not exposed.

H₀3: There is no significant difference in performance in chemistry of students exposed to different qualities of chemistry practicals and those not exposed.

H₀4: There is no significant difference in performance in chemistry of students exposed to differing frequencies of various types of chemistry practicals and those not exposed.

H₀5: There is no significant difference in performance in chemistry between girls or boys exposed to chemistry practicals and those not exposed.

1.6 Significance of the Study

The study attempted to provide evidence on the effects of chemistry practicals on learners' performance in chemistry in Kenyan public secondary schools. By so doing, the findings of this study has added to the existing body of knowledge about the role and effects of chemistry practicals in the teaching and learning of chemistry. Using this knowledge, the teachers of chemistry, science teacher trainers and science educators may be able to maximize the benefits of using the chemistry practicals as a teaching and learning strategy. The findings may give some necessary feedback to tutors in science teachers training colleges, which will probably improve on the training of chemistry teachers. This may in turn boost the teaching of chemistry at the secondary school level, which may lead to higher performance at KCSE. The study might be of immediate benefit to those developing secondary school science curriculum and text books, for example, Kenya Institute of Curriculum Development (KICD). The study may also bring out suggestions and ways of inspiring and teaching chemistry students.

1.7 Limitations of the Study

There were some constraints that could have influenced the results of the study. First, there was limited control on the teachers' attitude towards chemistry practicals which may have influenced the outcome of the students' performance in the examination. Similarly, there was limited control on the size of classes in these schools. The number of students in a class may affect the quality of the chemistry practicals which might influence the outcome of the students' performance in the examination. Some schools were not willing to participate in the study as control groups where teaching and learning of chemistry was to take place without practicals.

This affected sampling. There could have been other confounding variables that may have influenced learners' performance. According to Kothari (2008), confounding variables are not related to the purpose of the study, but may affect the dependent variables. To address this, the researcher applied analysis of covariance (ANCOVA) technique during data analysis. According to Field, (2013), ANCOVA can help us to exert stricter experimental control by taking account of confounding variables to give us a 'purer' measure of effect of the experimental manipulation. Mayers (2013), states that ANCOVA is a useful statistical procedure which can be employed in a wide range of contexts such as: exploring pre-test versus post-test effects; filtering out error variance; and statistically controlling variables which have not been done so physically.

1.8 Delimitation of the Study

The study was conducted in form 2 classes from selected public secondary schools in two counties in Kenya. For this study, one form 2 topic (Chemical Families: Patterns in Properties) was chosen, taught and examined. This topic was chosen because of its nature. The content of the topic is such that it provides an excellent opportunity for exposing the student to various types of experiments during teaching. Teaching of chemistry as a science subject should be approached by use of investigatory methods and so experiments should be performed in all topics that demand them (KNEC, 2008). According to the KNEC KCSE report (2010), students should be allowed to experiment, discover and develop creative critical thinking skills and therefore, it is necessary for teachers of science to use the practical approach during teaching and learning. Observation and creative thinking skills feature very prominently in qualitative analysis questions in KCSE chemistry practical examinations. The qualitative analysis questions are identified as among those performed poorly (KNEC, 2010).

1.9 Basic Assumptions

The study had the following assumptions:

- i) The first assumption was that schools sampled offer chemistry as an examinable subject.
- ii) It was also reasonable to assume that the nature and quality of chemistry practicals has effect on performance in chemistry in secondary schools.
- iii) Learning chemistry was a convenient way to introduce students to science, and integrating chemistry practicals during teaching of chemistry would be the most reliable method of imparting this knowledge.
- iv) Another assumption was that students were not affected by the experiment itself, that is, there will be no Hawthorn Effect.

1.10 Definition of the Key Terms

Frequency of chemistry practicals: Refers to the number of lessons per week or term planned involving chemistry practicals.

Inquiry method: Refers to research-based science teaching through experimentation by learners, rather than teaching through class lectures.

Nature of chemistry practicals: Refers to the kind of experiments carried out during lessons. For example, teacher demonstration, class experiment.

Performance: Refers to the students' scores obtained in a test.

Practicals: Refers to the experiments carried out by the learners themselves or with the help of the teacher during the learning.

Quality of chemistry practicals: Refers to the degree of learner involvement in the practical. For example, experiments done by students individually, in pairs, in groups of five or in groups of more than five students.

Resources for chemistry practicals: Refers to the laboratories, the equipment, apparatus and reagents necessary for chemistry chemistry practicals.

Secondary school: Refers to an institution that offers educational experiences to students for four years after primary education.

1.11 Organization of the study

This report is organized into five chapters. Chapter one includes the background of the study, statement of the problem, purpose of the study, research objectives and hypotheses, significance of the study, limitations and delimitations of the study, basic assumptions and definition of significant terms in the study. A review of the related literature, the theoretical framework and the conceptual framework are presented in chapter two. The third chapter consists of the research design, target population, the sample and sampling procedure, the research instruments, validity and reliability of the instruments, procedure for data collection and data analysis techniques. Presentation, analysis and discussion of the findings of the study are dealt with in chapter four. Chapter five presents the summary of findings, conclusions and recommendations for practice, policy and further research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This section deals with the review of the related literature. The review was done under the following sub-headings: Secondary school chemistry instruction, performance in secondary school chemistry, chemistry practicals and performance in school chemistry, nature of school chemistry practicals, quality of school chemistry practicals, frequency of school chemistry practicals, availability of facilities and equipment in chemistry learning and gender and performance in school chemistry. Theoretical and conceptual frameworks that underpinned the study are also presented.

2.2 Secondary School Chemistry Instruction

Instruction in chemistry is done through practicals and theory work. Typically, the term practicals mean experiences in school settings where students interact with materials to observe and understand the natural world. The practicals are mainly done as student experiments in the laboratory and as teacher demonstrations either in laboratories or in classrooms, while the theory is often done in the classroom (Twoli, 2006). Wellington (1998), describes chemistry practicals as teacher demonstrations or as class experiments where all learners are on similar tasks, working in small groups or a circus of experiments with small groups of learners engaged in different activities, rotating in a carousel. In secondary schools, laboratory activities are designed and conducted to engage students individually, or in small groups (student experiments) and in large-group demonstration settings (teacher demonstrations) (Hofstein and Mamlok-Naaman, 2007). Successful learning of chemistry depends partly on correct use of a teaching method

whose activities target most learning senses. Since chemistry is a subject that encourages 'hands on' experiences, more practical oriented modes of instruction should be selected (Twoli, 2006).

Practicals are a very prominent feature of school science in many countries and a high proportion of lesson time is given to them. Science practicals are very much a characteristic of the school science curriculum. They have been part of school science curriculum for over a century, and their place in a chemistry lesson has often gone unquestioned (Bennet, 2003). For example, the West African Examinations Council (WAEC) syllabus had over the years recommended that the teaching of all science subjects listed in the syllabus should be practical based, and after several decades of emphasizing the assumed importance of practicals in science teaching and learning, the importance became elevated to the level of a dogma (Abimbola, 1994). Similarly Hodson (1991, 176) argued that, "teachers have been socialized by the powerful, myth-making rhetoric of the science teaching profession that sees hands-on practical work in small groups as the universal panacea - the route to all learning goals and the educational solution to all learning problems."

Like other sciences, chemistry teaching and learning is supported by laboratory experiments (practical sessions) (Reid & Shah, 2007). Chemistry practical classes (experiments) are believed to help students in understanding theories and chemical principles which are difficult or abstract (Lagowski, 2002). Moreover, practicals offer several opportunities to students such as: handling of chemicals safely and with confidence, acquiring hands-on experience in using instruments and apparatus, developing scientific thinking and enthusiasm to chemistry, developing basic manipulative and problem solving skills, developing investigative skills, identifying chemical hazards and learning to assess and control risks associated with

chemicals (Lagowski, 2002; Pickering, 1987; Carnduff and Reid, 2003; Ravishankar and Ladage, 2009).

However, Hofstein (2004) argues that research has failed to show a simplistic relationship between experiences provided to the students in the laboratory and learning chemistry. There are concerns about the effectiveness of laboratory work in helping the students understand the various aspects of scientific investigation (Lazarowitz & Tamir, 1994; Schwartz et al., 2004). Teachers usually want to develop students higher order thinking skills, like critical thinking, through laboratory work; but to what extent they can achieve this is controversial (Bol & Strage, 1996; Ottander & Grelsson, 2006). Therefore, it is important to analyze the purposes related to laboratory work, as the purposes need to be well understood and defined by teachers and students alike for the chemistry practicals to be effective.

Traditionally, chemistry courses at all levels have included instruction in laboratory settings where students follow procedures directing them to mix chemicals, make measurements, analyze data, and draw conclusions. At the elementary, secondary, and early college levels, chemistry practicals frequently consists of what is generally described as "cook-book" exercises (Shakhashiri, 2009). The goals and desired outcomes of chemistry practicals are the subject of considerable debate. Important aspects of the debate center around the value versus cost of any laboratory experience and safety versus hazards of chemicals. Administrators cite these concerns to justify the elimination of chemistry practicals all together (Hodson, 1990).

Reports of the Board of Directors of the National Science Teachers Association (NSTA, 1982) in the USA (Abimbola, 1994) recognized that there were widespread doubts about the importance of science practicals in science teaching and learning in the seventies. For example,

the national science education standard and other science education literature emphasize the importance of rethinking the role and practice of practicals in chemistry and science teaching in general (Hofstein, 2004). Likewise, the Ministry of Education in Singapore was examining the role that science practicals played in science education and re-evaluating how school science practicals could be made more meaningful and productive for students (Ling & Towndrow, 2010). It is due to such concerns that this study is seeking to find out the effectiveness of chemistry practicals in chemistry learning with a view of making it more productive and meaningful for learners in the Kenyan context.

Teaching and learning of chemistry can also be supported and improved through use of information and communication technology (ICT). ICT is considered as a versatile source of scientific data, theoretical information and offers a viable means to support authentic learning in chemistry (Awad, 2014). Prior to Internet being available, the only learning materials were textbooks, chemistry laboratory facilities and equipment, and the only authority figures were teachers. However, (Awad, 2014) reports that there are so many learning materials such as html documents, *e-books* and electronic encyclopedias in the Internet and also many ways to get in touch with authority figures such as scientists and other school teachers. All what a student may want to know can be obtained through searching the Internet.

One of the ICT opportunities in teaching and learning chemistry is to help students to visualize the spatial three-dimensional (3D) elemental and molecular structures, and allows collaborative interactions between teachers and students, and among students themselves (Awad, 2014). Furthermore, these learning technologies expand the range of topics that can be taught in the classroom. The computer and its Internet access extend student-learning experiences beyond the classroom by introducing real-world issues with movies, simulations and animations. They

promote contextualized understanding of scientific phenomena in real world. In his research, Kearney (2004) used computer-mediated video clips to show difficult, expensive, time consuming or dangerous demonstrations of real projectile motions. The real-life physical settings depicted in the video clips provided interesting and relevant contexts for students.

2.3 Performance in School Chemistry

Poor performance in chemistry is not unique to Kenyan secondary students only. For example, the biggest challenge facing science educators and researchers in the Caribbean is the underachievement in science subjects among the secondary school students. A review of Caribbean School Examination Council (CSEC) results in biology, chemistry, physics and integrated science for ten years indicated that pass rates had fallen below 50% in these science subjects (Ogunkola & Fayombo, 2009). Similarly, international studies of educational performance revealed that USA students consistently rank near the bottom in science and mathematics (Rutherford, & Ahlgren, 1991) an indication of poor performance in these subjects. Since the 1960s, Kenya's secondary school students' chemistry achievement has remained low (KNEC, 1999), necessitating interventions such as the SMASSE project in 1996. The KNEC (2001) KCSE examination report indicated that the candidates' overall performance in mathematics and all the science subjects was very poor when compared to the performance in the other subjects. For example, according to chemistry 2011 KCSE results, the overall candidates' performance in chemistry was a mean of 23.66% (KNEC, 2012).

2.4 Chemistry practicals and Performance in School Chemistry

Chemistry practicals have been and are being used in chemistry teaching to support theoretical chemistry instruction. The success of any given chemistry practical task depends on

the intended learning objectives of that task. Learning objectives of chemistry practical tasks can be divided into two categories, for example, categories A and B. In category A, the practical tasks should be to enable the learners to: (i) identify objects (ii) learn a fact(s) (iii) identify phenomena. In Category B, the practical tasks should be to enable learners to: (i) learn a concept (ii) learn a relationship and (iii) learn a theory/model (Millar, 2004). The science educators' criticisms on chemistry practicals are on tasks with objectives in category (B) and not those in category (A). Millar (2004) describes the tasks with objectives in category (A) as being effective as many other forms of instruction. The observable aspects of practical tasks are often remembered many months or even years later if the event is a striking one. For example, seeing a piece of sodium put into water or the 'pop' sound of burning hydrogen gas.

The role of chemistry practicals is to help students make links between two 'domains' of knowledge: the domain of objects and observable properties and events on the one hand, and the domain of ideas on the other (Millar, 2004). The learning objectives of category (B) above are more strongly involved in chemistry practicals than those in category (A). Students are unlikely to grasp a new scientific concept or understand a theory or model (category B objectives) as a result of any single chemistry practical task, however well designed. Students acquire deeper and more extended understanding of an abstract idea or set of ideas in a gradual process, hence the need for frequent and varied practical activities.

Designing practical tasks that animate the students' thinking before they make any observations can make them more effective. One approach which has been found strikingly successful for this is the Predict – Observe – Explain (POE) task structure (White & Gunstone, 1992). In this approach, students are first asked to predict what they would expect to happen in a given situation and to write this down, then to carry out the task and make some observations,

and finally to explain what they have observed (which may or may not be what they predicted). The POE structure makes the practical task more purposeful and to play a pivotal role in students' learning of chemistry and eventually improve performance in the subject. Otherwise a practical task designed to enable the students to observe an object or phenomenon can easily become rather dull and uninspiring, unless it is striking and a memorable one.

The above role of chemistry practicals of helping students to make links between two 'domains' of knowledge: the domain of objects and observable properties and events on the one hand, and the domain of ideas on the other is nowadays being met by using ICT in teaching and learning of chemistry. According to Awad (2014), there is an obvious growth in the importance of information and communication technology (ICT) in science education. ICT is being used as a tool for designing new learning environments, integrating virtual models and creating learning communities (e-learning). Awad (2014) also points out that, the e-learning being used in teaching and learning chemistry, includes informative material in electronic forms such as: www-pages, e-mails and discussion forums enhances the teaching and learning of chemistry. ICT is a versatile source of scientific data, theoretical information and offers a viable means to support authentic learning in chemistry. In teaching and learning of chemistry, ICT helps students to visualize the spatial three-dimensional (3D) elemental and molecular structures, and allows collaborative interactions between teachers and students, and among students themselves (Awad, 2014).

Schools should have many charged teaching sites about high school curricula. These sites should not only offer the video clips showing the lectures and experiments but also many referential learning materials. Internet websites provide student centered learning environments. The control over pacing of computer-based learning gives students the flexibility and time to

thoroughly build their understandings of the subject at hand. For example, the use of computer program such as *e-chem* helps students create more scientifically acceptable representations of molecules. According to Singer, Marx, and Krajcik, (2000) softwares support complex processes that students are not capable of completing without assistance. Therefore, extensive use of learning technologies can help students to develop deep understanding of chemistry concepts and processes by themselves and in so doing improve performance in the subject.

The effect of practicals in learning of chemistry in schools may be influenced by several factors. Factors such as nature, quality, and frequency of chemistry practicals, facilities and equipment available and gender of the learners among others are leading influences on the teaching and learning of chemistry. They have crucial roles in determining different attitudes and learning styles of students and consequently different educational impacts on different individuals (Nieswandt & McEneaney, 2009). This affects how chemistry instruction takes place in schools and indeed the students' performance in the chemistry examination.

2.5 Nature of School Chemistry Practical

To date, many studies have been conducted on the importance of laboratory work while teaching science. Currently, science educators and teachers agree that laboratory work is indispensable to the understanding of science (Cardak et al., 2007; Ottander & Grelsson, 2006; Tan, 2008). The role of laboratory work in science education has been detailed by some researchers (Lazarowitz & Tamir, 1994; Lunetta, 1998). The main purpose of laboratory work in science education is to provide students with conceptual and theoretical knowledge to help them learn scientific concepts, and through scientific methods, to understand the nature of science. Laboratory work also gives the students the opportunity to experience science by using scientific

research procedures. In order to achieve meaningful learning, scientific theories and their application methods should be experienced by students. Moreover, laboratory work should encourage the development of analytical and critical thinking skills and encourage interest in science (Ottander & Grelsson, 2006).

Teaching and learning of science has over the years tried to mimic what ‘real’ scientists do. The processes of science, the scientific method, the inquiry process, the content of science and the habits of scientists are all re-contextualized in the science curriculum for schools in many parts of the world (Ling & Towndrow, 2010). In mimicking the real scientist, the rationale for using chemistry practicals as a form of instruction is sometimes forgotten.

Some teachers and students place great emphasis on obtaining the correctness of the answers leaving the mastery of process skills to chance (Goh & Chia, 1988). In such cases, the range of investigations is narrowed and is dominated by the perceived demands of assessed coursework. However, the major barrier to improving the quality and variety of practical activity is the constraints felt by teachers in terms of two interrelated factors: time and the demands of the national assessment frameworks. This may force teachers to use demonstration experiments rather than student experiments and sometimes teachers end up in applying 'drill and practice' to train students to pass examinations (Lunetta, Hofstein and Clough, 2007).

Traditional laboratory classes normally involve students carrying out teacher-structured laboratory exercises or/and experiments, where each step of a procedure is vigilantly prescribed and students are expected to follow and adhere to the procedures precisely. This kind of laboratory activity is frequently known as a ‘recipe lab’ (Domin, 1999), in which little student involvement with the content is required. For such kind of activities, Johnstone, et al.(1994) add that students can be successful in their laboratory class even with little understanding of what

they are actually doing. Nevertheless, the student may have little option but to accept this passive approach whilst, they deal with new techniques and/or equipment, particularly when the lab preparation involves no more than reading and understanding the laboratory manual. On a similar note, Johnstone (1991) commented that the laboratory is regarded as an information overload place, resulting in students with little 'brain space' to process information and consequently, they blindly and thoughtlessly follow the instructions. In addition, they seldom interpret their observations or/and the results obtained during the experiment.

There are two extreme thoughts regarding the importance of Chemistry laboratory experiments/practicals (Achor, Kurumeh & Orokpo, 2012). The first one is that in traditional approaches, little opportunity is given to student initiatives or circumstance. In this approach, all the laboratory procedures are carefully listed in the provided manual, and frequently the student is simply asked to fill in a well planned report template. At the end of a laboratory session, students have no real opportunity of understanding or learning the process of doing Chemistry. The second one is that a student is given an opportunity to engage in deep learning (Gunstone & Champagne, 1990). This would provide a student an opportunity in identifying the main objectives of the work and in planning and executing it, of identifying the conceptual and practical difficulties encountered, recording and discussing the results and observations and of suggesting practical alterations and improvements (Teixeira-Dias, Pedrosa de Jesus, Neri de Souza & Watts, 2005). The latter, thus, could result in a significant positive impact on a students' ability to learn both the desired practical skills and also the underlying theory (Akpa, 2005).

Chemistry practicals should be conducted in such a way that they interact with ideas, as much as the phenomena themselves. It is necessary for teaching to focus upon scientific ways of talking and thinking about phenomena, rather than the phenomena themselves (Leach & Scott,

2003). Teachers can employ a wide variety of teaching strategies to engage students' minds in learning. Reports emphasize that teaching science with the help of chemistry practicals makes chemistry to be more enjoyable and stimulating to students than teaching the same subject matter only through lecture (Hofstein, 2004). Students have a lot to benefit from chemistry practicals which may include increasing students' interest and abilities in the subject as well as their achievement in chemistry (Pavesic, 2008).

2.6 The Quality of School Chemistry Practicals

The quality of chemistry practicals varies considerably around the world (Lunetta, Hofstein & Clough, 2007). Most curricula specify that practical and investigative activities must be carried out by students. However, there is a gap between policy and practice, between what is written in curriculum documents, what teachers say they do, and what students actually experience. Hodson (2001) found that the lesson objectives stated by teachers frequently failed to be addressed during actual lessons.

Despite curriculum reforms aimed at improving the quality of chemistry practicals, students spend too much time following recipes and, consequently, practicing lower level skills (Dillon, 2008). Similarly, where students only carry out instructions from worksheets to complete a practical activity, they are limited in the ways they can contribute. As a result, students fail to perceive the conceptual and procedural understandings that were the teachers' intended goals for the laboratory activities (Lunetta *et al.*, 2007). This is a case of under utilisation of the opportunities provided by practical activities. If teachers do not select appropriate chemistry practicals, this may end up in laboratory work of doubtful quality. Such an approach is demotivating for students and a poor use of teaching and learning resources and which may end up contributing to poor performance in the subject.

2.7 The Frequency of School Chemistry Practicals

Teachers usually control the frequency and, to some extent, the quality of chemistry practicals in schools. The volume and variety of chemistry practicals in schools has lessened over time (Ofsted, 2005). In many situations, the cause of this is the focus on 'teaching for examination', which has squeezed out some types of chemistry practicals. Many teachers complain that, with pressure to get through the syllabus, they cannot find room for many chemistry practicals (Dillon, 2008). Teachers are being required to achieve better examination results and one response to this has been to focus more on 'book learning' which is more easily managed than chemistry practicals. Ofsted (2005), reports that teachers had to teach didactically to get through the content according to the examining body specifications.

Practicals in chemistry are expensive, particularly the costs of replenishing apparatus and chemicals. When combined with insufficient budgets to provide enough technical support, materials and equipment and lack of time to prepare the chemistry practicals, the frequency of performing practical definitely suffers (Dillon, 2008). Apart from being expensive on resources and time, student laboratory experiments are more difficult to plan or organize and supervise (Twoli, 2006). National Endowment for Science, Technology and the Arts (NESTA) (2005) survey of science teachers (in UK) on factors affecting teachers' use of chemistry practicals found that 64% lacked time for experiments while many teachers said that safety rules had put them off. 87% of respondents said learning which allowed more experiments and scientific enquiry would have a more significant impact on performance. According to Dillon (2008) UK science teachers are not alone in reporting lack of time as a barrier to doing more chemistry practicals. For example, a study in Hong Kong, found that science teachers generally find enquiry-based laboratory work very difficult to manage. The high costs and constraints of

chemistry practicals limit the number of lessons planned involving chemistry practicals and hence the frequency of chemistry practicals goes down.

2.8 Availability of Facilities and Equipment

The place of experimental work in laboratories has always assumed a high profile at all levels of chemical education (Reid & Shah, 2007). Laboratory classes are an ideal place to integrate the active learning approach. Science laboratories have long played a unique role in science education, providing an opportunity for inquiry-based investigative learning (Hofstein & Lunetta, 2004). These classes provide an opportunity for hands-on experiences designed to help students further understand concepts learned in the classroom (Reid & Shah, 2007). The modern laboratory provides students opportunities to learn specific procedures and instrumentation and to develop skills such as problem-solving and communication (Carnduff & Reid, 2003).

In secondary schools where the provision of science laboratories is less than satisfactory, the teaching and learning of chemistry is hindered in a number of ways: (i) when classes are not taught in these specialised rooms, the opportunities to investigate and engage in chemistry practicals are reduced, and hence the effectiveness of teaching, and (ii) timetabling difficulties make the nature and frequency of chemistry practicals and learning more difficult to manage. There is a clear need for the standards of accommodation to be improved and improvement of laboratory stock. If the nature and quality of chemistry practicals are to improve, then there is a continuing need for the upgrading and refurbishment of laboratories, and for new laboratories to be built in schools (Ofsted, 2005). Some barriers to effective chemistry practicals associated with facilities include: too many students in practical classes and the associated behavioural problems; insufficient funding being devolved to science departments; under resourced and old fashioned

laboratories in schools. These barriers impact heavily on the nature, quality and frequency of chemistry practicals.

2.9 Gender and Performance in School Chemistry

Gender and its manifestation in various human activities appears to be a strong predictor of human conduct. In education, many differences have been documented between achievements of males and females. Many researchers and educationalists feel that gender difference is one of the factors that affect academic performance (Ssempala, 2005). Gender has a crucial role in determining different attitudes and learning styles and consequently different impacts of educational activities on different individuals. The sex role stereo type students are attached to could influence how they perform in both practical and theoretical aspects of chemistry examination (Akpa, 2005). The biased way in which science is presented at school and portrayed by media continues to feed usual gender stereotypes. Gender differences in competence beliefs concerning science are reported as early as kindergarten level (Cuomo, Serpico & Balzano, 2007).

Science learning is a typical gender role–stereotyped domain in which boys and girls tend to be strongly conditioned by the self-perception of their competences and skills. This may result in resistances and lack of self-confidence (typical in girls) or in overestimation and excess of desire to be in the limelight (typical in boys) (Cuomo, et al, 2007), which has strong impacts on academic performance. For example, although the performance in science subjects at all levels of the Uganda education system is poor, the performance of girls is always poorer than that of boys (Kakinda, 2007). Other observations by the Permanent European resource Centre for Informal Learning (PENCIL) pilot projects (Cuomo, et al., 2007) showed that educational programmes

can be designed which are attractive for both girls and boys, leading to success in science learning. Therefore, gender is an important factor that contributes to performance in chemistry.

Studies by (Okeke, 1990; Maduabum, 2006) clearly indicate the state of affairs at the secondary level of education in Nigeria which shows that a greater proportion of males enrolled and achieved higher than their female counterparts. Their study also showed that at all levels of education in Nigeria, females were grossly underrepresented in terms of enrolment, participation and achievement in science, technology and Mathematics education. Elsewhere observations on the disparity in male-female performance in sciences exist (Ssempala, 2005; Hodson, 1999). Studies carried out by Tamir (1982) and Burns (1987) in Israel and New Zealand respectively, also showed that male students outperformed their female counterparts in the physical sciences. The report of similar study conducted by Anderson (1987) indicated that in America, there were too few women in the sciences and related professions like Engineering and Technology.

Okeke (1990), reported that boys perform better than girls on physical science questions and high level questions (application, analysis and synthesis) whereas girls do as well as, or better than boys on questions in Biological sciences and lower level (knowledge, recall and comprehension) questions. Research study carried out by Mari (2001) focused mostly on the effect of gender factors on students' understanding of science process skills in science learning among junior secondary schools students. The results showed that female students were significantly better in their understanding of science process skills than their male counterparts and that there was significant difference between the male and female students in their ability to solve problems requiring their understanding of the process skills. Process skills are developed through doing chemistry practicals.

2.10 Theoretical Framework

The study was guided by the constructivist leaning theory as postulated by John Dewey who noted that humans generate knowledge and meaning from their experiences (Dewey, 1938 & Bruner, 1960). The theory describes learning as an active, internal process of constructing new understandings. It says that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. The learner must play an active role in taking on new knowledge (Millar, 2004). He or she has to make sense of the experiences and discourse of the chemistry class and use it to construct meaning. This is the constructivist view of learning.

The constructivist model suggests that learners construct their ideas and understanding on the basis of series of personal experiences. Learning science at school level is not discovery or construction of ideas that are new and unknown to learners rather it is making what others already know your own (Millar, 2004). Experiences given during chemistry practicals can provide such opportunities for chemistry students. For example, Barton (2004) suggests that, after an illustrative chemistry practical, students are offered explanations, models and analogies from the teacher to help them in their efforts to construct their own understanding of what they have experienced. The primary criterion which a practical activity should satisfy is that of being an effective means of communicating the ideas it is intended to convey. This study is asking how this happens in school chemistry practicals and how effectively this augments other forms of communication (verbal, pictorial, symbolic) that teachers might use. According to Hofstein and Lunetta (2003), a constructivist model currently serves as a theoretical organizer for many science educators who are trying to understand cognition in science.

According to Miha (2006), constructivism provides a perspective on teaching and learning science in classrooms, with a view to improving the effectiveness of science teaching in enhancing students' learning. Solomon (1987) argues that, according to constructivism the most important thing in science teaching and learning is providing students with learning environment that promotes their understanding of science by co-constructing and negotiating ideas through meaningful peer and teacher interactions. This study identifies nature, quality and frequency of chemistry practicals as major parts of learning environment which influence construction of chemistry knowledge in secondary school students. The core view of constructivists on learning science suggests that students construct their knowledge strongly influenced by social environments, such as whether the school is single gender or mixed gender in nature. Therefore, constructivists acknowledge social dimension of learning such as the classroom and learning community whereby students make meaning of the world through both personal and social processes (Driver et al, 1994; Kearney, 2004).

According to Miha (2006), the emphasis of learning activities means two things: student-centered teaching and laboratory –centered teaching. The center of instructional activities are the students themselves, so teacher-centered teaching does little good in students' learning processes. Activities such as performance of experiments (class experiments) and discussion about the results with peers can help students to build understandings. The nature, quality and frequency of the laboratory –centered teaching (chemistry practicals) are crucial in constructing new knowledge and concepts by students. During these laboratory activities, students have opportunities to learn the procedure and skills that are facilitating conceptual changes that may lead to increased performance in chemistry.

Constructivism transforms the student from a passive recipient of information to an active participant in the learning process. Research indicates that student achievement and motivation for the study of science improves dramatically if students are active participants in constructing their own knowledge and in learning to use that knowledge to analyze scientific processes (Khan, Hussain, Ali, Majoka & Ramzan, 2011). Meaningful learning in the laboratory would occur if students were given sufficient time and opportunities for interaction and reflection. Also, Tobin (1990) and Ikeobi (2004), report that meaningful learning is possible from a given laboratory experiments if the students are given ample opportunities to operate equipments and materials that help them to construct their knowledge of phenomena and related scientific concepts. The construction of deep scientific knowledge results from actively practicing science in structured learning environments, that is, where the nature and quality of laboratory activities are taken into consideration. Secondary schools in Kenya are categorized into boys', girls' and mixed schools. This categorization implies differing social and cultural learning environments. Individual learners' interactions with their peers is important to each learner's active construction process.

2.11 Conceptual Framework

A conceptual framework is a written or visual presentation that explains either graphically, or in narrative form, the main things to be studied, such as, the key factors, concepts or variables and the presumed relationship among them. According to Mutai (2000), a conceptual framework is a hypothesised model identifying various variables and the relationship among them. The study was based on the assumption that chemistry practicals influence learners' performance in chemistry. Various aspects of chemistry practicals such as, nature; quality; amount of chemistry practicals and also the gender of students influence how chemistry practicals affect students'

performance in chemistry. These aspects of the independent variable (chemistry practicals) are interconnected to show how they influence the dependent variable (students' performance in chemistry) which constitutes the conceptual framework of the study. This is presented in Figure 2.1.

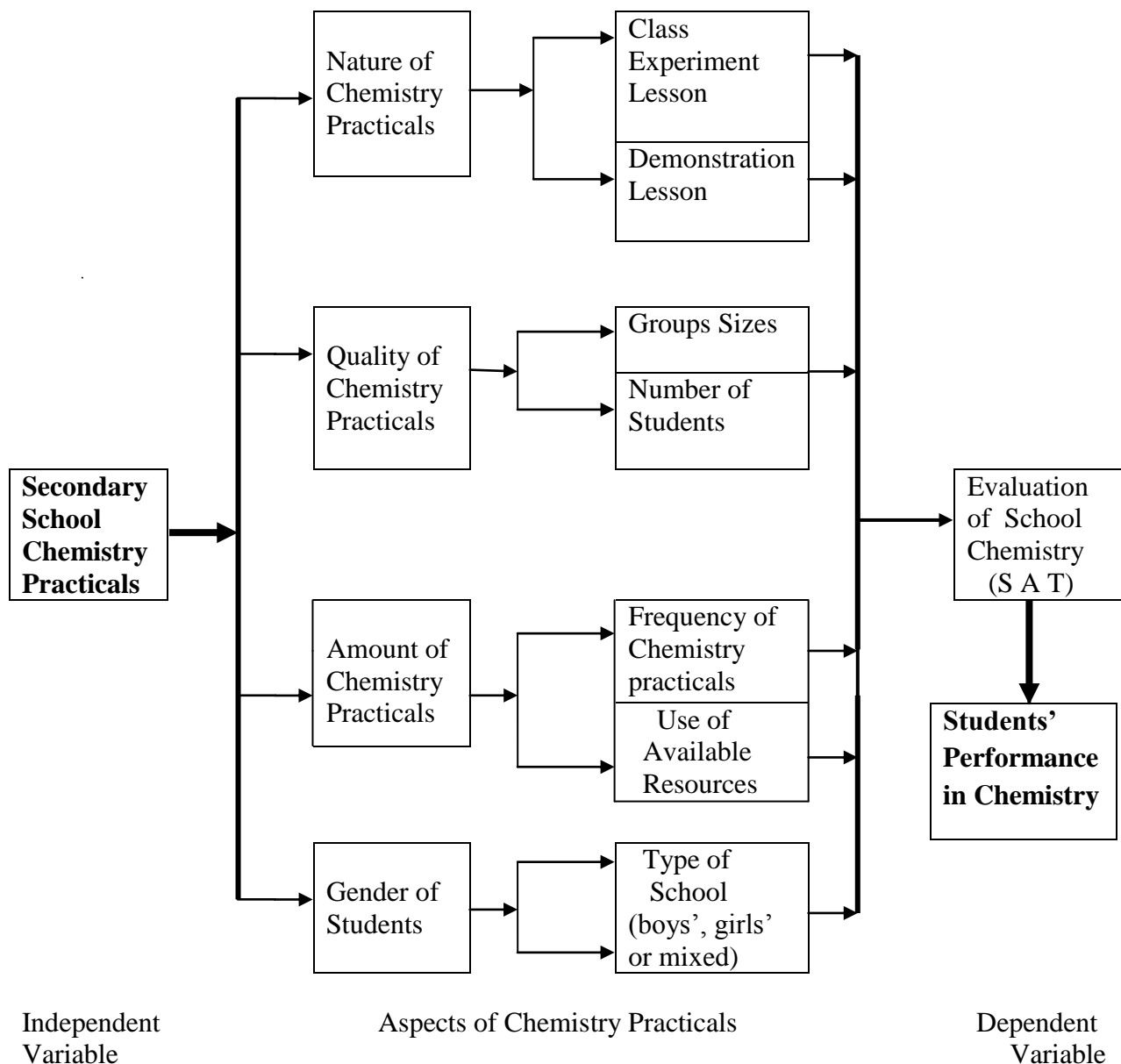


Figure 2.1 A Conceptual Framework on Effect of Chemistry Practical on Students' Performance

Chemistry practicals are an approach that is used in the teaching and learning of chemistry. The effectiveness of chemistry practicals as an approach of learning chemistry can be shown by devising chemistry practicals, showing their various aspects and their influences on learning of chemistry at different stages, and then evaluating the students to determine their performance in the subject as Figure 2.1 shows. Nature of chemistry practicals which implies whether the lesson is a class experiment or a demonstration indicates what the students actually do in that lesson. Do they participate by doing the experiment/s or do they just observe it being done?

The resources available in the school will affect the quality of chemistry practicals in that they determine the frequency and the amount of chemistry practicals done and the nature of these practicals. The available resources will also determine the number of groups and their sizes into which students will be divided into. The quality of the chemistry practicals can also be affected by the number students in a class, if too many, the apparatus and reagents may not be enough for all students or the constituted groups would be too large for effective participation in the practical activity. The type of school, that is, whether it is a boys', a girls' or a mixed secondary school determines the kind of social interactions and the attitude of students towards chemistry practicals which may in turn affect their performance in the subject. The achievement of learning objectives is determined by evaluating the students after the learning activities. Their performance in the student achievement test (SAT) is an indicator of what the students have learnt and hence an indicator of the effect of the chemistry practicals.

2.12 Summary of the Literature Reviewed

The literature review highlights the need to investigate the effect of chemistry practicals on performance in chemistry in order to establish the effectiveness of chemistry practicals as a

teaching and learning strategy in secondary school chemistry. Practicals are a characteristic feature of science teaching at all levels of education (Adane & Adams, 2011). However, Abrahams and Millar (2008), report that, questions have been raised by some science educators about the effectiveness of chemistry practicals as a teaching and learning strategy. This brought out a need for a study to find out the effectiveness of chemistry practical and to establish whether the use of chemistry practicals as a teaching learning strategy had an effect on performance of chemistry at secondary school level.

This chapter has included literature review on: Secondary school chemistry instruction, performance in secondary school chemistry, chemistry practicals and performance in school chemistry, nature of school chemistry practicals, quality of school chemistry practicals, frequency of school chemistry practicals, availability of facilities and equipment for chemistry learning and gender and performance in school chemistry. From the review, Abrahams and Millar (2008) report that they were unaware of any systematic study that compared the amount or type of chemistry practicals used in schools to performance in chemistry, although, it is widely recognised that more practical work is carried out in school science teaching in the UK than in most other countries.

Dillon (2008) points out that there have been concerns about practical work in schools science where the range of investigations are cited as narrow and dominated by the perceived demands of assessment at the end of the four year course. He also pointed out that the concerns were echoed by sections of the science community, industry and business, and teachers themselves who argued that schools in general are not doing enough practical work, both in and out of the classroom, and that its quality was uneven. Lerman (2014), points out that many students tend to shy away from chemistry and so to attract students to chemistry, creative methods for teaching

and learning should be developed for all levels, from primary school to university. All these concerns indicate a need to find out the role and effect of practicals in science learning.

Abrahams and Millar (2008) point out that many within the science education community and beyond see chemistry practicals carried out by students as an essential feature of chemistry education. Hofstein (2004) reports that, teaching science with the help of practicals makes it more enjoyable and stimulating to students than when teaching the same subject matter only through lecture. Students have a lot benefits from chemistry practicals which may include increasing students' interest and abilities in the subject as well as their achievement in science (Pavesic, 2008). Despite all these, Wellington (1998) commented that "teachers are always surprised, even shocked, when asked to consider what practical work in science is for". Dillon (2008) adds that there are nagging questions regarding the effectiveness of chemistry practicals as a pedagogical tool.

Report by Hofstein (2004) shows that, research has failed to show a simplistic relationship between experiences provided to the students in the laboratory and learning science. Likewise, Barton (2004) reports that literature on practicals in school science, indicates that there is no clear consensus about the relative merits of these science practicals and why we devote so much of our time and limited resources to it. Abimbola (1994) shows that reviews of research carried out in this area conclude that science education researchers have failed to provide conclusive evidence to support the view that using practicals, as a method of teaching science is superior to other methods, at least, as measured by paper and pencil achievement tests.

Millar (2004) states that, the role of chemistry practicals is to help students make links between two 'domains' of knowledge: the domain of objects and observable properties and events on the one hand, and the domain of ideas on the other. This same role is nowadays being

met by using ICT in teaching and learning of chemistry. According to Awad (2014), there is an obvious growth in the importance of information and communication technology (ICT) in science education. ICT is a tool for designing new learning environments, integrating virtual models and creating learning communities (e-learning). The e-learning being used in teaching and learning chemistry, including informative material in electronic forms such as: www-pages, e-mails and discussion forums enhances teaching and learning of chemistry.

The literature review shows that the study was guided by the constructivist leaning theory as postulated by John Dewey who noted that humans generate knowledge and meaning from their experiences (Dewey, 1938 & Bruner, 1960). The constructivist model suggests that learners construct their ideas and understanding on the basis of series of personal experiences (Barton, 2004). Personal experiences given during chemistry practicals can provide such opportunities for chemistry students. According to Miha (2006), constructivism provides a perspective on teaching and learning science in classrooms, with a view to improving the effectiveness of science teaching in enhancing students' learning. Also, as stated by Tobin (1990) and Ikeobi (2004), meaningful learning is possible from given laboratory experiments if the students are given ample opportunities to operate equipment and materials that help them to construct their knowledge of phenomena and related scientific concepts and improve performance in the subject. Is this the case in all schools in all countries?

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter deals with the description of the methods and procedures that were used in carrying out this research study. The description is organized into the following sections: research design, target population, sample size and sampling techniques, research instruments, data collection procedures, data analysis and ethical considerations.

3.2 Research Design

Kumar (2005) defines a research design as a plan, structure, and strategy of investigation to obtain answers to research questions or problems, while Kothari (2004) defines it as the blueprint for collection, measurement and analysis of data. This study employed a quasi-experimental approach of the pre-test – post test type. The non-equivalent pre-test, post-test, control group experimental design was adopted. According to Kumar (2005) a pre-test – post test design is the most appropriate design for measuring the impact or effectiveness of a program, where one group is treated and the other is not.

The quasi-experimental approach of the pre-test – post test design was suitable for this study because the performance in chemistry of the group of students taught with methods integrating chemistry practicals (experimental group) was compared to the performance in chemistry of the group taught without chemistry practicals (control group). In both groups a pre-test and a post- test was used to determine the performance of the groups before and after treatment. Student Achievement Tests (SAT) were used to test learners' performance in

chemistry. The use or non use of chemistry practicals in teaching was done without affecting the classroom set up so that the learners were not aware of their involvement in the study. The Statistical test, ANCOVA, was used to control some extraneous variables. According to Mayers (2013), ANCOVA is a useful statistical procedure which can be employed in a wide range of contexts such as: exploring pre-test vs post-test effects; filtering out error variance; and statistically controlling variables which have not been done so physically. According to Field, (2013), ANCOVA can help us to exert stricter experimental control by taking account of confounding variables to give us a 'purer' measure of effect of the experimental manipulation. This is because analysis of covariance (ANCOVA) explores outcomes after accounting for other variables that may be related to that outcome.

However, to minimize the Hawthorne Effect, an equal number of schools for the control and experimental groups was not pre- tested, but all groups, did the post test as shown in Table 3.1 which also shows the experimental and control groups.

Table 3.1**The Pre-Test – Post Test Groups of Respondents**

| Groups (Schools) | Pre-Test | Treatment | Post Test | Difference |
|---|-----------------|------------------|------------------|-------------------|
| EB _{x1} , EG _{x1} , EB _{x2} , EG _{x2} | PT1 | Y | PT2 | PT2 – PT1 |
| CB _{x1} , CG _{x1} , CB _{x2} , CG _{x2} | PT1 | - | PT2 | PT2 – PT1 |
| EM _{x1} EM _{x2} | PT1 | Y | PT2 | PT2 – PT1 |
| CM _{x1} CM _{x2} | PT1 | - | PT2 | PT2 – PT1 |
| EB _{x1} , EG _{x1} , EB _{x2} , EG _{x2} | - | Y | PT2 | PT2 – PT1 |
| CB _{x1} , CG _{x1} , CB _{x2} , CG _{x2} | - | - | PT2 | PT2 – PT1 |
| EM _{x1} EM _{x2} | - | Y | PT2 | PT2 – PT1 |
| CM _{x1} CM _{x2} | - | - | PT2 | PT2 – PT1 |

Where –EB_{x1} – Experimental group for boys and CB_{x1} – Control groups for boys

EG_{x1} – Experimental group for girls

CG_{x1} – Control groups for girls

EB_{x2} – Experimental group for boys

CB_{x2} – Control groups for boys

EG_{x2} – Experimental group for girls

CG_{x2} – Control group for girls

EM_{x1} – Experimental Mixed

CM_{x1} – Control Mixed

EM_{x2} – Experimental Mixed

CM_{x2} – Control Mixed

X₁ = County-1 and **X₂** = County-2

This is a before – and – after research design that was intended to reveal whether students who were taught using methods integrating chemistry practicals showed significantly greater academic achievement in chemistry than students taught without chemistry practicals. The change was measured by comparing the difference in the performance in the pre-test (before) and the post test (after the intervention).

3.3 Target Population

Target population or universe of a study is all the members or objects involved in the study (Kothari, 2004). The population of the study consists of all chemistry students in public

secondary schools in Machakos and Nairobi counties in Kenya. There were 272 public secondary schools of which 212 were in Machakos county and 60 in Nairobi county. Mugenda and Mugenda (2003) assert that the target population is the population to which a researcher wants to generalize the results of a study.

This study involved all Form Two students who were taking chemistry and all chemistry teachers in the selected twenty four public secondary schools in Machakos and Nairobi counties in Kenya. The Form Two class was chosen because at this point the students had been introduced to chemistry as a subject and chemistry practicals in form one. Also, because the form two students were not purposively being prepared for examination as it happens in form three and four classes of public secondary schools.

3.4 The Sample and Sampling Procedures

Multi-stage cluster sampling and purposive sampling were used to obtain a sample of 24 out of 272 public secondary schools in Machakos and Nairobi counties for this study. The non-equivalent group design most often uses intact groups that are thought to be similar, as control and treatment groups. Therefore, the unit of sampling was the secondary school rather than individual students because schools operate as intact groups (Gall, Borg, & Gall, 1989). According to Kumar (2005), if the population is large as in the case of a city, state or country, it becomes difficult and expensive to identify each sampling unit, hence the use of cluster sampling is most appropriate. Clusters can be formed on the basis of geographical proximity or a common characteristic that has a correlation with the main variable of the study. Cluster sampling involves identification and selection of an intact group. Therefore each secondary school was considered as one intact group.

This study therefore applied multi-stage cluster sampling, beginning at the national level where due to geographical proximity, the two counties (Nairobi and Machakos) were purposively sampled. At the county level, twelve schools were purposively sampled to provide boys', girls' and mixed public secondary schools in each county. For this study, cluster sampling was done at national level and at county level, hence the multi-stage cluster sampling technique.

At each of these two counties, the researcher obtained a sample of twenty four public secondary schools, that is, four boys', four girls' and four mixed secondary schools per county of almost comparable students' abilities and facilities through purposive sampling. Mugenda and Mugenda (2003) maintain that purposive sampling can be used as part of multistage sampling where it is applied to get location in which the units of observation have the required characteristics. The desired sample of 24 county schools was distributed as shown in Table 3.2.

Table 3.2
Research Sample Distribution

| <u>County</u> | School Type | | | <u>Total</u> |
|---------------|--------------------|--------------|--------------|--------------|
| | <u>Boys</u> | <u>Girls</u> | <u>Mixed</u> | |
| County-1 | 4 | 4 | 4 | 12 |
| County-2 | 4 | 4 | 4 | 12 |
| <u>Total</u> | 8 | 8 | 8 | 24 |

Table 3.2 shows that four boys', four girls' and four mixed gender schools were selected for the study in each county. Two boys', two girls' and two mixed gender public secondary schools from each of the selected counties constituted the experimental group. The other set of two boys', two girls' and two mixed public secondary schools from each of the selected counties constituted the control group. The unit of analysis was the student, so, the study sample was

made up of seven hundred and thirty five form two chemistry students in their intact classes in twenty four public secondary schools in Machakos and Nairobi counties.

3.5 Research Instruments

The data for this study was collected using student achievement tests (SAT) – through the Pre-test and the Post test results and questionnaires for students and for the chemistry teachers.

3.5.1 Student Achievement Tests (SAT)

Student academic achievement in both the experimental and control groups in the study was evaluated using the researcher created chemistry student achievement tests (SAT). Two student achievement tests: a pre-test and a post test, were constructed and used by the researcher. A pre-test was administered to the respondents in the first week of the study to assess student pre-treatment chemistry academic abilities. Pre-tests are administered as formative evaluations to assess student pre-treatment chemistry academic levels (Creswell, 2005). The pre-test (Appendix III) consisted of five structured questions which tested the entry behavior (pre-requisite knowledge) of the students before learning the study topic. The pre-test had items from the sub-topics: acids, bases and indicators, the structure of the atom, the periodic Table, ion formation and chemical formulae and equations. The pre-test was planned for one hour and consisted of questions that were of knowledge, comprehension and application levels while a few were of the analysis level in Blooms taxonomy of objectives.

After the five weeks of teaching the topic ‘Chemical Families: Patterns in Properties’, a post test was administered to both the control and the experimental groups. A post test is administered as summative assessment after every treatment period to measure student academic gain in chemistry (Ormrod, 2003). The sub-topics taught in this topic included: Alkali metals

(Group I elements), Alkaline earth metals (Group II elements), Halogens (Group VII elements), Noble gases (Group O elements) and Properties and Trends across period 3. The topic was conveniently chosen because it is normally taught to form two classes at that time of the school calendar and which was also the chosen time of the study. The topic thus caused little inconvenience to teachers during their planning process and also the learners were not aware of their involvement in the study. The post test (Appendix IV) consisted of four structured questions and was planned to take place for one hour. It consisted of questions that were of knowledge, comprehension and application levels while a few were of the analysis level in Blooms taxonomy of objectives. Performance of the students was based on the scores attained after marking the achievement tests.

3.5.2 Questionnaires

Two sets of questionnaires were used in the study: questionnaire for chemistry teachers (Appendix V) and questionnaire for students (Appendix VI). The questionnaires were used to solicit information on the teaching and learning experiences during secondary school chemistry lessons involving chemistry practicals. They were structured to capture information required in helping to elucidate the relationship between chemistry practicals and performance in secondary school chemistry. Students' and teachers' views were sought on several areas that affect the use of chemistry practicals in the study of chemistry.

The questionnaires consisted of closed ended questions and were divided into two sections: Section A sought information about the schools and the students. Such information included: county where school is located, type of school (boys, girls or mixed), discipline, attitude towards chemistry subject and its activities, academic and general ability in chemistry

and in science activities. Section B solicited information about the teaching and learning practices in chemistry such as: the teaching and learning resources in schools such as laboratories, apparatus and reagents, teachers, chemistry textbooks and time allocation for theory and chemistry practicals, quality and frequency of use of the various teaching and learning strategies in chemistry and information about perceptions on the value of chemistry practicals on learning of chemistry.

3.6 Validity of the Research Instruments

Validity of the research instrument is the ability of an instrument to measure what it is designed to measure. According to Kumar (2005), the judgement that an instrument is measuring what it is supposed to is primarily based upon the logical link between the questions and the objectives of the study. In this study, triangulation was used to enhance data validation.

The researcher used supervisors, departmental lecturers and other science education experts in verifying face and content validity of the SATs and the questionnaires. The supervisors, departmental lecturers and the science education experts assessed the relevance of the content used in the research instruments and necessary modifications were made based on their feedback. Content validity of research instruments is judged by the researcher and experts in the field (Kumar, 2005). To further establish face and content validity of the research instruments, the researcher carried out a pilot study. The pilot study tested data collection and analysis procedures, clarity of the responses and the research assistants and ensured that the research instruments were not only valid but captured the required data.

The pilot study sample comprised of one boys', one girls' and one mixed public secondary schools selected randomly, in Murang'a county, a county outside the designated area of study. During the pilot study, the researcher and the research assistants visited the selected

schools and reported to the principal's offices to seek authority to administer the research instruments to the teachers and the students. All the research instruments for this study were administered to the respondents. The pilot study was carried out to determine the difficulty level of the questions in the SAT and to appraise the questionnaires so as to check the weaknesses and clarity of the questions. The results of the pilot study indicated that that the instruments could be used to solicit information for the study. Also, based on the results and observations from the pilot study, the instruments were refined by modifying or eliminating inappropriate items or by adding more items to capture more information.

3.7 Reliability of the Research Instruments

Reliability of a research instrument is the degree of accuracy or precision in the measurements made by the research instrument (Kumar, 2005). Therefore, a measuring instrument is reliable if it provides consistent results (Kothari, 2004). The results from piloting were used to determine the level of the reliability of the instruments. To determine the reliability of the questionnaire, the researcher used the test-retest method. According to Trochim (2000), the test-retest reliability is estimated by administering the same test to the same sample on two different occasions. The questionnaires were administered to the chemistry teachers and students on two different occasions within an interval of two weeks (Muijs, 2004). The results were scored and a comparison was made on the score of the first test and the scores of the second test to provide a reliability coefficient. The Pearson product-moment correlation coefficient was used to compute the reliability coefficient of the questionnaire. It is a number ranging from +1 (a perfect positive correlation) through 0 (no relationship) to -1 (a perfect negative relationship). The correlation coefficient for the teachers' questionnaires was found to be 0.82 and that of the students questionnaires was 0.79. These were accepted as good indications of reliability.

According to Fraenkel and Wallen (2002), an alpha value of 0.7 is considered suitable to make inferences that are accurate enough.

To determine reliability for the student achievement tests (SAT), the split half method was used. In split-half reliability, all items that purport to measure the same construct are randomly divided into two sets and then administer the entire instrument to the sample and calculate the total score for each randomly divided half (Trochim, 2000). After marking the SAT administered in the piloting, the marks were organized in ascending order. The correlation of scores between the two halves was found by using the Pearson r formula (r = estimated correlation between two halves).

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right) \left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}}$$

X = Scores of first half Y = Scores of second half and n = total number of items in each half

The Pearson correlation coefficient, r , can take a range of values from +1 to -1. A value of 0 indicates that there is no association between the two variables. A value greater than 0 indicates a positive association; that is, as the value of one variable increases, so does the value of the other variable. A value less than 0 indicates a negative association; that is, as the value of one variable increases, the value of the other variable decreases. The positive (increase, increase) correlation coefficient can range from 0.00 to 1.00. The closer the r value is to 1.00, the stronger the reliability. The r values for the pre-test and post test were computed and found to be 0.86 and 0.81 respectively. The value of 0.7 and above was accepted as a good indication of reliability. Hence, the values were accepted as good indications of reliability.

3.8 Procedure for Data collection

A permit to conduct the study was obtained from the National Commission for Science, Technology and Innovation (NACOSTI). A visit was made to Nairobi County Education Office and Machakos County Education Office and the researcher was allowed to carry out the research in Nairobi and Machakos counties. The researcher was provided with lists of public secondary schools in the two counties from which the study schools were selected. The sampled schools were visited and the respective principals were briefed on the nature of the research.

Four research assistants were trained on how to use the research tools. They were trained on the procedures to be followed in data collection and demonstration was done by the researcher. Practice was done on the use of the prepared schemes of work that was used during the teaching. The pilot study was particularly useful in training the research assistants since they accompanied the researcher in the visits to the schools. Discussions were held with the research assistants on how to behave professionally and appropriately when explaining the schemes of work or when administering the tests (SAT). The training of the research assistants helped to standardize the data collection procedure as it strengthened the consistency of the procedure (Muijs, 2004).

Data collection was done by the researcher and the trained research assistants. The researcher and the research assistants visited the identified secondary schools. Appointments were booked with chemistry teachers in each identified secondary school to brief them on the nature of the research and its importance. This was followed by training of teachers on how to teach the different groups. A training module which consisted of sample lesson plans and schemes of work to be followed when teaching the chosen form two topic was used. To ensure uniformity, the researcher designed, prepared and discussed with the chemistry teachers the sample lesson plans and schemes of work to be used by the selected schools. The schemes of

work used were for the topic: “Chemical Families: Patterns in Properties”. The sub-topics taught in this topic included: Alkali metals (Group I elements), Alkaline earth metals (Group II elements), Halogens (Group VII elements), Noble gases (Group O elements) and Properties and Trends across period 3.

Before the teaching began, teachers with the assistance of the research assistants were requested to administer the pre-test to the specified groups (form two classes) so as to determine the entry behavior of the learners. The pre-test was about the pre-requisites for learning the form two topic “Chemical Families: Patterns in Properties”. After the test was done, the scripts were collected and forwarded by the research assistants to the researcher for marking and recording of the scores. The researcher marked the pre-test and recorded the scores out of 40 marks. Also, the questionnaires for the teachers were administered during the time of administering the pre-test and the completed ones were collected immediately. Administration of the questionnaires before the study commenced was to ensure that the responses given by the teachers are not influenced by the study process. The immediate collection of the completed questionnaires was to ensure a higher return rate.

The teaching commenced after the administration of the pre-test and was done by the concerned chemistry teachers using the provided and discussed schemes of work. The teaching took place for five weeks while the researcher and the research assistants monitored the implementation of the schemes of work by regularly visiting the involved schools. The experimental group was taught using schemes of work containing chemistry practicals (Appendix I) while the control group was taught using schemes of work without chemistry practicals (Appendix II). During the period of study, all the form two students in the selected schools were involved in the research process. In schools with more than one stream of the form

two class, all streams were involved in the study. This was to eliminate the interaction effect where the learners may have felt that they were being observed.

After the five weeks of teaching, the teachers with the assistance of the research assistants were requested to administer the post test to both the control and the experimental groups. The immediate testing after teaching was to ensure that no new learning experience(s) interfered with the experimental condition and to ensure that learners did not forget what they had learnt. After the post test was done, the scripts were collected and forwarded by the research assistants to the researcher for marking and recording the scores. The researcher marked the post test and recorded the scores out of 40 marks. The questionnaires for the students were administered by the chemistry teachers with the help of the research assistants to the same form two students four weeks after the post test. The completed questionnaires were collected immediately to ensure a high return rate and were forwarded to the researcher for editing, organization and coding.

3.9 Data Analysis

Both quantitative and qualitative data were generated by the study. Data analysis involves scrutinizing the acquired information and making inferences (Kombo & Tromp, 2006). The student assessment tests (SAT), both the pre-test and the post test were marked and marks recorded for each respondent while the data from the questionnaires was sorted, edited and recorded. The data generated from questionnaires and student achievement tests (SAT) was ordered, coded, categorized, classified and labelled as per the themes and objectives of the study. The themes were then connected together in the form of key relationships and related to the research objectives. The Statistical Package for the Social Sciences (SPSS) programme was used to analyze the data. Descriptive statistics such as frequencies and percentages were computed

and the results presented in tables and descriptive form. Statistical tests such as ANOVA, ANCOVA, Regression, T-test and correlation were used for data analysis. These were used to address the research objectives and to test the null hypotheses of the study.

The data obtained from the students' and teachers' questionnaires was organized, coded and presented using descriptive statistics. Their analysis and discussion was done under various themes as spelt out in the study objectives and hypotheses. SPSS was used in calculating ANOVA and ANCOVA. The ANOVA and ANCOVA aim at establishing the relationship between the independent and dependent variable and so were used to test the hypotheses. The analysis of covariance (ANCOVA) was used to determine whether there was any difference in learners' performance between the group exposed to chemistry practicals and those who were not. According to Mayers (2013), ANCOVA is a useful statistical procedure which can be employed in a wide range of contexts such as: exploring pre-test vs post-test effects; filtering out error variance; and statistically controlling variables which have not been done so physically.

3.10 Ethical Considerations

Ethical standards were upheld during the research as the principles of confidentiality; anonymity and informed consent were applied. Prior to carrying out the research, the researcher sought permission from NCSTI and the concerned schools' administration. Permission was sought from the principals of the selected secondary schools involved in the study. The researcher explained to the school principals and chemistry teachers, the purpose of the study and the methods to be used to carry out the study. The research assistants were trained and instructed on the need for upholding ethical standards. Confidentiality of the respondents' identities and the protection of private information given during the study were adhered to. The identity of all the respondents and all their responses was treated with utmost anonymity. Due to

ethical issues, the learners in the control group were later taught using chemistry practicals so that they could get the same exposure.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter presents the results of the analysis, the interpretation and discussions of findings of this study. The purpose of the study was to investigate the effect of chemistry practicals on performance in chemistry among public secondary school students of Machakos and Nairobi counties in Kenya. The presentation of the results of the study was done based on the following objectives which were to: Establish whether students learning chemistry using chemistry practicals perform better than those learning without; find out the effect of nature of chemistry practicals on students' performance in secondary school chemistry; examine the effect of quality of chemistry chemistry practicals on students' performance in secondary school chemistry; determine the effect of frequency of chemistry practicals on students' performance in secondary school chemistry and to evaluate whether boys and girls exposed and those not exposed to chemistry practicals differ significantly in their average score.

The following research hypotheses had been generated for the study and were tested at a significance alpha level of 0.05. H₀₁: There is no significant difference between the post-test mean score in chemistry of students exposed to chemistry practicals and those not exposed; H₀₂: There is no significant difference in performance in chemistry of students exposed to various types of chemistry practicals and those not exposed; H₀₃: There is no significant difference in performance in chemistry of students exposed to different qualities of chemistry practicals and those not exposed; H₀₄: There is no significant difference in performance in chemistry of students exposed to differing frequencies of various types of chemistry practicals and those not

exposed; H₀₅: There is no significant difference in performance in chemistry between girls or boys exposed to chemistry practicals and those not exposed.

4.1.1 Response Rate

The study targeted a total of 790 students and 38 chemistry teachers. Table 4.1 shows the response rate of instruments used in the study.

Table 4.1
Response Rate of Instruments

| | Teachers' Questionnaires | Students' Questionnaires | Pre – Test | Post – Test |
|----------------|-----------------------------|-----------------------------|------------|-------------|
| Machakos | 20 | 419 | 423 | 420 |
| Nairobi | 14 | 316 | 311 | 315 |
| Total Returned | 34 | 735 | 734 | 735 |
| Total expected | 38 | 790 | 790 | 790 |
| % Return rate | 89% | 93% | 93% | 93% |

Table 4.1 indicates that an average of 91% of the questionnaires were returned. The respondents filled the questionnaires as the researcher waited. The return rate for the pre-test and post-test was an average of 93%. According to Mugenda and Mugenda (2003), a return rate of 70% is considered to be good enough. Therefore, this was a good representation of the sampled respondents.

4.2 Demographic Variables of the Respondents

This section presents the demographic variables of the students and chemistry teachers involved in the study. The study found it necessary to gather this information as it offered data on the sample characteristics.

4.2.1 Number of Respondents

The study sought details on the number of respondents of this study. Table 4.2 shows the results obtained.

Table 4.2

Number of Respondents

| Respondents | Gender | | | | | | Total | % |
|-------------|--------|------|--------|------|-------|------|-------|-----|
| | Male | % | Female | % | Mixed | % | | |
| Student | 184 | 25.0 | 254 | 34.6 | 297 | 40.4 | 735 | 100 |
| Teacher | 14 | 41.2 | 20 | 58.8 | - | - | 34 | 100 |

The finding in Table 4.2 indicate that there were 769 respondents out of which 95.6 % were students while 4.4 % were chemistry teachers. The study involved only form two students and the chemistry teachers in the selected public secondary schools.

4.2.2 Respondents' Group Type

The study used the quasi-experimental approach of the pre-test – post test design. The respondents were categorized as either the experimental group or the control group. The experimental group consisted of students taught using methods integrating chemistry practicals

while the control group consisted of students taught using methods without chemistry practicals.

Table 4.3 shows the data on the respondents' group type.

Table 4.3

Distribution of Respondents' Group Type

| Respondents' Group Type | Frequency | Percent |
|--------------------------------|------------------|----------------|
| Experimental | 443 | 60.3 |
| Control | 292 | 39.7 |
| Total | 769 | 100.0 |

The data presented in Table 4.3 shows that 60.3% of the respondents formed the experimental group while 39.7% the control group. The percentage of respondents in the control group is far much lower than in the experimental group. This is due to the fact that most schools did not want to participate in the study as control groups where the teaching and learning of chemistry was to take place without chemistry practicals.

4.3 Chemistry practicals and Students' Performance in Chemistry

The first objective of the study was to establish whether students learning chemistry using chemistry practicals perform better than those learning without. To achieve this objective, the study sought details on the performance of the pre-test and post test administered to all students involved in the study. The study tested first null hypothesis, H_01 , that there is no significant difference between the post-test mean score in chemistry of students exposed to chemistry practicals and those not exposed. Table 4.4 gives summary of the descriptive statistics on the pre-test and post test analysis results.

Table 4.4**Pre-test and Post Test Analysis**

| | N | Minimum score | Maximum score | Mean | Std. Deviation |
|-----------|----------|----------------------|----------------------|-------------|-----------------------|
| Pre-test | 735 | 2 | 37 | 14.04 | 5.669 |
| Post test | 735 | 4 | 38 | 15.11 | 4.574 |

From Table 4.4 the findings indicate that there was an increase of minimum and maximum scores from the pre-test scores to the post test. The findings show that the mean for the pre-test was 14.04 and the mean for post test was 15.11. The mean values indicate there was a 1.07 point improvement from the pre-test score to the post test score. This shows that chemistry practicals have a significant positive effect on learners' performance.

4.3.1 Performance of Students in Experimental and Control Groups

The study sought to test the first null hypothesis, H_01 , that there is no significant difference between the post-test mean score in chemistry of students exposed to chemistry practicals and those not exposed. Tables 4.5, 4.6 and 4.7 show the results of the study.

Table 4.5**Descriptive Statistics on Post Test Scores of Experimental and Control Groups**

| | Test type | N | Mean | Std. Deviation | Std. Error Mean |
|-----------|------------------|----------|-------------|-----------------------|------------------------|
| Post Test | Experimental | 443 | 15.73 | 4.321 | .205 |
| | Control | 292 | 14.18 | 4.791 | .280 |

Table 4.5 shows the descriptive statistics of the post test scores for both experimental and control groups. In experimental group, N=443 had a mean score of 15.73 and a standard

deviation of 4.321. In the control group, N=292 had a mean score of 14.18, and a standard deviation of 4.791. From the findings, the experimental group's mean score is higher than the control group's mean score implying that the chemistry practicals treatment had a positive effect on students' performance in chemistry.

Table 4.6 shows the results of the independent T-test on post test scores between experimental and the control groups. The test was used to decide whether to accept or reject the H_0 . That is, to determine whether there is a statistically significant difference between the means of the post tests scores of the two groups. This is because the independent-samples t-test (or independent t-test, for short) compares the means between two unrelated groups on the same continuous, dependent variable.

Table 4.6
T-Test Results on Post Test Scores between Experimental and Control Groups

| Independent T test | | T | DF | Sig. (2-tailed) | Mean Difference | Std. Error Difference |
|--------------------|-----------------------------|-------|-----|-----------------|-----------------|-----------------------|
| Post Test | Equal variances not assumed | 4.470 | 577 | .000 | 1.553 | .348 |

Table 4.6 shows the results of the independent T-test on post test scores between experimental and the control groups. Assuming unequal variances, the findings show that the t-value is 4.47 with degrees of freedom of 577. The two-tailed p value associated with the test is 0.000. From the decision rule that: If $p \leq \alpha$, then reject H_0 , then in this analysis $p < .05$, so we reject H_0 . This implies that there is a significant difference between the post test mean score in chemistry of students exposed to chemistry practicals and those not exposed.

Table 4.7 shows analysis of covariance (ANCOVA) for the post test scores of the experimental and control groups. This analysis helped in testing the null hypothesis, H_0 , that

there is no significant difference between the post-test mean score in chemistry of students exposed to chemistry practicals and those not so exposed.

Table 4.7

The ANCOVA Results of the Post Test Scores of the Experimental and Control Groups

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. |
|--------------------|----------------------------|----|----------------|---------|------|
| Corrected Model | 10040.888 ^a | 1 | 10040.888 | 492.907 | .000 |

Results in Table 4.7 indicate that, $F = 492.91$ and $p = 0.00$. From the decision rule that: If $p \leq \alpha$, then reject H_0 , then in this analysis $p < 0.05$, meaning that we reject the null hypothesis (H_0), that there is no relationship between post test scores and experimental or control groups meaning that there is a significant difference between the post test scores of experimental and control groups. These findings imply that the use of chemistry practicals had a significant influence in the performance of chemistry at the secondary school level.

In order to find out if treatment had any effect on the overall results, the data for the pre-test between the experimental and the control groups was analyzed and presented in Tables 4.8, 4.9 and 4.10.

Table 4.8**Descriptive Statistics on Pre-Test Scores of Experimental and Control Groups**

| | Test type | N | Mean | Std. Deviation | Std. Error Mean |
|----------|--------------|-----|-------|----------------|-----------------|
| Pre Test | Experimental | 443 | 13.39 | 5.960 | .283 |
| | Control | 292 | 13.45 | 5.047 | .295 |

Table 4.8 shows the descriptive statistics for both experimental and control group. In the experimental group, the mean is 13.39 while the control group the mean is 13.45. From these findings, the groups' mean score are almost equal (a difference of 0.06) implying that the two groups of students were similar in chemistry achievement before the treatment was done.

Table 4.9 shows the results of the independent T-test on pre-test scores between experimental and the control groups. The test was used to decide whether to accept or reject the H_0 . That is, to determine whether there is a statistically significant difference between the means of the pre- test scores of the two groups.

Table 4.9**T-Test Results on Pre-Test Scores between Experimental and Control Groups**

| Independent T test | T | DF | Sig. (2-tailed) | Mean Difference | Std. Error Difference |
|---------------------------------------|-------|-----|-----------------|-----------------|-----------------------|
| Pre- Test Equal variances not assumed | 4.017 | 688 | .170 | 0.140 | .409 |

Table 4.9 shows that the t value is 4.02 with degrees of freedom of 688. The two-tailed p value associated with the test is 0.17. From the decision rule that: If $p \leq \alpha$, then reject H_0 , then in this analysis, 0.17 is greater than 0.05, so we accept H_0 . This implies that there is no significant

difference between the pre-test mean scores in chemistry of students exposed to chemistry practicals and those not exposed.

Table 4.10 shows analysis of covariance (ANCOVA) for the pre-test scores of the experimental and control groups. This analysis helped in finding out whether there was any significant difference between the pre-test mean score in chemistry of students exposed to chemistry practicals and those not so exposed.

Table 4.10

The ANCOVA Results of the Pre-Test Scores of the Experimental and Control Groups

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. |
|-----------------|-------------------------|----|-------------|------|------|
| Corrected Model | 15.669 ^a | 1 | 15.669 | .461 | .170 |

Results in Table 4.10 indicate that, $F = 0.46$ and $p = 0.17$ meaning that we accept the null hypothesis H_0 , that there is no significant difference between experimental and control mean for pretest. Therefore, there is no relationship between pre-test marks and experimental or control groups. The pretest was done before treatment was given. This means that either group had the same chance of performing well if they had been exposed to similar learning environments and conditions, hence the lack of relationship between the experimental and control groups and the pre-test scores. The ANCOVA results show that the difference in the post test was indeed due to the treatment and not by other variables.

4.4 Nature of Chemistry Practicals and Students' Performance in Chemistry

The second objective of the study was to find out the effect of nature of chemistry practicals on students' performance in secondary school chemistry. To achieve this objective,

this section described the nature of chemistry practicals implemented by chemistry teachers and their effect on students' performance in secondary school chemistry and also examined the effect of the nature of chemistry practicals on students' performance in secondary school chemistry. There are certain factors which correlate with the nature of chemistry practicals undertaken in secondary schools and have a bearing on students' performance in chemistry. According to Hattingh, Aldous and Rogan (2007), these factors are based on the characteristics of the students such as students' discipline, academic ability, students' attitude and some on the capacity of the schools. The findings on these factors are presented in the following sub-sections:

4.4.1 Students' Discipline

Effective discipline is needed in school for good academic achievement. A school without effective discipline is unmanageable and often results in unmotivated and demoralized teachers and learners. The study sought details on respondents' discipline. The respondents were requested to rate the level of discipline among the students in their class. The responses were rated on a five point Likert type scale where 1= very undisciplined 2= undisciplined 3= not sure 4= disciplined and 5= very disciplined. The results are shown in the Figure 2.

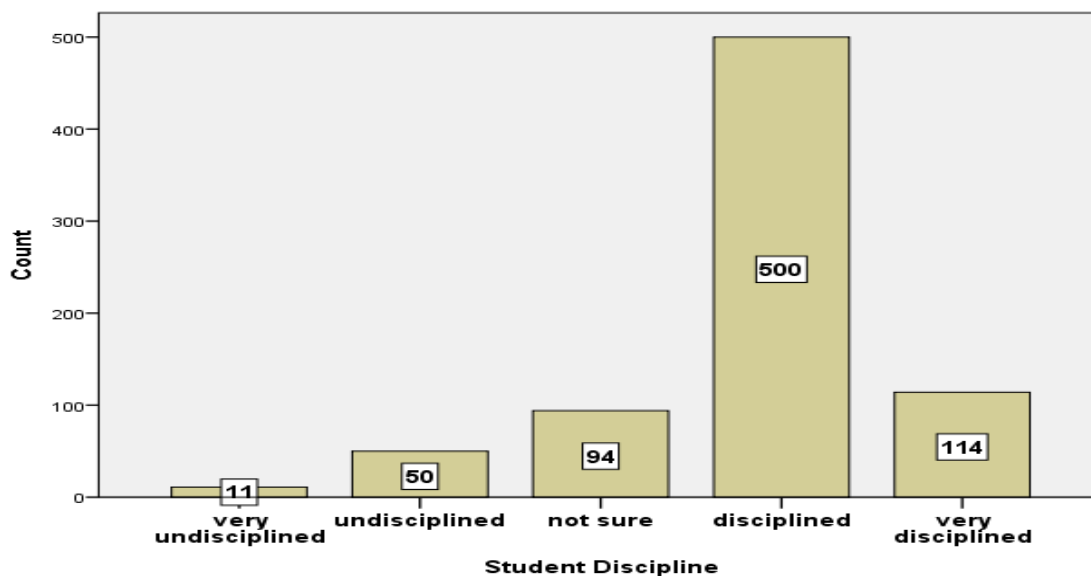


Figure 2 Discipline levels among Students

The results shown in Figure 2 indicate that most students, 65 % (N=500) were disciplined, only 22.8 % (N=141) indicated being undisciplined while 12.2% (N=94) were not sure. Effective discipline is important for maintaining a positive atmosphere in the classroom and supporting students' learning. When there is effective discipline in a school and in the classroom, effective teaching and learning takes place. The learners need order in the classroom if the activities, which take place, are to facilitate effective learning. A study by Khuluse (2009) showed that classroom management is a necessary condition for effective student learning and that discipline has a major effect on academic achievement in secondary schools.

4.4.2 Students' Rating on Various Academic Abilities

The study sought details on the rating of various academic characteristics by teachers and students themselves. The rating involved the following students' academic characteristics: Academic ability, Academic ability in sciences, academic ability in chemistry and ability in

chemistry practicals. The responses were rated on a five point Likert scale where 1= very low 2= low 3= average 4= high and 5= very high. Table 4.11 gives the summary of the findings.

Table 4.11

Rating of the Various Students' Academic Characteristics

| Student's rating in terms of the following academic characteristics | | very Low | Low | Average | High | very High |
|---|-----------|----------|------|---------|------|-----------|
| Academic ability | Frequency | 30 | 42 | 370 | 219 | 108 |
| | Percent | 3.9 | 5.5 | 48.1 | 28.5 | 14.0 |
| Academic ability in sciences | Frequency | 30 | 140 | 393 | 144 | 62 |
| | Percent | 3.9 | 18.2 | 51.1 | 18.7 | 8.1 |
| Academic ability in chemistry | Frequency | 68 | 192 | 305 | 135 | 69 |
| | Percent | 8.8 | 25.0 | 39.7 | 17.6 | 9.0 |
| Ability in chemistry practicals | Frequency | 67 | 120 | 301 | 167 | 114 |
| | Percent | 8.7 | 15.6 | 39.1 | 21.7 | 14.8 |

The results indicated in Table 4.11 show the ratings of various students' academic characteristics. The findings indicate that majority of students were average: in academic ability (48.1 %); in academic ability in sciences (51.1 %); on students' academic ability in chemistry (39.7 %); and in chemistry practicals ability (39.1 %). These findings indicate the students were of average ability implying that chemistry practicals can easily be introduced during the teaching of chemistry and that may help in improving performance. This implies that practicals can be used to teach the learners how to follow simple instructions which is important in developing basic science process skills like: measuring, observation and recording.

4.4.3 Students' Attitude towards Various Activities in Chemistry

The study sought to find out the attitude of students towards various activities in chemistry. The responses by students and the chemistry teachers were rated using the Likert scale and the findings presented in Table 4.12.

Table 4.12

Nature of Students' Attitude towards Various Aspects of Chemistry

| Student's attitude towards various aspects of chemistry | | Negative | Not Sure | Positive |
|---|-----------|----------|----------|----------|
| Science subjects | Frequency | 106 | 375 | 288 |
| | Percent | 13.8 | 48.8 | 37.4 |
| Chemistry subject | Frequency | 196 | 289 | 284 |
| | Percent | 25.5 | 37.6 | 37 |
| Chemistry assignments | Frequency | 144 | 259 | 366 |
| | Percent | 18.7 | 33.7 | 47.6 |
| Chemistry practicals | Frequency | 154 | 249 | 366 |
| | Percent | 20.0 | 32.4 | 47.6 |
| Chemistry theory lessons | Frequency | 136 | 247 | 386 |
| | Percent | 17.7 | 32.1 | 50.2 |

The information in table 4.12 shows the kind of attitude the students have towards various aspects of chemistry learning. The findings indicate that most students had a positive attitude in: chemistry subject (37%); chemistry assignment (47.6%); chemistry practicals (47.6%); and chemistry theory lessons (50.2%), while the majority of the students were not sure of their attitude towards science. The situation of not being sure about attitude towards science could be attributed to inclusion of other science subjects such as Physics and Biology in the term science subjects.

The findings that secondary school students' have a positive attitude towards chemistry implies that the students can easily be moulded by a chemistry teacher. The implication of this study suggests that teachers need to be far more aware that students' attitudes to chemistry practicals need to be considered and utilized. According to Sharpe (2012), the classroom climate established by the teacher can have a major impact on learners' motivation and attitude towards learning and ultimately to performance in the subject. The teacher can use chemistry practicals as a means of improving student attitude toward chemistry and to increase student achievement levels in chemistry.

4.4.4 Students' Rating of Various Aspects of Chemistry Practical

The study evaluated students' rating in terms of individual characteristics that are related to various aspects of chemistry practicals. The aspects evaluated include: making accurate observations; interest in doing investigations; using theory when doing investigations; keeping neat and accurate records; ability to make interpretations and predictions; eagerness to investigate after school and eagerness to relate observations to theory work. The responses were evaluated using a Likert type scale. The frequency and percentage of the responses were computed and the values presented in Tables 4.13.

Table 4.13**Students' Rating of Various Aspects of Chemistry Practicals**

| Student's rating of various aspects of chemistry practicals | | very weak | Weak | Average | Strong | very strong |
|--|-----------|------------------|-------------|----------------|---------------|--------------------|
| Making accurate observations | Frequency | 45 | 92 | 358 | 174 | 100 |
| | Percent | 5.9 | 12.0 | 46.6 | 22.6 | 13.0 |
| Interest in doing investigation | Frequency | 77 | 125 | 258 | 221 | 88 |
| | Percent | 10.0 | 16.3 | 33.6 | 28.7 | 11.4 |
| Using theory when doing investigations | Frequency | 72 | 147 | 281 | 179 | 90 |
| | Percent | 9.4 | 19.1 | 36.5 | 23.3 | 11.7 |
| Keeping neat and accurate records | Frequency | 51 | 103 | 259 | 221 | 135 |
| | Percent | 6.6 | 13.4 | 33.7 | 28.7 | 17.6 |
| Ability to make accurate interpretation and predictions | Frequency | 55 | 170 | 309 | 155 | 80 |
| | Percent | 7.2 | 22.1 | 40.2 | 20.2 | 10.4 |
| Eagerness to investigate after school | Frequency | 118 | 138 | 181 | 149 | 183 |
| | Percent | 15.3 | 17.9 | 23.5 | 19.4 | 23.8 |
| Eagerness to relate observations to theory work | Frequency | 80 | 118 | 295 | 155 | 121 |
| | Percent | 10.4 | 15.3 | 38.4 | 20.2 | 15.7 |

The information contained in Tables 4.13 shows the ratings of students' individual abilities/characteristics related to various aspects of chemistry practicals. From the findings, it can be noted that the majority of students were of average ability in making accurate observations (46.6%), doing investigations (36.6%) and in making accurate interpretation and predictions (40.2%). The results show that the majority of students indicated average ability in using theory when doing investigations (36.5%), and in keeping neat and accurate records (33.7%), while majority of teachers found them weak in these abilities and having low eagerness

to investigate after school. The described abilities in table 4.13 are quite important basic science process skills. Teaching of science involves learners experiencing the basic and integrated processes of science (Abrahams & Millar, 2008). Research has established that achievement and skills improved when students are taught science using practicals (Watts, 2013). In science, learners do practical work to expand their knowledge in order to understand the world around them. Teachers should ensure that all these abilities are developed by learners during the learning of chemistry so that chemistry practicals become helpful in improving performance in chemistry.

4.4.5 Perspectives on Various Effects of Secondary School Chemistry Practical

The researcher requested the respondents to provide information about their rating of various effects of teaching and learning using chemistry practicals in secondary school chemistry. The effects evaluated include: chemistry practicals increases understanding; chemistry practicals increases enjoyment; pressure to cover syllabus is an obstacle to chemistry practicals; pressure on teachers to ensure good grades is an obstacle to chemistry practicals; chemistry practicals increases achievement of good grades; chemistry practicals reduces syllabus coverage; chemistry practicals is humdrum (monotonous) and routine, rather than engaging or inspiring; chemistry practicals is a drill and a practice only for passing examinations; teachers' work load is an obstacle to chemistry practicals and large numbers of students is an obstacle to chemistry practicals. The responses were rated using a Likert scale, and the findings are shown in Table 4.14

Table 4.14**Students' Rating of Some Effects of Chemistry Practicals**

| Rating of the Following effects of Chemistry practicals | | Disagree | Not Sure | Agree |
|--|-----------|-----------------|-----------------|--------------|
| Chemistry practicals increase understanding | Frequency | 77 | 54 | 638 |
| | Percent | 10 | 7.0 | 83.0 |
| Chemistry practicals increase enjoyment | Frequency | 142 | 97 | 530 |
| | Percent | 18.4 | 12.6 | 68.9 |
| Pressure to cover syllabus is an obstacle to chemistry practicals | Frequency | 428 | 113 | 228 |
| | Percent | 55.6 | 14.7 | 29.7 |
| Pressure on teachers to ensure good grades is an obstacle to chemistry practicals | Frequency | 253 | 163 | 253 |
| | Percent | 45.9 | 21.2 | 32.9 |
| Chemistry practicals increase achievement of good grades | Frequency | 109 | 71 | 559 |
| | Percent | 14.2 | 9.2 | 76.6 |
| Chemistry practicals reduce syllabus coverage | Frequency | 418 | 156 | 195 |
| | Percent | 54.3 | 20.3 | 25.4 |
| Chemistry practicals is monotonous and routine, rather than engaging or inspiring. | Frequency | 394 | 204 | 171 |
| | Percent | 51.2 | 26.5 | 22.2 |
| Chemistry practicals are drills and practices only for passing examinations | Frequency | 401 | 126 | 242 |
| | Percent | 52.1 | 16.4 | 31.5 |
| Teachers' work load is an obstacle to chemistry practicals | Frequency | 472 | 93 | 204 |
| | Percent | 61.4 | 12.1 | 26.5 |
| Large numbers of students is an obstacle to chemistry practicals | Frequency | 313 | 113 | 343 |
| | Percent | 40.7 | 14.7 | 44.6 |

The information contained in Table 4.14 shows the findings of some of the effects of chemistry practicals on learning and teaching of secondary school chemistry. The findings show that most respondents (83.0%) agreed that chemistry practicals increase understanding while 68.9% agreed that chemistry practicals increase achievement of good grades. These findings concur with the report by Lerman (2014) who says, methods which include practicals help students to remember and understand abstract scientific concepts.

Most (51.2%) of the respondents disagreed that chemistry practicals are monotonous and routine, rather than engaging or inspiring. This implies that most students find chemistry practicals exciting a fact which teachers can exploit to plan and increase the frequency of chemistry practicals. On whether chemistry practicals increases enjoyment, a majority (68.9 %) agreed. This is in agreement with the findings by Hofstein (2004), who reported that teaching science with the help of chemistry practicals makes it more enjoyable and stimulating to students than teaching the same subject matter only through chalk and talk.

The findings on whether pressure to cover syllabus is an obstacle to chemistry practicals, a majority of chemistry teachers agreed. On whether pressure on teachers to ensure good grades in chemistry is an obstacle to chemistry practicals, a majority of respondents (76.6%) agreed. For the observation that chemistry practicals reduces syllabus coverage, a majority of chemistry teachers agreed. These findings are in agreement with the report by Ofsted (2005) that the volume and variety of chemistry practicals in schools has lessened over time. In many situations, the cause of this is the focus on 'teaching for examination', which has squeezed out some types of chemistry practicals. Many teachers complain that, with pressure to get through the syllabus, they cannot find room for many chemistry practicals (Dillon, 2008). Dillon continues to state that

teachers are being required to achieve better examination results and one response to this has been to focus more on ‘book learning’ which is more easily managed than chemistry practicals.

On whether chemistry practicals is a drill and a practice only for passing examinations, a majority (52.1%) of respondents disagreed and on the issue of whether teachers’ work load is an obstacle to chemistry practicals, majority (61.4%) of respondents disagreed. Finally on whether large numbers of students is an obstacle to chemistry practicals, a majority of chemistry teachers agreed. These findings confirm the observations and findings made by other researchers.

Pavesic (2008) reported that students have a lot to benefit from chemistry practicals which may include, increasing students’ interest and abilities in science subjects as well as their achievement in science. According to Adane & Adams (2011), laboratory experiments are characteristic features of science teaching at all levels of education. Demonstrations by instructors are also be used as an option to support theories and lectures given in classrooms in institutions without adequate facilities to let students do the experiments by themselves (McKee, 2007). However, as stated by Tobin (1990) and Ikeobi (2004), meaningful learning is possible from a given laboratory experiments if the students are given ample opportunities to operate equipment and materials that help them to construct their knowledge of phenomena and related scientific concepts.

4.4.6 Types of Chemistry practicals

There are two main ways of performing chemistry practicals. These are: demonstration experiments and class experiments. Demonstration experiments are those that are performed by the teacher as students observe. The demonstration can be performed in the laboratory, classroom or outside the classroom. The teacher performs a demonstration using bought or

improvised apparatus. The demonstrations can be performed with or without learner participation and are used to illustrate concepts and to promote inquiry (Sharpe, 2012). Class experiments are those experiments where the students perform the practical activities, make and record the observations themselves. In this type, learners perform chemistry practicals either as individuals or in groups using the provided apparatus and are told what to do, either by the teacher or a worksheet.

The study sought to test second hypothesis, H_02 , that there is no significant difference in performance in chemistry of students exposed to various types of chemistry practicals and those not exposed by finding out how often each of these two types of chemistry practicals was used during the teaching and learning of chemistry. In the study, the respondents were requested to estimate how frequently each of the two types of chemistry practicals was adopted during the teaching and learning of chemistry. The findings are shown in Table 4.15.

Table 4.15

Rating on the Usage of Demonstration and Class Experiment Types of Lessons

| Usage of various types of chemistry practicals | | Never | Occasionally | Frequently | very frequently |
|--|---|-------|--------------|------------|-----------------|
| | | | | | |
| Demonstration experiment | N | 187 | 296 | 199 | 87 |
| | % | 24.3 | 38.5 | 25.9 | 11.3 |
| Class Experiment | N | 433 | 153 | 128 | 55 |
| | % | 56.3 | 19.9 | 16.6 | 7.2 |

The results indicated in Table 4.15 shows the findings of how frequently each of the two types of chemistry practicals was adopted during the teaching and learning of chemistry. The findings indicate that most respondents (38.5%) indicated that they occasionally adopted demonstration experiment type of practical activity. On class experiment type of practical

activity, the majority (43.4 %) of respondents indicated never, implying that the teaching and learning of chemistry in secondary schools done either through teacher demonstration type of chemistry practicals or other methods such as chalk and talk which do not involve practical work. Practical work caters for learning in different ways such as experiential, independent, team and peer dialogue (Abram & Millar, 2008).

4.4.7 Effect of Types of Chemistry practicals on Students' Performance in Secondary School Chemistry

In achieving the second objective, that is, to find out the effect of nature of chemistry practicals on students' performance in secondary school chemistry, the study tested the second hypothesis, H₀₂, that there is no significant difference in performance in chemistry of students exposed to various types of chemistry practicals and those not exposed. The study sought to determine the effect of types of chemistry practicals on students' performance in secondary school chemistry. Table 4.16 shows the coefficients analysis results.

Table 4.16

Coefficients Analysis on Effect of Types and Quantity of Chemistry Practical on Post Test Scores

| Coefficients | | | |
|-------------------------------|----------------------------------|----------|-------------|
| Model | Standardized Coefficients | T | Sig. |
| (Constant) | | 16.552 | .000 |
| Class experiment lesson | .316 | 23.54 | .000 |
| teacher demonstrations lesson | .057 | 1.74 | .000 |

a. Dependent Variable: Post Test

Table 4.16 shows individual predictors variables, standardized coefficients, T-value and significance of the two types of chemistry practical lessons. On chemistry lessons involving student chemistry practicals (class experiment) lesson, the table shows that a T-value of 23.54 is significant at .000 which is less than .05 (or 95% confidence level). The null hypothesis is therefore rejected, implying that the student chemistry practicals (class experiments) significantly predict the post test grade. Finally on chemistry lessons involving teacher demonstrations, the table shows that a T-value of 1.74 is significant at .000 which is less than .05 (or 95% confidence level). The null hypothesis is therefore rejected. This implies that the teacher demonstration significantly predicts the post test grade. Therefore, various types of chemistry practical lessons of chemistry play a significant role of determining students' performance.

The second hypothesis, H_02 , was also tested using ANOVA analysis and the results are shown in Table 4.17

Table 4.17

ANOVA Results on Effect of Exposure to Various Types of Chemistry Practical Lessons

| ANOVA | Sum of Squares | Df | Mean Square | F | Sig. |
|--------------|-----------------------|-----------|--------------------|----------|-------------|
| Regression | 46.604 | 2 | 15.535 | 74.2 | .000 |

a. Dependent Variable: Post Test

b. Predictors: (Constant): teacher demonstrations; student chemistry practicals (class experiments)

The output of the ANOVA in Table 4.17 shows the results for the effect of exposure to various types of chemistry practical lessons. This was to test the null hypothesis, H_02 , that there was no significant difference in performance in chemistry of students exposed to various types of chemistry practicals and those not exposed.

A large F value of 74.2 and a significance of $0.000 < 0.05$ makes us to reject the null hypothesis and conclude that exposure to various types of chemistry practicals of chemistry had a significant effect on students' performance. Different teachers use different types of practical work. Kibirige, Maake, and Mavhunga, (2014) argue that different types of practical work achieve different purposes. There is practical work to achieve basic skills like: measuring, observation and recording, while investigative skills include analysis and drawing inferences. The selection of the types of practical work requires that teachers know which practical applies to what concept. It also suggests that teachers should have a tacit knowledge of how to do the practical work themselves. Pre-service and in-service teacher training institutions should inculcate practical skills, confidence and positive attitudes towards practical work when training chemistry teachers.

4.5 Quality of Chemistry Practicals Used in Teaching and Learning Chemistry

The third objective aimed at examining the effect of quality of chemistry practicals on students' performance in secondary school chemistry. To achieve this objective, the study tested the third null hypothesis, H_{03} , that there is no significant difference in performance in chemistry of students exposed to different qualities of chemistry practicals and those not exposed and explored factors which correlate with the quality of chemistry practicals undertaken in secondary schools. These factors are derived from a framework of curriculum implementation proposed by Rogan and Grayson (2003) and are based on the capacity of the school. Some of these factors include, types and quantity of chemistry practicals employed in teaching and learning chemistry, and adequacy of teaching and learning resources in the schools. The information on these factors is presented in the following sub-sections:

4.5.1 Types and Quantity of Chemistry Practicals

The study sought to establish the types and quantity of the various types of chemistry practicals adopted while teaching and learning chemistry. Hence, the study evaluated how the respondents rated the quantity of the various types of chemistry practicals in terms of percentage of time spent during the teaching and learning of chemistry. This was to find out what percentage of chemistry lessons was each of the following types of chemistry practicals: chemistry lessons, is chemistry practicals; chemistry lessons, is student chemistry practicals and chemistry lessons, is teacher demonstrations. The respondents were asked to estimate what percentage of their learning time was allocated to chemistry practicals and the responses were evaluated using the Likert scale. Table 4.18 gives a summary of the findings.

Table 4.18

Students' Perspective on Types and Quantity of Chemistry Practical Used

| Percentage of time of chemistry lessons is the following type | | No time | A little time | Half the time | Most of the time | All the time |
|--|-----------|----------------|----------------------|----------------------|-------------------------|---------------------|
| Chemistry lessons is student practicals | Frequency | 0 | 49 | 124 | 339 | 257 |
| | Percent | 0 | 6.4 | 16.1 | 44.1 | 33.4 |
| Chemistry lessons is teacher demonstrations | Frequency | 42 | 198 | 187 | 309 | 33 |
| | Percent | 5.5 | 25.7 | 24.3 | 40.2 | 4.3 |

The results in Table 4.18 show the findings on quantity and types of chemistry practicals employed in the teaching and learning of chemistry in public secondary schools. The findings indicate that chemistry teaching and learning employed practical work in most of the lessons as shown by (44.1%) students practicals and (40.2%) teacher demonstrations. The findings also indicate no time ever is spent in teaching of chemistry without student practicals (0%). This is anomalous especially considering the time tables and laboratory facilities in secondary schools.

4.5.2 Adequacy of Chemistry Teaching and Learning Resources

The study involved the students and the chemistry teachers to evaluate the adequacy of chemistry teaching and learning resources in secondary schools. The aspects evaluated include: adequate chemistry Laboratory/s (Space and equipment); adequate chemistry apparatus and reagents; adequate relevant chemistry textbooks; adequate qualified chemistry teachers; adequate Time for teaching chemistry; and adequate time for chemistry practicals. The responses were evaluated using a five point Likert type scale. The findings are presented in Table 4.19

Table 4.19

Adequacy of Teaching and Learning Resources in the School

| Teaching and Learning Resources in the School | | Disagree | Not Sure | Agree |
|--|-----------|-----------------|-----------------|--------------|
| Adequate chemistry Laboratory/s (Space & equipment) | Frequency | 206 | 80 | 483 |
| | Percent | 26.5 | 10.4 | 62.8 |
| Adequate chemistry apparatus & reagents | Frequency | 128 | 103 | 538 |
| | Percent | 16.6 | 13.4 | 70.0 |
| Adequate relevant chemistry textbooks | Frequency | 243 | 138 | 388 |
| | Percent | 31.6 | 17.9 | 50.4 |
| Adequate Qualified chemistry teachers | Frequency | 123 | 82 | 564 |
| | Percent | 16.0 | 10.7 | 73.4 |
| Adequate Time for teaching chemistry | Frequency | 135 | 98 | 536 |
| | Percent | 17.6 | 12.7 | 69.7 |
| Adequate Time for chemistry practicals | Frequency | 248 | 117 | 404 |
| | Percent | 32.2 | 15.2 | 52.5 |

The information contained in Table 4.19 show the findings on the adequacy of chemistry teaching and learning resources in public secondary schools. The findings indicate that chemistry teaching and learning resources in public secondary schools are adequate. The percentages are as follows: Adequate chemistry laboratory/s (Space & equipment) 62.8%; adequate chemistry apparatus & reagents (70.0%); adequate relevant chemistry textbooks (50.4%); adequate qualified chemistry teachers (73.4%); adequate time for teaching chemistry (69.7%) and adequate time for chemistry practicals (52.5%). These findings show that most secondary schools were adequately equipped for chemistry practicals. This implies that chemistry practicals can be used as a chemistry teaching and learning method in Kenyan public secondary schools.

Ofsted, (2005) reports that, in secondary schools where the provision of science resources is less than satisfactory. This hinders teaching and learning of chemistry in a number of ways: (i) learners are not taught in specialist rooms, (ii) learners miss opportunities to investigate and engage in chemistry practicals or are reduced and so the effectiveness of chemistry teaching diminishes, and (iii) timetabling difficulties arise which make the sequence and frequency of chemistry practicals and learning more difficult to manage. All these affect performance in the subject negatively.

To achieve the third objective, the study tested the third null hypothesis, H_03 , that there is no significant difference in performance in chemistry of students exposed to different qualities of chemistry practicals and those not exposed and explored factors which correlate with the quality of chemistry practicals undertaken in secondary schools. The study used ANCOVA analysis to show the effect of quantity and types of chemistry practical lessons in secondary schools on performance. The results are presented in Table 4.20.

Table 4.20**ANCOVA Analysis Results on the Effects of the Types and Quantity of Chemistry Practicals on Performance**

| Tests of Between-Subjects Effects | | | | | | |
|--|-------------------------|-----|-------------|---------|------|--|
| Dependent Variable: Post Test | | | | | | |
| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. | |
| Corrected Model | 46.884 ^a | 2 | 15.628 | .746 | .525 | |
| Intercept | 5727.721 | 1 | 5727.721 | 273.488 | .000 | |
| student chemistry practicals Percentage | 2.634 | 1 | 2.634 | 12.6 | .000 | |
| teacher demonstrations Percentage | .917 | 1 | .917 | 4.4 | .001 | |
| Error | 15309.516 | 731 | 20.943 | | | |
| Total | 183261.000 | 735 | | | | |
| Corrected Total | 15356.400 | 734 | | | | |

a. R Squared = .003 (Adjusted R Squared = -.001)

Results in Table 4.20 indicate that, the first covariate, student chemistry practicals (class experiment lessons) percentage, has a significant *F* statistic (12.6) as can be seen from its associated significance level (.000). The second covariate, teacher demonstrations chemistry lessons percentage, also has a significant *F* statistic (4.4) as can be seen from its associated significance level (.001). In both cases, the results indicate that the values of the dependent variable, post test, increases as the values of the covariates increase.

From the results in Table 4.20, the third of the study objective which aimed at examining the effect of quality of chemistry chemistry practicals on students' performance in secondary school chemistry is achieved since the results indicate that there is a linear relationship between covariates and the dependent variable, the post test. This is contrary to the null hypothesis (H_03) which stated that there was no significant difference in performance in chemistry of students exposed to various types of chemistry practicals and those not exposed. This is in agreement with

Pavesic (2008) who stated that students have a lot to benefit from chemistry practicals. The benefits may include increasing students' interest and abilities in science subjects as well as their achievement in science.

The study also explored factors which correlate with the quality of chemistry practicals undertaken in secondary schools. Laboratory experiments are characteristic features of science teaching at all levels of education (Adane & Adams, 2011). Demonstrations by instructors are also used as an option to support theories and lectures given in classrooms in institutions without adequate facilities (McKee, 2007). However, as stated by Tobin (1990) and Ikeobi (2004), meaningful learning is possible from a given laboratory experiments if the students are given ample opportunities to operate equipment and materials that help them to construct their knowledge of phenomena and related scientific concepts.

4.6 Frequency of Chemistry Practical and Students' Performance

The fourth objective aimed at determining the effect of frequency of chemistry practicals on students' performance in secondary school chemistry. To achieve this objective, the study sought to find out the effects of frequency of adopting various types of chemistry practical lessons in chemistry on the performance of students. The study was also used to test the null hypothesis, H_04 , that there is no significant difference in performance in chemistry of students exposed to differing frequencies of various types of chemistry practicals and those not exposed.

4.6.1 Frequency of the Various Types of Chemistry Practical Lessons

This objective sought to establish the types and frequency of the various types of chemistry practicals adopted while teaching and learning chemistry. The types of chemistry

practicals lessons evaluated included: discussion only; demonstration experiment only; demonstration experiment and discussion; demonstration experiment in the classroom; class experiment of 1 or 2 students per group and class experiment of >5 students per group. Respondents were asked to estimate the percentage of their lesson time that was allocated to various types of chemistry practicals lessons. The responses were rated on a five point Likert Scale and the results shown in Table 4.21.

Table 4.21

Frequency of Adopting Various Types of Chemistry Practicals in Chemistry Learning

| Frequency of adopting the following teaching strategies while teaching chemistry | | don't know | Never | occasionally | Frequently | very frequently |
|---|-----------|-------------------|--------------|---------------------|-------------------|------------------------|
| Demonstration experiment only | Frequency | 51 | 136 | 296 | 199 | 87 |
| | Percent | 6.6 | 17.7 | 38.5 | 25.9 | 11.3 |
| Demonstration experiment and discussion | Frequency | 49 | 106 | 224 | 239 | 151 |
| | Percent | 6.4 | 13.8 | 29.1 | 31.1 | 19.6 |
| Demonstration experiment in the classroom | Frequency | 62 | 157 | 298 | 185 | 67 |
| | Percent | 8.1 | 20.4 | 38.8 | 24.1 | 8.7 |
| Small group class experiment lesson | Frequency | 99 | 334 | 153 | 128 | 55 |
| | Percent | 12.9 | 43.4 | 19.9 | 16.6 | 7.2 |
| Large group class experiment lesson | Frequency | 87 | 199 | 166 | 165 | 152 |
| | Percent | 11.3 | 25.9 | 21.6 | 21.5 | 19.8 |

The information contained in Table 4.21 indicates the frequency of adopting various types of chemistry practicals during learning and teaching of secondary school chemistry. The findings indicate that most (38.5 %) of respondents indicated that demonstration experiment only type of

chemistry practicals, was adopted occasionally, while 31.1% (most) of respondents indicated that demonstration experiment and discussion type of practical activity, was adopted frequently. The findings also indicate that most (38.8 %) of respondents adopted demonstration experiment in the classroom type of practical activity occasionally. 43.4% (most) of respondents indicated that adopted small group class experiment lesson was never adopted and most (25.9 %) of the respondents reported that large group class experiment lesson was never adopted.

From these findings demonstrations type of lessons where the learners mainly observe as the teacher executes the demonstration is used more frequently than class experiment type of lessons. A teacher uses classroom demonstrations to help develop concepts by using available equipment, apparatus and reagents to illustrate lessons. This appears to be in line with the report by Sharpe (2012) that the chemistry practicals that is performed has strong emphasis on teacher-led demonstrations, primarily for the illustration of particular concepts, however, the approach was found to be far from being perfect in engaging students in learning science through chemistry practicals.

Ideally, small group class experiment is most suitable whereby the teacher designs chemistry practicals in such a way as to encourage learner discovery of information. In this type of chemistry practicals type of lesson, the learners perform guided experiments in small groups engaging in hands-on activities. Learners then write a scientific report in which they justify their conclusions based on the data collected. Abrahams (2011) argue that students learn so much more by actually doing it than by just being told or even watching it being done. Science practicals are quite efficient in creating new images of a particular subject and by doing things, you are likely to remember (Abrahams, 2011). However, the quality of the practical activity is a

big concern as it determines the images created during learning process and ultimately performance in the subject.

4.6.2 Effects of Frequency of Exposure to Various Types of Chemistry practicals

This section sought to test the null hypothesis H_0 , that there is no significant difference in performance in chemistry of students exposed to differing frequencies of various types of chemistry practicals and those not exposed. The performance of students and the frequencies of various types of chemistry practicals were evaluated using regression, ANOVA, coefficients and ANCOVA analyses. Tables 4.22, 4.23, 4.24 and 4.25 below show the findings for the regression, ANOVA, coefficients and ANCOVA analyses respectively.

Table 4.22

Regression Analysis Results of Effect of Frequency of Exposure to Various Types of Chemistry Practical on Post Test Scores

| Model | R | R Square | Adjusted Square | R Std. Error of the Estimate |
|--------------|----------|-----------------|------------------------|-------------------------------------|
| 1 | .504 | .254 | .003 | 4.568 |

a. Predictors: (Constant), Large group class experiment frequency, Demonstration experiment in the classroom frequency, Demonstration experiment and discussion frequency, Demonstration experiment only frequency, Small group class experiment frequency

The information shown in Table 4.22 indicates the quantity of variance that is explained by the predictor variables. The first statistic, R , is the multiple correlation coefficients between all of the predictor variables and the dependent variable (post test). The value .504 indicates that there is quite a variance shared by the independent variables and the dependent variables. Multiple stepwise regression is a procedure that determines which set of independent variables

best correlates with the dependent variable, in this case the post test scores. The higher the R-squared, the greater the relationship between the set of independent variables and the dependent variable. In this analysis, the value is .254, which indicates that 25.4% of the variance in the dependent variable is explained by the independent variables in the analysis. Using multiple regression analysis for the hypothesis, the results show that the frequency of practical lessons shown had a significant contribution to the post test. That is, the overall relationship between frequencies of various types of chemistry practicals lessons and post test was significant.

Table 4.23

ANOVA Results of Effect Of Frequency Of Various Types Of Chemistry Practical On Post Test Scores

| ANOVA ^a | Sum of Squares | Df | Mean Square | F | Sig. |
|--------------------|----------------|-----|-------------|-------|------|
| Regression | 166.140 | 6 | 27.690 | 132.7 | .000 |
| Residual | 15190.260 | 728 | 20.866 | | |
| Total | 15356.400 | 734 | | | |

a. Dependent Variable: Post Test

b. Predictors: (Constant), Large group class experiment, Demonstration experiment in the classroom, Demonstration experiment and discussion, Demonstration experiment only, Small group class experiment

The information in Table 4.23 helps to determine the null hypothesis that there is no effect of frequency of chemistry practicals on students' performance in secondary school chemistry. A large F value (132.7) and a significance of $0.000 < 0.05$ make us reject the null hypothesis and conclude that frequency of various chemistry practicals lessons had a significant effect on students' performance in secondary school chemistry.

Table 4.24**Coefficients Analysis Results on the Effect of Frequency of Exposure to Various Types of Chemistry Practicals on Post Test Scores**

| Model | Beta | T | Sig. |
|---|-------------|----------|-------------|
| (Constant) | | 18.160 | .000 |
| Demonstration experiment only frequency | .017 | .408 | .000 |
| Demonstration experiment and discussion frequency | .040 | .745 | .000 |
| Demonstration experiment in the classroom frequency | .022 | .543 | .000 |
| Small group class experiment frequency | .042 | .767 | .000 |
| Large group class experiment frequency | -.031 | -2.016 | .000 |

a. Dependent Variable: Post Test Scores

Table 4.24 shows individual predictors variables standardized coefficients, T value and significance and was used to test the null hypothesis, H_{04} , that there is no significant difference in performance in chemistry of students exposed to differing frequencies of various types of chemistry practicals and those not exposed. On demonstration experiment only frequency type of practical activity, the findings show that a T value of .408 is significant at .000 which is less than .05 (or 95% confidence level). The null hypothesis is therefore rejected. This implies that the frequency of demonstration experiment only type of lesson, also significantly explains the post test score. On demonstration experiment and discussion frequency, the findings show that a T value of 0.745 is significant at .000 which is less than .05 (or 95% confidence level). The null hypothesis is therefore rejected. This implies that the frequency of demonstration experiment and discussion type of lessons significantly explains the post test scores.

For the demonstration experiment in the classroom type of practical, Table 4.24 shows that a T value of .543 is significant at .000 which is less than .05 (or 95% confidence level). The null hypothesis is therefore rejected implying that the frequency of demonstration experiment in the classroom type of practical lesson explains the post test scores. On small group class experiment, Table 4.24 shows that a T value of .767 is significant at .000 which is less than .05 (or 95% confidence level). The null hypothesis is therefore rejected. This implies that the frequency of small group class experiment frequency significantly explains the posttest grade. Finally on large group class experiment frequency, the table shows that a T value of -2.02 is significant at .000 which is less than .05 (or 95% confidence level). The null hypothesis is therefore rejected. This implies that the frequency of large group class experiment type of practical lesson significantly explains the post test scores.

Table 4.25**ANCOVA Analysis Results of the Effects of Frequency of the Various Types of Chemistry Practicals on Post Test Scores**

| Tests of Between-Subjects Effects | | | | | |
|---|-------------------------------|-----|----------------|---------|------|
| Dependent Variable: Post Test | | | | | |
| Source | Type III Sum of Squares | Df | Mean Square | F | Sig. |
| Corrected Model | 165.519 ^a | 6 | 27.586 | 1.322 | .245 |
| Intercept | 6876.894 | 1 | 6876.894 | 329.565 | .000 |
| Demonstration experiment only frequency | 3.365 | 1 | 3.365 | .161 | .688 |
| Demonstration experiment and discussion frequency | 8.335 | 1 | 8.335 | 39.03 | .000 |
| Demonstration experiment in the classroom frequency | 8.943 | 1 | 8.943 | 42.87 | .000 |
| Small group class experiment frequency | 1.230 | 1 | 1.230 | 105.06 | .000 |
| Large group class experiment frequency | 85.082 | 1 | 85.082 | 4.077 | .064 |
| Error | 15190.881 | 728 | 20.867 | | |
| Total | 183261.000 | 735 | | | |
| Corrected Total | 15356.400 | 734 | | | |

a. R Squared = .011 (Adjusted R Squared = .003)

The information in Table 4.25 indicates that the second, third and fourth covariates had significant linear relationship with the post test scores. The second covariate, demonstration experiment and discussion type of practical activity, the *F* statistic (39.03) and its associated significance level (.000) has a significant linear relationship with the dependent variable (post test). The third covariate, demonstration experiment in the classroom, also has a significant *F* statistic (42.87) as can be seen from its associated significance level (.000) while the fourth covariate, small group class experiment practical activity, has a significant *F* statistic (105.06) as can be seen from its associated significance level (.000). In all the three types of practical lessons, the findings indicate that the values of the dependent variable, (post test), increases as the values of the covariates increase. This is contrary to the null hypothesis, H_0 , that there is no

significant difference in performance in chemistry of students exposed to differing frequencies of various types of chemistry practicals and those not exposed.

On the other hand the first and fifth covariates have no significant linear relationship with the post test scores. The first covariate, demonstration experiment only type of practical activity has F value of .161 and significance of .688 meaning it has no significant linear relationship with the dependent variable. The last covariate large group class experiment type of practical activity has an F value of 4.077 and a significance level of .064 indicating that it has no significant linear relationship with the dependent variable. This supports the null hypothesis, H_{04} , that there is no significant difference in performance in chemistry of students exposed to differing frequencies of various types of chemistry practicals and those not exposed.

4.7 Gender and Performance in Schools' Chemistry

The fifth objective of the study was focused on finding out whether boys and girls exposed and those not exposed to chemistry practicals differ significantly in their average score. To achieve this objective, the study used the pre-test and post test scores for the different types of groups involved in the study to test the fifth null hypothesis, H_{05} , that there is no significant difference in performance in chemistry between girls and boys exposed to chemistry practicals and those not exposed. While practical work is assumed to be necessary for all learners, some studies show that boys and girls differ in the reception of the practical approach (Gardner, 1975). Learners benefit through engagement with concepts in practical work through interactions, hands-on activities and application in science. Without such benefits, Gardner (1975) shows that sex may determine students' attitude towards science. This is further confirmed by research in Israel (Trumper, 2006) where boys and girls of the same age tend to have different attitudes to

similar teaching methods. However, a study by Kibirige and Tsamago (2013) shows that the attitudes of boys and girls towards science are not different when using similar methods. Due to such differing views, this study will find out whether there is gender difference in performance in chemistry when learners are taught using methods incorporating practicals.

4.7.1: Performance of Girls and Boys Exposed To Chemistry practicals and Those Not Exposed

The study sought to test the null hypothesis that there was no significant difference in performance in chemistry between girls and boys exposed to chemistry practicals and those not exposed. Table 4.26 shows the descriptive statistics in performance in chemistry between girls and boys exposed to chemistry practicals and those not exposed and Table 4.27 shows the findings obtained after conducting independent T test on performance in chemistry of girls and boys exposed to chemistry practicals and those not exposed.

Table 4.26
Comparison of Boys' and Girls' Performance

| | Type of School | N | Mean | Std. Deviation | Std. Error Mean |
|-----------|-----------------------|----------|-------------|-----------------------|------------------------|
| Post Test | Boys | 184 | 14.80 | 4.870 | .359 |
| | Girls | 254 | 15.41 | 4.284 | .269 |
| Pre Test | Boys | 184 | 13.30 | 5.584 | .412 |
| | Girls | 254 | 14.47 | 5.365 | .337 |

Table 4.26 gives the descriptive statistics for each of both pre-test and post test for boys and girls. In post test, the mean for boys mean was 14.80 while that of the girls was 15.41. In pre-test

the mean was 13.30 while that of the girls was 14.47. The findings indicate that girls had performed better than the boys in both tests.

Table 4.27

T-Test Results on Performance of Girls and Boys Exposed to Chemistry Practicals and Those Not Exposed

| Independent T test | T | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference |
|---------------------------|----------|-----------|------------------------|------------------------|------------------------------|
| Post test | -1.377 | 436 | .169 | -.605 | .439 |
| Pre-test | -2.203 | 436 | .208 | -1.164 | .528 |

The information in Table 4.27 shows the findings obtained after conducting independent T test on performance in chemistry of girls and boys exposed to chemistry practicals and those not exposed. The independent T test compares any significant difference between two means for both pre-test and post-test of girls and boys. In the post test mean comparison for boys and girls, assuming equal variances, the t value is -1.377 with degrees of freedom of 436. The two-tailed p value associated with the test is 0.169. 0.169 is greater than 0.05, so we accept the null hypothesis, that is, there is no significant difference in post test performance in chemistry of girls and boys exposed to chemistry practicals and those not exposed.

In the pre-test mean comparison for boys and girls schools, assuming equal variances, the T value is -2.203 with degrees of freedom of 436. The two-tailed p value associated with the test is 0.208. The decision rule is given by: If $p \leq \alpha$, then reject H_0 . In this analysis, .0.208 is greater than 0.05, so we accept the null hypothesis. This implies that there is no significant difference in pre-test performance in chemistry of girls and boys exposed to chemistry practicals and those not exposed.

4.7.2: Performance in Chemistry by Gender for Experimental and Control Groups

The study sought to find out if there was any significant difference in performance in chemistry between girls and boys in either experimental or control groups. Tables 4.28 and 4.29 show descriptive statistics on performance in chemistry for experimental girls' and boys' groups, and for control girls' and boys' groups respectively.

Table 4.28

Performance in Chemistry by Gender for Experimental Groups

| | Type of School | N | Mean | Std. Deviation |
|-----------|----------------|-----|-------|----------------|
| Post Test | Boys | 123 | 16.07 | 4.706 |
| | Girls | 143 | 15.24 | 3.334 |
| Pre Test | Boys | 123 | 13.41 | 6.096 |
| | Girls | 143 | 13.17 | 5.412 |

Table 4.28 shows the descriptive statistics for the pre-test and post test for experimental boys and experimental girls. The findings on the post test indicate a mean of 16.07 for boys and a mean of 15.24 for the girls. In pre-test the, findings indicate a mean of 13.17 for boys and a mean of 13.17 for the girls. This tentatively suggests that boys performed better than girls after being taught using chemistry practicals.

Table 4.29**Performance in Chemistry by Gender for Control Groups**

| | Type of School | N | Mean | Std. Deviation |
|------------------|----------------|-----|-------|----------------|
| Post Test | Girls | 111 | 15.62 | 5.271 |
| | Boys | 61 | 12.25 | 4.166 |
| Pre Test | Girls | 111 | 16.14 | 4.838 |
| | Boys | 61 | 13.08 | 4.413 |

Table 4.29 shows the descriptive statistics for the post test and pre- test for control boys and control girls. The findings on the post test indicate a mean of 12.25 for boys and a mean of 15.62 for girls while in the pre-test, the findings indicate a mean of 13.08 for boys and a mean of 16.14 for the girls. This indicates that girls performed better than boys before treatment.

Table 4.30 below, shows the findings of the independent T- test on pre-test and post test performance in chemistry by gender for the experimental group. The independent T test is used to decide whether the difference between the two means for both pre-test and post test scores are significant.

Table 4.30**T Test Results on Performance in Chemistry by Gender for the Experimental Groups**

| Independent T test | T | Df | Sig. (2-tailed) | Mean Difference | Std. Error Difference |
|--------------------|------|-----|-----------------|-----------------|-----------------------|
| Post test | 1.63 | 264 | .096 | .828 | .495 |
| Pre-test | .340 | 264 | .734 | .240 | .706 |

Tables 4.31 and 4.32 show the Levene's test for equality of Variances of the pre-test and post test results in Table 4.30 above..

Table 4. 31

Levene's Test for Equality of Variances for the Pre-Test

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|----------|-----------------------------|---|------|------------------------------|---------|-----------------|-----------------|-----------------------|---|-------|
| | | F | Sig. | T | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | Lower | | Upper |
| Pre Test | Equal variances assumed | .711 | .400 | .340 | 264 | .734 | .240 | .706 | -1.150 | 1.629 |
| | Equal variances not assumed | | | .337 | 246.242 | .737 | .240 | .712 | -1.163 | 1.642 |

For the pre-test, to check whether to assume equal variance or unequal variance we check the significant under the Levene's Test for Equality of Variances if <0.05 . In this case we assume equal variance as we have a significance of $0.400 > 0.05$

Table 4.32

Levene's Test for Equality of Variances for the Post Test

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|-----------|-----------------------------|---|------|------------------------------|---------|-----------------|-----------------|-----------------------|---|-------|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | Lower | | Upper |
| Post Test | Equal variances assumed | 5.976 | .015 | 1.673 | 264 | .096 | .828 | .495 | -.147 | 1.803 |
| | Equal variances not assumed | | | 1.632 | 215.548 | .104 | .828 | .508 | -.172 | 1.829 |

For the post test, to check whether to assume equal variance or unequal variance we check the significant under the Levene's Test for Equality of Variances if <0.05 . In this case, 0.015 is <0.05 therefore we go for unequal variance.

The information in Table 4.30 shows the post test mean comparison for experimental boys and girls, assuming unequal variances. The value $T(264) = 1.63$, $p > 0.05$, so we accept the null hypothesis. This implies that there is no significant difference in post test performance in chemistry by gender for the experimental groups.

The pre-test mean comparison for experimental boys and girls, assuming equal variances, yielded a $T(264)$ value of 0.340, where $p > 0.05$. So we accept the null hypothesis which implies that there is no significant difference in pre-test performance in chemistry by gender for experimental groups.

Table 4.33

T Test Results on Performance in Chemistry by Gender for Control Groups

| Independent T test | T | Df | Sig. (2 tailed) | Mean Difference | Std. Error Difference |
|--------------------|-------|-----|-----------------|--------------------|--------------------------|
| Post test | 4.616 | 149 | .000 | 3.376 | .731 |
| Pre-test | 4.082 | 170 | .000 | 3.053 | .748 |

The information in Table 4.33 shows the post test and pre-test mean comparison by gender for control groups, assuming equal variances. For the post test, the value $T(149) = 4.62$, $p < 0.05$, so we reject the null hypothesis implying that there is significant difference in post test performance in chemistry by gender for control groups. The pre-test mean comparison for control boys and girls, assuming equal variances, the value of $T(170) = 4.08$, $p < .05$, so we reject the null

hypothesis which implies that there is significant difference in pre-test performance in chemistry between control groups. Whereas there was a difference between the performances of boys and girls revealed in the pre-test, boys and girls performed equally well in the post test. This implies that practicals have an equalizing effect for girls and may indicate that a change in the teaching method for girls could make a difference in their achievement in chemistry. This is in agreement with observation by Ssempala (2005) that there was no statistical significant differences between girls and boys in their ability to manipulate the apparatus/equipment, take observation, report/record results correctly, and compute/interpret/analyze results during the chemistry practicals.

Akpa (2005) states, “how familiar students are to what is expected of them and what sex role stereo type they are attached to could influence how they perform in both practical and theoretical aspects of chemistry examination”. Research study carried out by Mari (2001), which focused mostly on the effect of gender factors on students’ understanding of science process skills in science learning among junior secondary schools students showed that there was significant difference between the male and female students in their ability to solve problems requiring their understanding of the process skills. Elsewhere observations on the disparity in male-female performance in sciences exist (Ssempala, 2005; Hodson, 1999). Studies carried out by Tamir (1982) and Burns (1987) in Israel and New Zealand respectively also showed that male students outperformed their female counterparts in the physical sciences.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the findings of the study and presents conclusions and recommendations for improvement of teaching of secondary school chemistry in Kenya. Also included in this chapter are suggestions for further research.

The purpose of this study was to investigate the effects of chemistry practicals on performance in chemistry among public secondary school students in Kenya. A number of research objectives were set to guide the collection of the needed information. The first objective was to establish whether students learning chemistry using chemistry practicals perform better than those learning without. The other specific objectives dealt on finding out and examining the effect of the nature and quality of chemistry practicals on students' performance in secondary school chemistry. Other areas investigated were the effects of frequency of chemistry practicals on students' performance and whether boys and girls exposed and those not exposed to chemistry practicals differ significantly in their average score.

To investigate these issues, the following null hypotheses were generated:

H₀1: There is no significant difference between the post-test mean score in chemistry of students exposed to chemistry practicals and those not exposed.

H₀2: There is no significant difference in performance in chemistry of students exposed to various types of chemistry practicals and those not exposed.

H₀3: There is no significant difference in performance in chemistry of students exposed to different qualities of chemistry practicals and those not exposed.

H₀₄: There is no significant difference in performance in chemistry of students exposed to differing frequencies of various types of chemistry practicals and those not exposed.

H₀₅: There is no significant difference in performance in chemistry between girls or boys exposed to chemistry practicals and those not exposed.

The review of related literature focused on secondary school chemistry instruction, performance in secondary school chemistry, chemistry practicals and performance in school chemistry, nature of school chemistry practicals, quality of school chemistry practicals, frequency of school chemistry practicals, availability of facilities and equipment in chemistry learning and gender and performance in school chemistry.

The study was conducted in 24 public secondary schools in two counties of Kenya. The study involved 735 form two students and 34 chemistry teachers. Multi-stage cluster sampling and purposive sampling were used to obtain a sample of 24 public secondary schools for this study. The unit of sampling was the secondary school rather than individual students because schools operate as intact groups.

The research instruments used in the study included student achievement tests, teachers' and students' questionnaires. The data from the questionnaires was displayed using descriptive statistics and analyzed using SPSS that was used to test the hypotheses. ANCOVA, ANOVA and independent t-test were used to test the hypotheses. Regression analysis was also used to compare the contribution of each parameter of the independent variable to the dependent variable which was the performance in the post test.

5.2 Summary of the Findings

The study found that there was a significant difference in performance between the learners who were exposed to chemistry practicals and those who were not. There was a significant difference between post test scores of experimental and control groups. The post test results showed that the experimental group had a mean score of 15.73 while the control group had a mean score of 14.18. From the findings, the experimental group's mean score is higher than the control group's mean score implying that chemistry practicals treatment had a positive effect on students' performance in chemistry. This shows that the use of chemistry practicals had a significant improvement in the performance of chemistry at the secondary school level and so it is a better method of teaching and learning chemistry.

The study found that there is a linear relationship between various types of practical activities and learners' performance in chemistry. The ANCOVA analysis indicated that the values of the dependent variable, (post test), increases as the values of the covariates, (types of chemistry practicals), increase. For example, the findings showed that, demonstration experiment and discussion type of practical activity had F (39.03) and its associated significance level (.000), indicating a significant linear relationship with the dependent variable (post test). This implies that the teaching and learning of chemistry in secondary schools is improved and performance improves when different types of chemistry practicals are used. This is in agreement with Pavesic (2008) who stated that students have a lot to benefit from chemistry practicals. The benefits may include increasing students' interest and abilities in science subjects as well as their achievement in science.

The Study also found that most secondary school students have a fair attitude towards chemistry and chemistry activities. This finding suggests that secondary students' attitudes to

chemistry practicals are, generally speaking, positive. The implication of this study suggests that teachers need to be more aware that students' attitude to chemistry practicals is positive, rather than seeing the students' attitudes as negative and unchanging. Teachers should consider the content being studied and create a more conducive classroom environment. Sharpe (2012) reported that, the classroom climate established by the teacher can have a major impact on learners' motivation and attitude towards learning and ultimately to performance in the subject.

The study established that there was no relationship between chemistry practicals and performance in chemistry among students of mixed gender schools and those of single gender. The ANCOVA findings indicated that the F statistic was 0.977 and its associated significance level of 0.377 which showed that the school type covariate (boys, girls or mixed school), had no significant linear relationship with the dependent variable (post test). This implies that school type had no relationship to performance in chemistry irrespective of whether there were chemistry practicals or not.

Other findings on gender indicated that there was no significant difference in performance in chemistry between experimental girls and experimental boys. The calculated T value was 1.67 with degrees of freedom of 264 and the two-tailed p value associated with the test was 0.096. Since 0.096 was greater than 0.05, the null hypothesis was accepted, implying that there was no significant difference in post test performance in chemistry between girls and boys exposed to chemistry practicals.

5.3 Conclusions

The findings confirm that the use of chemistry practicals is an effective method in improving students' performance in chemistry in secondary schools regardless of their gender.

They also confirm that the nature, quality and frequency of chemistry practicals in teaching and learning of chemistry boosts learner performance in chemistry. Use of chemistry practicals enhances students' knowledge and understanding in a better way compared to none use of the chemistry practicals. While it is important to encourage use of chemistry practicals in the teaching and learning of chemistry, it is equally important to consider the nature, quality and frequency of the practical work.

The study showed that exposure to various types of chemistry practicals had a significant positive effect on students' performance. Students have a lot of benefits from chemistry practicals. Chemistry practicals increase students' interest and abilities in science subjects as well as their achievement in science. This is because chemistry practical classes help students in understanding theories and chemical principles which are difficult or abstract. Moreover, chemistry practicals offers several opportunities to students such as: developing scientific thinking and enthusiasm to chemistry, developing basic manipulative and problem solving skills, hands-on experience in using instruments and apparatus, and identifying chemical hazards and handling chemicals safely and other science process skills.

To improve quality of chemistry practicals, it is important to consider reducing the number of learners in chemistry classrooms. This will imply that more chemistry teachers be employed, more classrooms and laboratories built and equipped. In terms of classroom routines, the activities and the exercises should be designed in a way that promotes making links between the practical and the theoretical. Enough time and attention should be dedicated to discussing and reflecting on the connections between the natural world and the ideas of chemistry.

It can also be concluded from the study that irrespective of gender, students perform better in chemistry when chemistry practicals are used in teaching and learning chemistry. The

chemistry teachers should ensure that both male and female students are actively involved in chemistry practicals and should give everybody opportunity to participate irrespective of gender. This will go a long way to enhance students' knowledge during chemistry practicals. The use of chemistry practicals in learning of chemistry is not gender biased because performance of boys and girls in the experimental group did not differ significantly. This is not surprising because both genders are endowed with equal opportunities to succeed in science. A particular sex should not have access to laboratory facilities and equipment more than the other since the knowledge gained during this stage is considered foundational.

5.4 Recommendations

Based on the findings, the study recommends the following:

- i) More practical work should be used when teaching and learning school chemistry in Kenyan public secondary schools. This requires that chemistry teachers undergo intensive in-service training in practical work management and latest research to improve their practices. Pre-service training of teachers should have significant practice in basic and higher order science process skills so that new teachers are more confident to use practical work when they teach chemistry and other sciences. Also, teacher training colleges should train teachers to use hands-tools so that they can improvise, where possible, science equipment for practical work.
- ii) To improve quality of chemistry practicals, the numbers of learners in chemistry classrooms need to be reduced. This could be done by separating large classes into many small classes. This implies that more chemistry teachers be employed, more classrooms

and laboratories built and equipped, an action which can be addressed by the ministry of education.

- iii) For chemistry practicals to result in a significant positive impact on a students' ability to learn both the desired practical skills and also the underlying theory, it is recommended that students be given an opportunity to engage in 'deep learning'. Deep learning provides opportunities in identifying the main objectives of the work and in planning and executing it, of identifying the conceptual and practical difficulties encountered, recording and discussing the results and observations and of suggesting practical alterations and improvements.
- iv) It is also recommended that that there should be further scrutiny of the curriculum and learning standards for chemistry practicals in secondary school chemistry and an in-depth study of teacher competence in the teaching of practical chemistry is suggested.
- v) Another recommendation is on the integration of information communication and technology (ICT) in the teaching and learning of chemistry. The computer and its Internet access have a lot of potential to improve science education. The integration will help to improve the quality of chemistry practical work, reduce problems of lack of enough laboratory facilities and equipment and other such factors that affect the effectiveness of chemistry practicals. The scope of information that is available over the Web and in other ICT- based cognitive tools and also in virtual laboratories and simulations should be part of teaching and learning chemistry at all levels, in order to enrich the understandings of its concepts and theories in different contexts.

5.5 Policy Brief

Chemistry Practicals: Improving Students' Performance in Secondary School Chemistry. This can be a policy to be adopted by the ministry of education. It is a policy that can be developed to encourage teachers to reflect more fully and deeply on the learning objectives of the practical activities they use and, in particular, the kinds of thinking that such practical work requires of students if it is to be effective in developing conceptual understanding. Rather than simply suggesting that teachers should do even more practical work than they are currently doing there is a need to focus on how to improve the effectiveness of the practical work that science teachers already use, even if the result of this means that they end up doing less, but more effective, practical work in their lessons.

Since including chemistry practical work in the teaching of chemistry requires relatively large amount of resources and time, the following policy recommendations are suggested:

- i) The quantity and quality of practical work being undertaken in schools and colleges in Kenya, and any patterns of activity should be looked at.
- ii) Advocates of more practical work in school science need to be clear about why they take this position and what types of activities they want to see happening.
- iii) The impact of practical work for those learning science, particularly how benefits can be maximized, and how far they extend across all types of learner should be further investigated.
- iv) Training, both pre-service and in-service in using practical activities needs to be refocused and supported by more effective resources than are currently available.
- v) Highlight the place of practical work: within the curriculum; as part of 'enrichment and enhancement' activities; and outside the classroom; and how this is changing over time.

- vi) Emphasise the role that information technology can and might play in supporting teaching and learning in practical work.
- vii) Embrace research, comparative or otherwise, exploring practical work in science in other countries.
- viii) The relative strength of factors cited as barriers to practical work in Kenya such as the assessment system, teacher confidence, technical support, finances, and health and safety concerns should be addressed.

5.6 Recommendations for Further Research

Based on the findings of the study, further studies need to be carried out in the following areas:

- i) Investigate the effect of other independent variables such as the quality and expertise in scientific knowledge of secondary school chemistry teachers on performance in chemistry.
- ii) A further research to find out specifically what practical styles the students are being exposed to, in relation to students' performance in chemistry and on the basis of their gender.
- iii) Do research to find out the extent to which the usage of the computer in the classroom is building students' understanding of secondary school chemistry.
- iv) Further research is required on how to make the quality of chemistry practicals worthwhile in order to implement better and more efficient practices.

REFERENCES

- Abimbola, I. O. (1994). A critical appraisal of the role of laboratory chemistry practicals in science teaching in Nigeria. *Journal of Curriculum and Instruction*, 4 (1&2), pp.59-65.
- Abrahams, I. & Millar, R. (2008). Does chemistry practicals really work? A study of the effectiveness of chemistry practicals as a teaching and learning method in school science. *International Journal of Science Education*. **30**.14: 1945-1969.
- Achor, E. E., Kurumeh, S. M. & Orokpo C. A. (2012). *Gender Dimension in Predictors of Students' Performance in MOCK-SSCE Practical and Theory Chemistry Examinations in Some Secondary Schools in Nigeria*. California, USA: Scientific & Academic Publishing Co.
- Anaso, J. N. (2010). *Strategies for Improving the Performance of Students in Chemistry at the Tertiary Level*. Abuja, Nigeria: National Mathematical Centre.
- Awad, B. (2014). Empowerment of teaching and learning chemistry through information and communication technologies. *AJCE*, 2014, 4(3), *Special Issue (Part II)*
- Barton, R. (2004). *Teaching secondary science with ICT*. Berkshire, England: Open University Press.
- Bennett, J. (2003). *Teaching and Learning Science*. London, England: The Continuum International Publishing Group Ltd.
- Bodner, G. M. (1986). Constructivism: A theory of knowledge. *Journal of Chemical Education*, 63, 873-878.
- Bol, L. & Strage, A. (1996). The contradiction between teachers' instructional goals and their assessment practices in high school biology courses. *Science Education*, 80(2), 145–163.
- Cardak, O., Onder, K. & Dikmenli, M. (2007). Effect of the usage of laboratory method in primary school education for the achievement of the students' learning. *Asia-Pacific Forum on Science Learning and Teaching*, 8(2), Article 3.

http://www.ied.edu.hk/apfslt/v8_issue2/cardak/.

Bruner, J. (1960). *Process of Education*. Cambridge; Harvard University Press.

Carnduff, J. & Reid, N. (2003). *Enhancing undergraduate chemistry laboratories:*

Pre-laboratory and post-laboratory exercises. London: Royal Society of Chemistry.

Cuomo, F., Serpico, M. & Balzano, E. (2007). *Interpretation of gender differences: Science & Society – European Science Education Initiative*. Permanent European resource Centre for Informal Learning (PENCIL): University of Naples “Federico II”

Creswell, J. W. (2005). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (2nd ed.)*. Columbus, OH: Pearson – Merrill Prentice Hall.

Daily Nation, (2012, March 3). *KCSE results*. Nairobi, Kenya: Nation Media Group.

Daily Nation, (2014, January 15). *Form One selection; 200,000 to miss Form 1 places*. Nairobi, Kenya: Nation Media Group.

Dewey, J. (1938). *Experience and Education*. Toronto: Collier-McMillan Canada Ltd.

Dillon, J. (2008). *A review of the research on practical in school science*. London: Kings College.

Domin, D.S. (1999). A review of laboratory instruction styles. *Journal of Chemical Education*, 76: 543-547

Donnelly, J. F. & Jenkins E.W. (2001). *Science Education, Policy, Professionalism and Change*. London: Paul Chapman Publishing Ltd.

Driver, R., Asoko, H., Leach, J., Mortimer, E. & Scott, P. (1994). *Constructing Scientific Knowledge in the Classroom*, *Educational Researcher*, 23(7), 5-12.

Ebbing, D. D. (1996). *General Chemistry*. Fifth edition. Boston, USA: Houghton Mifflin Company.

Edomwonyi-Out, L., and Avaa, A. (2011). *The challenge of effective teaching of chemistry: A case study*. Zaria, Nigeria. http://lejpt.academicdirect.org/A18/001_008.htm

- Engida, T. (2014). *Chemistry Teacher Professional Development using the Technological Pedagogical Content Knowledge (TPACK) Framework*. *AJCE*, 2014, 4(3), Special Issue (Part II). ISSN 2227-5835.
- Field, A. P. (2013). *Discovering statistics using IBM SPSS Statistics: And sex and drugs and rock 'n' roll* (4th ed.). London: Sage.
- Fraenkel, J. & wallen, N. (2002). *How to design and evaluate research in education*. New York: McGraw-Hill.
- Freedman, M. P. (1998). Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching*, 34: 343-357. John Wiley & Sons, Inc.
DOI: 10.1002/(SICI)1098-2736(199704)34:4<343::AID-TEA5>3.0.CO;2-R
- Gabel, D. (1999). Improving Teaching and Learning through Chemistry Education Research: A Look to the Future. School of Education, Indiana University, Bloomington, IN 47408 *J. Chem. Educ.*, 1999, 76 (4), p 548. doi: 10.1021/ed076p548.
- Gall, M. D., Borg, W. R. & Gall, J. P. (1989). *Educational research: an introduction*, sixth edition. New York, USA: Longman Publishers.
- Gardner, P. L. (1975). Attitudes to Science. *Studies in Science Education*, 2(1): p 1-41
- Goh, N. K., & Chia, L. S. (1988). *Improving chemistry laboratory work: Teaching and Learning*. Manila: Singapore Institute of Education.
- Government of Kenya, (2008). *Kenya Vision 2030*. Nairobi ,Kenya: Government Printer.
- Gunstone, R.F. & Champagne, A. B. (1990). Promoting conceptual change in the laboratory. In E. Hegarty-Hazel (Ed.). *The student laboratory and the science curriculum* London: Routledge.
- Hattingh, A., Aldous, C. & Rogan J. (2007). Some factors influencing the quality of practical

- work in science classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, 11:1, 75-90
- Hodson, D. (1990). A critical look at chemistry practicalising school science. *School Science Review*, 70, 33-40.
- Hodson, D. (2001). Chemistry practicals in science: Time for a reappraisal. *Studies in Science Education*, 19, 175-184.
- Hofstein, A. (2004). The laboratory in chemistry education: Thirty years of experience with developments, implementation, and research. *Chemistry Education: Research and Practice*, Vol. 5, No. 3, pp. 247-264. Published Online.
- Hofstein, A. & Lunetta, V. N. (2003). The laboratory in science education: Foundations for the twenty-first century. *Wiley Periodicals, Inc. Sci Ed* 88:28 – 54; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/sce.10106
- Hofstein, A. & Mamlok-Naaman, R. (2007). The laboratory in science education: the state of the art. *Chemistry Education Research and Practice*, 8(2), 105-107. The Royal Society of Chemistry
- Hofstein, A., & Walberg, J. (2005). *Instructional strategies*. International Educational Journal, Vol. 5 No 1 p. 26. Published online.
- Hofstein, A., & Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational research*, Vol. 52, 2: pp.201-217.
- Ikeobi, I. (2004). *Identification and teaching of different concepts in Chemistry*. STAN Bulletin, 11(2), 3 – 5.
- Inyega, J., & Thomson, N. (2002). *Change in attitudes towards teaching strategies in secondary school teachers in Kenya following in-service professional development*: Paper presented at annual conference of SAETS, Kennesaw, GA. Retrieved from

<http://jinyega.myweb.uga.edu/index-files/SAETS.pdf>.

Jenkins, E. W. (2000). Constructivism in School Science Education: Powerful Model or the Most Dangerous Intellectual Tendency? *Science & Education*, 9, pp 599-610.

Johnstone, A.H., Sleet, S. J. and Vianna, J. F. (1994). An information processing model of learning: Its application to an undergraduate laboratory course in chemistry. *Stud. Higher Educ.*, 19: 77-87.

Johnstone, K. (1991). High school science teachers conceptualizations of teaching and learning: Theory and practice. *Eur. J. Teach. Educ.*, 14: 65-78.

Kakinda, D. (2007). *Inspiring science education for girls*. CHECK. point e Learning published by INFO bases GmbH: Berlin. info@checkpoint-elearning.com

Kauffman, G. B., & Szmant, H. (1987). *Essays on the uses of Chemistry*. Texas: Christian University Press.

Kearney, M. (2004). Classroom Use of Multimedia-Supported Predict-Observe-Explain Tasks in a Social Constructivist Learning Environment. *Research in Science Education*, 34, pp 427-453

Khan, M.S., Hussain, S., Ali, R., Majoka, M. I., & Ramzan M. (2011). Effect of inquiry method on achievement of students in chemistry at secondary level. *International Journal of Academic Research*, Vol. 3. No.1. Part III: pp.955-959.

Khuluse, N. L. (2009). The effect of discipline on academic achievement in Secondary Schools. Dissertation submitted in partial fulfillment of the requirements for the degree Master of Education in the Department of Educational Psychology and Special Needs Education of the Faculty of Education at the University of Zululand. Retrieved from URI: <http://hdl.handle.net/10530/410> on 28/04/2015.

- Kibirige, I. Maake, M. R. & Mavhunga, F. (2014). Effect of practical work on Grade 10 learners' Performance in science in Mankweng Circuit, Sout Africa. *Mediterranean Journal of Social Sciences*, MCSER Publishing, Rome-Italy. 5(23).
- Kibirige, I. & Tsamago, H. (2013). Learners performance in Physical Sciences using laboratory investigations. *International Journal of Educational Sciences*, 5(4): 425-432.
- K I E, (2002). *Secondary Education Syllabus*. Volume Two. Nairobi, Kenya: K I E.
- K N E C, (1995, 1996,.... 2010, 2012). *K.C.S.E. Chemistry Examination Reports*. Nairobi: K N E C.
- Kothari, C.R. (2004). *Research methodology: Methods and Techniques*. 2nd Edition, New Delhi, India: New Age International Publishers.
- Krajcik, J. S., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredericks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *Journal of the Learning Sciences*, 7, pp 313-350
- Kumar, R. (2005). *Research methodology: a step by step guide for beginners*. 2nd Edition, London, UK: Sage Publications Ltd.
- Lagowski, J. J. (2002)The role of the laboratory in chemical education. Retrieved from http://www.utexas.edu/research/chemed/lagowski/jjl_beijing_02.pdf (Accessed on 15th Aug, 2015).
- Lazarowitz, R. & Tamir, P. (1994). *Research on using laboratory instruction in science*. In D.L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 94–128). New York: Macmillan.
- Leach, J., & Scott, P. (2003). *Individual and Sociocultural Views of Learning in Science Education*. *Science & Education*, 12, 91-113.
- Lerman, Z. M. (2014). The challenges for Chemistry Education in Africa. *The Lerman Institute for the Advancement of Science*. 1911 Grant St. Evanston, IL 60201: AJCE, 2014, 4(2),

Special Issue (Part I) ISSN 2227-5835.

- Ling, T. A., & Towndrow, P. A. (2010). *Giving students a voice in science practical assessments*. Centre for Research in Pedagogy and Practice, Singapore: National Institute of Education.
- Lunetta, V.N. (1998). *The school science laboratory: Historical perspectives and centers for contemporary teaching*. In: B.J. Fraser & K.G. Tobin (Eds), *International handbook of science education*. Dordrecht. Kluwer Academic Publishers.
- Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). *Teaching and learning in the school science laboratory*. An analysis of research, theory, and practice. In, S. K. Abell and N. G. Lederman (Eds), *Handbook of Research on Science Education* (pp. 393–431). Mahwah, NJ: Lawrence Erlbaum Associates.
- Mari, J.S. (2001). *The effect of science process based instruction on formal reasoning*. Unpublished PhD Thesis, Department of Education. A.B.U. Zaria, Kaduna: Nigeria.
- Maduabum, M.A. (2006). Strategies of improving the access of girls and women in Science, Technology and Mathematics (STM). University Education in Nigeria. *Ebonyi Journal of Science Education*, 1(1), 1– 12.
- Mayers, A. (2013). *Introduction to Statistics and SPSS in Psychology*. London: Pearson Education Ltd.
- Miha L. (2006). *What does constructivism suggest for science education*. Issue Paper: California State University, Northridge
- Millar, R. (2009). *Analysing practical activities to assess and improve effectiveness: The Practical Activity Analysis Inventory (PAAI)*. York: Centre for Innovation and Research in Science Education. University of York. Available from <http://www.york.ac.uk/depts/educ/research/ResearchPaperSeries/index.htm>

- Millar, R. (2004). *The role of chemistry practicals in the teaching and learning of science. High school science laboratories: role and vision*. Washington, DC: National Academy of Sciences.
- Millar, R. (2001). *Teaching and learning science through chemistry practicals*. York: University of York Science Education Group.
- Mugenda, O. M., & Mugenda, A.G. (2003). *Research methods, quantitative and qualitative approaches*. Nairobi, Kenya: Acts Press.
- Muijs, D. (2004). *Doing quantitative research in education with SPSS*. London: Sage Publications
- Mupanduki, B. T. (2009). *The effectiveness of a standards-based integrated chemistry and mathematics curriculum on improving the academic achievement in chemistry for high school students in Southern California*. California, U.S.A: Azusa Pacific University.
- Mutai, B. K. (2000). *How to write quality research proposal*. Nairobi: Thelley Publications.
- Ngau, P., & Kumssa, A. (2004). *Research design, data collection analysis: A training manual*. Nairobi: United Nations Centre for Regional Development.
- Nieswandt, M., & McEneaney, E. H. (2009). *Quality research in literacy and science education III*, Pages 189-211. <http://www.springerlink.com/content/978-1-4020-8426-3/>
- Nthiga, J., & Kagete, M.P. (2005). *Assessing practical subjects, the Kenyan experience*, 23rd Annual Conference of the Association Educational Assessment in Africa. Nairobi, Kenya.
- Nui, N. W., & Wahome, A.N. (2006). *SMASSE project*. Retrieved from http://www.criced.tsukuba.ac.jp/math/sympo_2006/nui.pdf
- Office for Standards in Education (Ofsted), (2005). *Science in Secondary Schools*. London: HMI/Ofsted. Available at: <http://live.ofsted.gov.uk/publications/annualreport0405/4.2.15.html>

- Ogunkola, B. J., & Fayombo, G. A. (2009). Investigating the combined and relative effects of some student related variables on science achievement among secondary school students in Barbados. *European Journal of Scientific Research*. ISSN 1450-216X Vol.37 No.3 (2009), pp.481-489. <http://www.eurojournals.com/ejsr.htm>
- Okeke, E.A. (1990). *Gender science and technology: A challenge for education*. The Bama Methal Lecture. Radcliffe College, February 2nd– 5th.
- Ormrod, J. E. (2003). *Educational psychology. Developing learners (4th ed.)*. Columbus, OH: Merrill Prentice Hall.
- Ottander, C. & Grelsson, G. (2006). Laboratory work: the teachers' perspective. *Journal of Biological Education*, 40(3), 113–118.
- Parkinson, J. (1994). *The effective teaching of secondary science*. London: Longman.
- Patton, M. Q. (2002). *Qualitative Research and Evaluation Methods*. California: Sage
- classes in Slovenia as evident in TIMSS studies. *Studies In Educ. Evaluation*. 34: 94-104.
- Perkins, D. (1993). Teaching for Understanding. *American Educator: The professional Journal of the American Publication, Inc.*
- Pavesic, B. J, (2008). Science achievement, gender differences, and experimental work in *Federation of Teachers*; 17(3) 28-35.
- Reid, N. & Shah, I. (2007). The role of laboratory work in university chemistry. *Chemistry Education Research and Practice*; 8 (2), 172-185.
- Rogan, J. M. & Grayson, D. (2003). Towards a Theory of Curriculum Implementation with Particular Reference to Science Education in Developing Countries. *International Journal of Science Education*; 25, 1171-1204.
- Roth, W. M. (1994). Experimenting in a constructivist high school physics laboratory. *Journal of*

- Research in Science Teaching*, 31, pp 197-223.
- Rutherford, F. J., & Ahlgren, A. (1991). *Science for all Americans*. New York, USA: Oxford University Press.
- Salomon, G., Perkins, D., & Globerson, T. (1991). Partners in cognition: extending human intelligence with intelligent technologies. *Educational Researcher*; 20(3), pp 2-9.
- Schwartz, R. S., Lederman, N. G. & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: an explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education*; 88(4), 610–645.
- Sharpe, R. M. (2012). Secondary school students' attitudes to chemistry practicals in school science. *Unpublished PhD thesis*. University of York.
- Singer, J., Marx, R. W., & Krajcik, J. (2000). Constructing Extended Inquiry Projects: *Curriculum Materials for Science Education Reform, Educational Psychologist*, 35(3), pp 165-178
- Solomon, J. (1987). Social influences on the construction of pupils' understanding of science. *Studies in Science Education*, 14, 63-82
- Ssempala, F. (2005). Gender Differences in Performance of Chemistry Practical Skills among Senior Six Students in Kampala District. *Dissertation.com*. Boca Raton, Florida USA.
- Staver, J.R. (2007). Teaching science. *International Academy of Education: Educational Practices Series*. Perth, Australia: International Bureau of Education and the Academy, <http://www.ibe.unesco.org/publications.htm>
- Tan, A-L. (2008). *Tensions in the biology laboratory: What are they?* *International Journal of Science Education*, 30(12), 1661–1676.
- Teixeira-Dias, J. J. C., Pedrosa de Jesus, M. H., Neri de Souza, F. and Watts, D. M. (2005). Teaching for quality learning in chemistry, *International Journal of Science Education*

27(9), 1123-1137.

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

Tobin, K. G. (ed.), (1993). *The practice of constructivism in Science and Mathematics Education*. Washington DC: AAAS press.

Trochim, W. (2000). *The Research Methods Knowledge Base*, 2nd Edition. Cincinnati, OH: Atomic Dog Publishing.

Trumper, R. (2006). Factors affecting Junior High school students' interest in Biology. *Science Education International*, 17(1): 31-48.

Twoli, N.W. (2006). *Teaching secondary school chemistry*. Nairobi, Kenya: Nehema Publishers.

Wachanga, S. W., & Mwangi. J. G. (2004). Effects of the cooperative class experiment teaching method on secondary school students' chemistry achievement in Kenya's Nakuru District. *International Education Journal*, Vol 5, No 1, 2004. <http://iej.cjb.net>

Watts, A. (2013). *The assessment of practical science: a literature review*. Cambridge Assessment.

Wellington, J. (1998). *Practical work in school science. Which way now?* London: Routledge.

White, R., & Gunstone, R. (1992). *Probing Understanding*. London, UK: Falmer.

APPENDICES

APPENDIX I: FORM II CHEMISTRY SCHEMES OF WORK – (EXPERIMENTAL GROUP)

| WEEK | LESSON | TOPIC/SUBTOPIC | LESSON OBJECTIVES | LEARNING ACTIVITIES | LEARNING RESOURCES/REFS | REMARKS |
|------|--------|--|--|---|---|---------|
| 4 | 1 | ALKALI METALS Electron Arrangement, Ions & trends in ionization energy | At the end of the lesson, the learner should be able to: i) Identify alkali metals in the Periodic Table. ii) Explain how they form ions. iii) Describe the trend of their I. Energy. | CLASS DISCUSSION On:- Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group 1 elements. | - Periodic Table chart. - Chart on I.E. of group 1 metals. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54 | |
| | 2&3 | ALKALI METALS Physical properties & Reaction with air, water and chlorine | At the end of the lesson, the learner should be able to: i) Describe the physical properties of alkali metals. ii) Explain the reactions of alkali metals with air, H ₂ O, and Chlorine | DEMONSTRATION EXPERIMENT On:- appearance, m.p., b.p., thermal and electrical conductivity. -reactions with air, water, and chlorine. | Elements Na & K, Water, Cl ₂ gas, scapel blade, Test tube racks + t.t., source of heat and electricity, litmus, pH chart. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54 | |
| | 4 | ALKALI METALS Similarity of ions & formulae of OH ⁻ , O ²⁻ & Cl ⁻ of alkali metals. Uses of alkali metals | At the end of the lesson, the learner should be able to: i) Write the formulae of the OH ⁻ , O ²⁻ and Cl ⁻ of alkali metals. ii) Write the word and symbol equations of the reactions of alkali metals with air, water and chlorine. iii) Explain the uses of alkali metals. | CLASS DISCUSSION On:- formulae of compounds group 1 elements. -writing equations for the reactions of group 1 elements. - explaining the uses of the elements. | Periodic Table chart, charts on formulae of alkali metal OH ⁻ , O ²⁻ and Cl ⁻ . Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54 | |

| | | | | | |
|---|-----|--|--|---|--|
| 5 | 1 | ALKALINE-EARTH METALS Electron Arrangement, Ions & trends in ionization | At the end of the lesson, the learner should be able to: i) Identify alkali-earth metals in the Periodic Table. ii) Explain how they form ions. iii) Describe the trend of their I. E. | CLASS DISCUSSION On:- Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group II elements. | - Periodic Table chart. - Chart on I.E. of group 2 metals Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66 |
| | 2&3 | ALKALINE-EARTH METALS Physical properties & Reaction with air, water, chlorine & dilute acids | At the end of the lesson, the learner should be able to: i) Describe the physical properties of alkali-earth metals. ii) Explain the reactions of alkali-earth metals with air, H ₂ O, and Cl ₂ . | CLASS EXPERIMENT On:- appearance, m.p., b.p., thermal and electrical conductivity. -reactions with air, water, and dil. Acids. -Explain reaction with Cl ₂ gas. | Elements Mg & Ca, Water, Cl ₂ gas, scapel blade, Test tube racks + t.t., source of heat and electricity, litmus, pH chart, dil. HCl, dil. H ₂ SO ₄ . Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66 |
| | 4 | ALKALINE-EARTH METALS Similarity of ions & formulae of OH ⁻ , O ⁻² & Cl ⁻ of alkali-earth metals. Importance of alkali-earth metals | At the end of the lesson, the learner should be able to: i) Write the formulae of the OH ⁻ , O ⁻² and Cl ⁻ of alkali-earth metals. ii) Write the word and symbol equations of the reactions of alkali-earth metals with air, water and chlorine. iii) Explain the uses of alkali-earth metals. | CLASS DISCUSSION On:- formulae of compounds group II elements. -writing equations for the reactions of group II elements. - explaining the uses of the elements. | Periodic Table chart, charts on formulae of group II metal OH ⁻ , O ⁻² and Cl ⁻ . Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66 |

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|---|-----|--|---|---|--|--|
| 6 | 1 | <p>HALOGENS</p> <p>Electron configuration of F and Cl atoms, gradation in size of atoms and ions</p> | <p>At the end of the lesson, the learner should be able to:</p> <p>i) Write the electron configuration of F & Cl atoms.</p> <p>ii) Explain the gradation in size of group 7 atoms and ions.</p> | <p>CLASS DISCUSSION</p> <p>On:- Listing and identifying the elements in P.T.</p> <p>-Formation of ions.</p> <p>-ionization energies of group 7 elements.</p> | <p>- Periodic Table chart.</p> <p>- Chart on I.E. of group 7 elements</p> <p>Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151.</p> <p>2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81</p> | |
| | 2&3 | <p>HALOGENS</p> <p>Physical properties (appearance, m.p., b.p., thermal and electrical conductivity). Reaction with metals, Na, Zn, Fe and water</p> | <p>At the end of the lesson, the learner should be able to:</p> <p>i) Explain the physical properties of group 7 elements</p> <p>ii) Explain the reactions of group 7 elements with H₂O, metals such as Na, Zn and Fe.</p> | <p>DEMONSTRATION EXPERIMENT</p> <p>On:- Preparation of Cl₂ gas.</p> <p>-Physical properties of Cl_{2(g)}</p> <p>-Its reactions with water, litmus, metals- Na, Zn, & Fe.</p> | <p>Reagents & apparatus for Cl₂ gas preparation. Na, Zn & Fe metals.</p> <p>Water, T.t. racks + t.t., source of heat and electricity, litmus paper & soln., pH chart.</p> <p>Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151.</p> <p>2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81</p> | |
| | 4 | <p>HALOGENS</p> <p>Similarity of ions & formulae of compounds. Importance of F, Cl, Br, and Iodine</p> | <p>At the end of the lesson, the learner should be able to:</p> <p>i) Write the formulae of compounds of group 7 elements.</p> <p>ii) Describe the importance of group 7 elements.</p> | <p>CLASS DISCUSSION</p> <p>On:- formulae of compounds group 7 elements.</p> <p>-writing equations for the reactions of group 7 elements.</p> <p>- explaining the uses of the elements.</p> | <p>Periodic Table chart, charts on formulae of group 7 ions & compounds.</p> <p>Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151.</p> <p>2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81</p> | |

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|---|-----|---|--|--|---|
| 7 | 1 | NOBLE GASES (He, Ne, & Ar) Electron arrangement & gradation in size of atoms. Electron arrangement as basis of low reactivity | At the end of the lesson, the learner should be able to: i) Explain the unreactive nature of the noble gases in terms of their electron arrangement. ii) Explain the importance of noble gases. | <u>CLASS DISCUSSION</u> On:- Listing and identifying the elements in P.T. -atomic structure, radii & ionization energies of group 7 elements. Physical properties & uses of Noble gases. | - Periodic Table chart. - Chart on the summary of physical properties of noble gases. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 151-153. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 81-85. |
| | 2&3 | PROPERTIES AND TRENDS ACROSS A PERIOD Period 3 elements (Na, Mg, Al, Si, P, S, Cl, and Ar -Physical & chemical properties of period 3 elements with | At the end of the lesson, the learner should be able to: i) Identify the elements of period 3 in the P.T. ii) Describe the physical properties of the period 3 elements. iii) Explain the reactions of period 3 elements with O ₂ , H ₂ O & dil. Acids. | <u>CLASS DISCUSSION</u> On:- Listing and identifying the elements in P.T. <u>DEMONSTRATION</u> <u>EXPERIMENT</u> On:- Physical properties of period 3 elements. -chemical properties of period 3 elements. | Periodic Table chart, charts on physical properties of period 3 elements. Gas jars, deflagrating spoons, period elements, O ₂ , H ₂ O & dil. Acids Ref: Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 85-95 |
| | 4 | PROPERTIES AND TRENDS ACROSS A PERIOD Electron arrangement of period 3 elements. -Importance of noble gases | At the end of the lesson, the learner should be able to: i) Write the electron arrangement of period 3 elements. ii) Explain the trends in physical and chemical properties of elements in a period. | <u>CLASS DISCUSSION</u> On:- Listing and identifying the elements in P.T. - summary of the properties of period 3 elements. - importance of noble gases. | Periodic Table chart. Charts on At. Size, I.E., electronic configuration of period 3 elements. Ref: Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 85-95 |

APPENDIX II: FORM II CHEMISTRY SCHEMES OF WORK – (CONTROL GROUP)

| WEEK | LESSON | TOPIC/SUBTOPIC | LESSON OBJECTIVES | LEARNING ACTIVITIES | LEARNING RESOURCES/REFS | REMARKS |
|------|--------|--|---|---|---|---------|
| 4 | 1 | ALKALI METALS Electron Arrangement, ions & trends in ionization energy | At the end of the lesson, the learner should be able to: i) Identify alkali metals in the Periodic Table. ii) Explain how they form ions. iii) Describe the trend of their I. Energy. | <u>CLASS DISCUSSION</u> On:- Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group 1 elements. | - Periodic Table chart. - Chart on I.E. of group 1 metals. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54 | |
| | 2&3 | ALKALI METALS Physical properties & Reaction with air, water and chlorine | At the end of the lesson, the learner should be able to: i) Describe the physical properties of alkali metals. ii) Explain the reactions of alkali metals with air, H ₂ O, and Chlorine | <u>CLAS DISCUSSION</u> On:- appearance, m.p., b.p., thermal and electrical conductivity. -reactions of alkali metals with air, water, and chlorine. | Periodic Table chart, charts on Physical and chemical properties of group 1 elements. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54 | |
| | 4 | ALKALI METALS Similarity of ions & formulae of OH ⁻ , O ²⁻ & Cl ⁻ of alkali metals. Uses of alkali metals | At the end of the lesson, the learner should be able to: i) Write the formulae of the OH ⁻ , O ²⁻ and Cl ⁻ of alkali metals. ii)Write the word and symbol equations of the reactions of alkali metals with air, water and chlorine. iii) Explain the uses of alkali metals. | <u>CLASS DISCUSSION</u> On:- formulae of compounds of group 1 elements. -writing equations for the reactions of group 1 elements. - explaining the uses of the elements. | Periodic Table chart, charts on formulae of alkali metal OH ⁻ , O ²⁻ and Cl ⁻ . Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 123-132. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 39-54 | |

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|---|-----|---|--|---|--|
| 5 | 1 | ALKALINE-EARTH METALS Electron Arrangement, Ions & trends in ionization | At the end of the lesson, the learner should be able to: i) Identify alkali-earth metals in the Periodic Table. ii) Explain how they form ions. iii) Describe the trend of their I. E. | CLASS DISCUSSION On:- Listing and identifying the elements in P.T. -Formation of ions. -ionization energies of group II elements. | - Periodic Table chart. - Chart on I.E. of group 2 metals Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66 |
| | 2&3 | ALKALINE-EARTH METALS Physical properties & Reaction with air, water, chlorine & dilute acids | At the end of the lesson, the learner should be able to: i) Describe the physical properties of alkali-earth metals. ii) Explain the reactions of alkali-earth metals with air, H ₂ O, and Cl ₂ . | CLASS DISCUSSION On:- appearance, m.p., b.p., thermal and electrical conductivity. -reactions with air, water, and dil. Acids. -Explain reaction with Cl ₂ gas. | Periodic Table chart, charts on Physical and chemical properties of group 2 elements. Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66 |
| | 4 | ALKALINE-EARTH METALS Similarity of ions & formulae of alkali-earth metals. Importance of alkali-earth metals | At the end of the lesson, the learner should be able to: i) Write the formulae of the OH ⁻ , O ⁻² and Cl ⁻ of alkali-earth metals. ii) Write the word and symbol equations of the reactions of alkali-earth metals with air, water and chlorine. iii) Explain the uses of alkali-earth metals. | CLASS DISCUSSION On:- formulae of compounds group II elements. -writing equations for the reactions of group II elements. - explaining the uses of the elements. | Periodic Table chart, charts on formulae of group II metal OH ⁻ , O ⁻² and Cl ⁻ . Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 132-139. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 54-66 |

| | | | | | | |
|---|-----|---|---|---|--|--|
| 6 | 1 | <p>HALOGENS</p> <p>Electron configuration of F and Cl atoms, gradation in size of atoms and ions</p> | <p>At the end of the lesson, the learner should be able to:</p> <p>i) Write the electron configuration of F & Cl atoms.</p> <p>ii) Explain the gradation in size of group 7 atoms and ions.</p> | <p>CLASS DISCUSSION</p> <p>On:- Listing and identifying the elements in P.T.</p> <p>- Formation of ions.</p> <p>- ionization energies of group 7 elements.</p> | <p>- Periodic Table chart.</p> <p>- Chart on I.E. of group 7 elements</p> <p>Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151.</p> <p>2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81</p> | |
| | 2&3 | <p>HALOGENS</p> <p>Physical properties</p> <p>- Reactions with metals - Na, Zn, Fe and water</p> | <p>At the end of the lesson, the learner should be able to:</p> <p>i) Explain the physical properties of group 7 elements</p> <p>ii) Explain the reactions of group 7 elements with H₂O, metals such as Na, Zn and Fe.</p> | <p>CLASS DISCUSSION</p> <p>On:- Preparation of Cl₂ gas.</p> <p>- Physical properties of Cl_{2(g)}</p> <p>- Its reactions with water, litmus, metals- Na, Zn, & Fe.</p> | <p>Periodic Table chart, charts on Physical and chemical properties of group 7 elements.</p> <p>Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151.</p> <p>2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81</p> | |
| | 4 | <p>HALOGENS</p> <p>Similarity of ions & formulae of compounds.</p> <p>Importance of F, Cl, Br, and Iodine</p> | <p>At the end of the lesson, the learner should be able to:</p> <p>i) Write the formulae of compounds of group 7 elements.</p> <p>ii) Describe the importance of group 7 elements.</p> | <p>CLASS DISCUSSION</p> <p>On:- formulae of compounds group 7 elements.</p> <p>- writing equations for the reactions of group 7 elements.</p> <p>- explaining the uses of the elements.</p> | <p>Periodic Table chart, charts on formulae of group 7 ions & compounds.</p> <p>Ref: 1. Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 139-151.</p> <p>2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 66-81</p> | |

| | | | | | |
|---|-----|---|--|--|--|
| 7 | 1 | NOBLE GASES (He, Ne, & Ar) Electron arrangement & gradation in size of atoms. Electron arrangement as basis of low reactivity | At the end of the lesson, the learner should be able to: i) Explain the unreactive nature of the noble gases in terms of their electron arrangement. ii) Explain the importance of noble gases. | CLASS DISCUSSION On:- Listing and identifying the elements in P.T. -atomic structure, radii & ionization energies of group 7 elements. Physical properties & uses of Noble gases. | - Periodic Table chart. - Chart on the summary of physical properties of noble gases. Ref: 1.Sec. Chem. F1&2 Teachers Bk, KIE: KLB. pp. 151-153. 2. Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 81-85. |
| | 2&3 | PROPERTIES AND TRENDS ACROSS A PERIOD Period 3 elements. -Physical & chemical properties of period 3 elements. | At the end of the lesson, the learner should be able to: i) Identify the elements of period 3 in the P.T. ii) Describe the physical properties of the period 3 elements. iii) Explain the reactions of period 3 elements with O ₂ , H ₂ O & dil. Acids. | CLASS DISCUSSION On:- Listing and identifying the elements in P.T. -Physical properties of period 3 elements. -chemical properties of period 3 elements. | Periodic Table chart, charts on physical properties of period 3 elements. Ref: Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 85-95 |
| | 4 | PROPERTIES AND TRENDS ACROSS A PERIOD Electron arrangement of period 3 elements. -Importance of noble gases | At the end of the lesson, the learner should be able to: i) Write the electron arrangement of period 3 elements. ii) Explain the trends in physical and chemical properties of elements in a period. | CLASS DISCUSSION On:- Listing and identifying the elements in P.T. - summary of the properties of period 3 elements. - importance of noble gases. | Periodic Table chart. Charts on At. Size, I.E., electronic configuration of period 3 elements. Ref: Principles of Chem. F2, By Muchiri & Maina Pezi Pub. Ltd pp. 85-95 |

APPENDIX III

CLASS EXPERIMENT/DEMONSTRATION LESSON PLAN

SCHOOL..... DATE.....

CLASS/FORM..... TIME.....

TOPIC.....

SUB-TOPIC.....

OBJECTIVES.....

.....

.....

| TIME | CONTENT | LEARNING ACTIVITIES | LEARNING RESOURCES |
|---------|--|---|--|
| 5 mins | <u>INTRODUCTION</u> Review the previous work on the sub-topic. ----- ----- | -Question and Answer -Demonstration | List any resource to be used. |
| 10 mins | <u>LESSON DEVELOPMENT</u> <u>STEP I:</u> Procedure of the experiment -Title -Aim -Instructions -Table of results/Observations | <u>CLASS EXPERIMENT</u> <u>/DEMONSTRATION ON:</u> ----- ----- Note taking Explanation Clarification/demonstration | - C/W/board. - Handout if any. Reference(s) |
| 40 mins | <u>STEP II</u> Experiment/Demonstration | PERFORMING THE EXPERIMENT/DEMONSTRATION | List the equipment, apparatus and the reagents to be used in the experiment. |

| | | | |
|---------|--|---|---|
| 20 mins | <p><u>STEP III</u> <u>DISCUSSION</u> <u>DEDUCTIONS and EXPLANATIONS</u></p> <p>From observations/results, the following points will be discussed. (i)----- (ii)-----</p> | <ul style="list-style-type: none"> -Clean up - Question and Answer -explanations -note taking -Drawing, etc. | <p>Results/observations</p> <p>Reagents/apparatus, References</p> |
| 5 mins | <p><u>CONCLUSION</u> Refer to your stated objectives when writing this step. -Decide best to check achievement of the objectives</p> <p><u>ASSIGNMENT</u> Indicate the assignment to be given.</p> <p><u>REMARKS</u> This should be written at the end of teaching the lesson.</p> | <p>May be- Q&A, highlighting, summarizing.</p> | <p>Reference(s)</p> |

APPENDIX IV

THEORY LESSON PLAN FORMAT

SCHOOL..... DATE.....

CLASS/FORM..... TIME.....

TOPIC.....

SUB-TOPIC.....

OBJECTIVES.....

.....

.....

| TIME | CONTENT | LEARNING ACTIVITIES | LEARNING RESOURCES |
|---------|--|--|---|
| 10mins | <u>INTRODUCTION</u> Review the previous work on the sub-topic. ----- ----- | -Question and Answer | List any resource to be used. |
| 20 mins | <u>LESSON DEVELOPMENT</u> <u>STEP I:</u> - content points on objective (i) | <u>CLASS DISCUSSION ON:</u> ----- ----- Note taking Explanation Clarification/demonstration | - C/W/board. - Handout if any. Reference(s) |
| 20 mins | <u>STEP II</u> - content points on objective (ii) | Question & Answer Explanations Note taking | Charts on:----- ----- ----- ----- ----- Reference(s) |

| | | | |
|---------|---|--|---|
| 15 mins | <u>STEP III</u> - content points objective (iii) | - Question and Answer -explanations -note taking -Drawing, etc. | Periodic Table Chart References |
| 10 mins | <u>STEP IV</u> Exercise | Supervised Practice Doing the Exercise | C/w/board Reference(s) |
| 5 mins | <u>CONCLUSION</u> Refer to your stated objectives when writing this step. -Decide best to check achievement of the objectives <u>ASSIGNMENT</u> Indicate the assignment to be given. <u>REMARKS</u> This should be written at the end of teaching the lesson. | May be- Q&A, highlighting, summarizing. | References Notes Reference(s) |

APPENDIX V – STUDENT ACHIEVEMENT TEST - (PRE-TEST)

This test paper consists of 5 questions. Answer all questions in the spaces provided. Do not write your name anywhere on this paper.

County..... School..... Adm. No.....

Type of school (Tick (√) as appropriate). Boys only () Girls only ()

Mixed () if mixed indicate whether B () or G ()

DATE.....

TIME: 1HOUR

1. The following table gives the structures of five different atoms. Study it and answer the questions that follow. (A, B, C, D, and E do not represent the actual symbols of the elements).

| Atom | Protons | Electrons | Neutrons |
|------|---------|-----------|----------|
| A | 5 | 5 | 6 |
| B | 9 | 9 | 10 |
| C | 10 | 10 | 11 |
| D | 15 | 15 | 16 |
| E | 10 | 10 | 12 |

(a) What is the mass number of atom B?..... (1 mark)

(b) Which of the atoms has a mass number of 11?..... (1mark)

(c) Which of the atoms represent isotopes of the same element?..... (1mark)

(d) Give a reason for your answer in (c) above..... (2marks)

(e) What is the atomic number of atom D?..... (1mark)

2. Five elements A, B, C, D and E have the electronic arrangements shown thus:

A- 2,8,1 B- 2,8,8,2 C- 2,7 D- 2,8,2 E- 2,8,8

The letters do not represent the actual symbols of the elements.

(a) Which two elements belong to the same group? Give a reason for your answer.

..... (2marks)

(b) Which element is an alkali metal? Give a reason for your answer.....

..... (2marks)

(c) Which of the elements is a highly reactive gas? Give the name of the group to which it belongs..... (2marks)

(d) Which of the elements is the most unreactive?..... (1mark)

(e) Which of the elements are metals?..... (1mark)

3. The table below gives the atomic numbers of the elements A, B, C, D, E, F and G. Study it and answer the questions that follow. The letters do not represent the actual symbols of the element.

| Element | A | B | C | D | E | F | G |
|---------------|----|----|----|----|----|----|----|
| Atomic number | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

(a) Which element belongs to group II of the Periodic Table?..... (1mark)

(b) Which element will not form an oxide? Explain..... (2marks)

(c) Give the type of structure and bonding that is present in element A..... (2marks)

(d) The elements represented by F and G have very little tendency to form covalent bonds. Explain..... (2marks)

(e) Which two elements will react most vigorously with each other? Explain..... (2marks)

.....

4.(a) What is the pH scale?.....(2marks)

(b) (i) State whether the solutions which have the following pH values are acidic, basic or neutral: (3marks)

pH= 6..... pH= 2..... pH= 12.....pH=7.....

pH=8.....

(ii) Which of the pH values listed above is of; (2marks)

I) a strong acid.....

II) a weak base.....

III) a strong base

IV) a weak acid.....

5. The table below shows the electronic arrangements of the ions of elements A to J. Study it and answer the questions that follow. The letters A to J are not the actual symbols of the elements.

| Element | Ion | Electronic arrangement of ion |
|---------|-----------------|-------------------------------|
| A | A ⁺ | 2,8 |
| B | B ²⁺ | 2,8,18 |
| C | C ⁻ | 2,8 |
| D | D ²⁺ | 2,8 |
| E | E ⁺ | 2 |
| F | F ⁺ | 2,8,8 |
| G | G ²⁺ | 2,8,8 |
| H | H ⁻ | 2,8,18,8 |
| I | I ³⁺ | 2,8 |
| J | J ⁻ | 2,8,8 |

(a) Write the electronic arrangement of the neutral atom of element E.

(1 mark)

.....

(b) Give the atomic number of element D. (1 mark)

(c) Give three elements that belong to the same group of the Periodic Table. (1 mark)

.....

(d) State any four elements that belong to the same period of the Periodic Table. (1 mark)

.....

(e) State two the non-metallic elements. Give a reason for your choice. (2 marks)

.....

(f) Write the formula of the compound that would be formed between D and J. (2 marks)

.....

(g) Which would be larger, the atomic radius of E or its ionic radius? Explain. (2 marks)

.....

APPENDIX VI – STUDENT ACHIEVEMENT TEST - (POST TEST)

This test paper consists of 4 questions. Answer all the questions in the spaces provided. Do not write your name anywhere on this paper.

County..... School..... Adm. No.....

Type of school: (Tick (√) as appropriate). Boys only () Girls only ()

Mixed () if mixed indicate whether B () or G ()

DATE.....

TIME: 1 HOUR

1. The grid below shows part of the Periodic Table. Use the information in the grid to answer the questions that follow. The letters do not represent the actual symbols of the elements.

| | | | | | | | | | | | | | | | |
|---|---|--|--|--|--|--|---|--|--|---|---|---|---|---|--|
| A | | | | | | | | | | | | | | | |
| D | | | | | | | | | | F | G | C | H | B | |
| | | | | | | | | | | | | | | | |
| K | L | | | | | | M | | | | | | | | |
| | | | | | | | | | | | R | Q | | | |
| P | | | | | | | | | | | | | | | |

a) Giving reasons select:

(i) An element that can form an ion with a charge of -2. (2 marks)

.....

(ii) The metallic element with the lowest melting point. (2 marks)

.....

(iii) The non-metallic element with the highest melting point. (2 marks)

.....

(b) Write down the formula of:

(i) The chloride of R. (1 mark)

(ii) The oxide of P. (1 mark)

(c) Explain the following observations:

(i) L is a hard solid with higher melting point than K. (1 mark)

.....

.....

(ii) The fourth ionization energy of F is much greater than the fourth ionization energy of C.

.....

..... (1 mark)

(d) Select any two elements which when combined:

(i) form a compound that conduct electricity in both fused state and in solution.

..... (1 mark)

(ii) and dissolved in water form an acidic solution..... (1 mark)

2. Chlorine is bubbled through aqueous solutions containing fluorides, bromide and iodide ions in turn. Enter the observations you would expect to make and give an explanation in each case in the table below. (6 marks)

| Solutions of | Observation | Explanation |
|---------------|-------------|-------------|
| Fluoride ions | | |
| Bromide ions | | |
| Iodide ions | | |

3. (a) The information in the table below shows the ionization energies of the elements marked A, B, and C. Use it to answer the questions that follow.

| Element | First ionization energy KJmol^{-1} |
|---------|---|
| A | 494 |
| B | 519 |
| C | 418 |

(i) Which element has the smallest atomic radius? Explain. (2 marks)

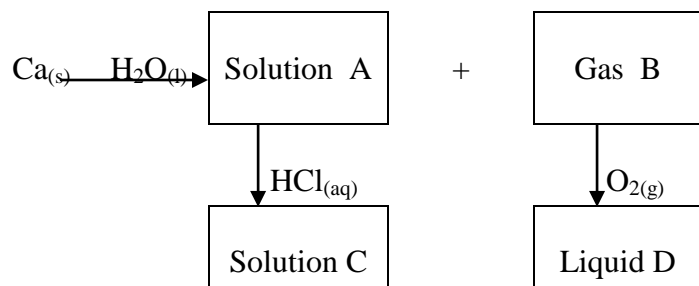
.....

(ii) Which element has the lowest melting and boiling points? (1 mark)

(iii) Which element would be a better conductor of both heat and electricity? Explain. (2 marks)

.....

(b) The reactions of calcium are typical of a group 2 element. Write the formulae for substances A – D shown in the flow chart below. (8 marks)



A.....

B.....

C.....

D.....

4. An imaginary new element called kenyanium (symbol, Ke) has been discovered. The element is a soft solid, which is easily cut with a knife to reveal a shiny surface that soon tarnishes. It reacts violently with water to form a highly inflammable gas and a strongly alkaline solution.

(a) To what group of the Periodic Table would you assign the element? (1 mark)

(b) Give a symbolic equation of the reaction between the element and water. (1 mark)

.....

(c) Would you expect the element to react with chlorine? If so, explain and give the formula of the expected product. (2 marks)

.....

.....

(d) Give the formulae for the kenyanium: (4 marks)

(i) oxide..... (ii) carbonate..... (iii) nitrate.....

(e) What would be the best way to store the element? Give a reason for your answer. (2 marks)

.....

.....

APPENDIX VII – TEACHERS’ QUESTIONNAIRE

The purpose of this questionnaire is to obtain information about the effect of chemistry practicals on learners’ performance in chemistry in Kenya. Your school is one of those that have been sampled for the study. Do not indicate your name on the questionnaire. Please answer all the questions honestly.

Please answer the questions by ticking (✓) in the brackets or write in the spaces provided.

County..... School.....

Type of school: Boys only () Girls only () Mixed()

Section A - Teacher Expectations

1. How would you rate the level of discipline among your students? -----

5= very disciplined

4= disciplined

3= not sure

2= undisciplined

1= very undisciplined

2. How would you rate the attitude of your students towards the following?

5= excellent

4= good

3= fair

2= poor

1= negative

Respond by ticking (✓) in the column with most appropriate number depending on how you rate each of the following statements.

| | Statements | 5 | 4 | 3 | 2 | 1 |
|---|--------------------------|----------|----------|----------|----------|----------|
| a | Science subjects | | | | | |
| b | Chemistry subject | | | | | |
| c | Chemistry assignments | | | | | |
| d | Chemistry practicals | | | | | |
| e | Chemistry theory lessons | | | | | |

3. How would you rate your students in terms of the following criteria?

5= very high 4= high 3= average 2= low 1= very low

Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

| | Statements | 5 | 4 | 3 | 2 | 1 |
|---|---------------------------------|----------|----------|----------|----------|----------|
| a | Academic ability | | | | | |
| b | Academic ability in sciences | | | | | |
| c | Academic ability in chemistry | | | | | |
| d | Ability in chemistry practicals | | | | | |

4. How would you rate your students in terms of the following characteristics?

5= very strong 4= strong 3= average 2= weak 1= very weak

Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

| | Statements | 5 | 4 | 3 | 2 | 1 |
|---|---|----------|----------|----------|----------|----------|
| a | Making accurate observations | | | | | |
| b | Interest in doing investigation | | | | | |
| c | Using theory when doing investigations | | | | | |
| d | Keeping neat and accurate records | | | | | |
| e | Ability to make accurate interpretation and predictions | | | | | |
| f | Eagerness to investigate after school | | | | | |
| g | Eagerness to relate observations to theory work | | | | | |

5. The following teaching/ learning resources in your school are rated as adequate. Do you: **5**=(Strongly Agree), **4**=(Agree), **3**=(Not Sure), **2**=(Disagree), **1**=(Strongly Disagree)? Respond by ticking (√) in the column with most appropriate letter(s) depending on how you feel about each of the following resources.

| | Statements | 5 | 4 | 3 | 2 | 1 |
|---|--|----------|----------|----------|----------|----------|
| a | Chemistry laboratory/s - (space and equipment) | | | | | |
| b | Chemistry apparatus and reagents | | | | | |
| c | Relevant chemistry text books | | | | | |
| d | Classrooms | | | | | |
| e | Qualified chemistry teachers | | | | | |
| f | Time for teaching chemistry | | | | | |
| g | Time for chemistry practicals | | | | | |

Section B – Teacher practices

1) How frequently do you adopt the following teaching strategies while teaching chemistry to your students?

5= very frequently 4= frequently 3= occasionally 2= never 1= I don't know

Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

| | Statements | 5 | 4 | 3 | 2 | 1 |
|---|--|---|---|---|---|---|
| a | Discussion only | | | | | |
| b | Demonstration experiment only | | | | | |
| c | Demonstration experiment and discussion | | | | | |
| d | Demonstration experiment in the classroom | | | | | |
| e | Class Experiment of 1or 2 students per group | | | | | |
| f | Class Experiment of >5 students per group | | | | | |

2) What percentage of your chemistry lessons is chemistry practicals? Respond by ticking (√) in the appropriate space.

100% () 75% () 50% () 25% () 0% ()

3) How much of your chemistry lessons is student chemistry practicals? Respond by ticking (√) in the appropriate space.

100% () 75% () 50% () 25% () 0% ()

4) How much of your chemistry lessons is teacher demonstrations? Respond by ticking (√) in the appropriate space.

100% () 75% () 50% () 25% () 0% ()

5) How would you rate the following statements about chemistry practicals? Indicate: **5**=(Strongly Agree), **4**=(Agree), **3**=(Not Sure), **2**=(Disagree), **1**=(Strongly Disagree)? Respond by ticking (√) in the column with most appropriate letter(s) depending on how you feel about each of the following statements.

| | Statements | 5 | 4 | 3 | 2 | 1 |
|---|---|----------|----------|----------|----------|----------|
| a | Chemistry practicals increase understanding | | | | | |
| b | Chemistry practicals increase enjoyment | | | | | |
| c | Pressure to cover syllabus is an obstacle to chemistry practicals | | | | | |
| d | Pressure on teachers to ensure good grades is an obstacle to chemistry practicals | | | | | |
| e | Chemistry practicals increase achievement of good grades | | | | | |
| f | Chemistry practicals reduce syllabus coverage | | | | | |
| g | Chemistry practicals are humdrum (monotonous) and routine, rather than engaging or inspiring. | | | | | |
| h | Chemistry practicals drills and practices only for passing examinations | | | | | |
| i | Teachers' work load is an obstacle to chemistry practicals | | | | | |
| j | Large numbers of students are obstacles to chemistry practicals | | | | | |

Thank you

APPENDIX VIII – STUDENTS’ QUESTIONNAIRE

The purpose of this questionnaire is to obtain information about the effect of chemistry practicals on learners’ performance in chemistry in Kenya. Your school is one of those that have been sampled for the study. Please answer the questions by ticking (✓) in the brackets or write in the spaces provided.

School..... Adm. No.....

Date..... County.....

Type of school: Boys only () Girls only () Mixed ()

Section A - Students Characteristics

1. How would you rate the level of discipline among students in your class? -----

5= very disciplined

4= disciplined

3= not sure

2= undisciplined

1= very undisciplined

2. How would you rate your attitude towards the following?

5= excellent

4= good

3= fair

2= poor

1= negative

Respond by ticking (✓) in the column with most appropriate column depending on how you rate each of the following statements.

| | Statements | 1 | 2 | 3 | 4 | 5 |
|---|--------------------------|----------|----------|----------|----------|----------|
| a | Science subjects | | | | | |
| b | Chemistry subject | | | | | |
| c | Chemistry assignments | | | | | |
| d | Chemistry practicals | | | | | |
| e | Chemistry theory lessons | | | | | |

3. How would you rate yourself in terms of the following criteria?

5= very high **4**= high **3**= average **2**= low **1**= very low

Respond by ticking (✓) in the column with most appropriate number depending on how you rate each of the following statements.

| | Statements | 1 | 2 | 3 | 4 | 5 |
|---|---------------------------------|----------|----------|----------|----------|----------|
| a | Academic ability | | | | | |
| b | Academic ability in sciences | | | | | |
| c | Academic ability in chemistry | | | | | |
| d | Ability in Chemistry practicals | | | | | |

4. How would you rate yourself in terms of the following characteristics?

5= very strong **4**= strong **3**= average **2**= weak **1**= very weak

Respond by ticking (✓) in the column with most appropriate number depending on how you rate each of the following statements.

| | Statements | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| a | Making accurate observations in chemistry practicals | | | | | |
| b | Interest in doing investigations in chemistry | | | | | |
| c | Using theory when doing investigations in chemistry | | | | | |
| d | Keeping neat and accurate records of chemistry practicals | | | | | |
| e | Ability to make accurate interpretation and predictions during chemistry practicals | | | | | |
| f | Eagerness to do science investigations after school | | | | | |
| g | Eagerness to relate observations to theory work | | | | | |

Section B – Teaching/Learning Resources

- The following teaching/ learning resources in your school are rated as adequate. Do you **5**=(Strongly Agree), **4**=(Agree), **3**=(Not Sure), **2**=(Disagree), **1**=(Strongly Disagree)? Respond by ticking (√) in the column with most appropriate letter(s) depending on how you feel about each of the following resources.

| | Statements | 1 | 2 | 3 | 4 | 5 |
|---|--|----------|----------|----------|----------|----------|
| a | Chemistry laboratory/s - (space and equipment) | | | | | |
| b | Chemistry apparatus and reagents | | | | | |
| c | Relevant chemistry text books | | | | | |
| d | Qualified chemistry teachers | | | | | |
| e | Time for learning chemistry | | | | | |
| F | Time for chemistry practicals | | | | | |

2. How frequently are the following teaching methods used while chemistry is being taught in your class?

5= very frequently 4= frequently 3= occasionally 2= never 1=don't know

Respond by ticking (√) in the column with most appropriate number depending on how you rate each of the following statements.

| | Statements | 1 | 2 | 3 | 4 | 5 |
|---|---|----------|----------|----------|----------|----------|
| a | Discussion/Lecture only | | | | | |
| b | Teacher demonstration experiment only | | | | | |
| c | Demonstration experiment followed by discussion in the lab. or in class | | | | | |
| d | Demonstration experiment in the classroom | | | | | |
| e | Students experiment of 1or 2 students per group | | | | | |
| f | Students experiment of >5 students per group | | | | | |

3) What percentage of your chemistry lessons is chemistry practicals? Respond by ticking (✓) in the appropriate space.

100% () 75% () 50% () 25% () 0% ()

4) How much of your chemistry lessons is student chemistry practicals? Respond by ticking (✓) in the appropriate space.

100% () 75% () 50% () 25% () 0% ()

5) How much of your chemistry lessons is teacher demonstrations? Respond by ticking (✓) in the appropriate space.

100% () 75% () 50% () 25% () 0% ()

6. How would you rate the following statements about chemistry practicals? Indicate: **5**=(Strongly Agree), **4**=(Agree), **3**=(Not Sure), **2**=(Disagree), **1**=(Strongly Disagree)? Respond by ticking (✓) in the column with most appropriate letter(s) depending on how you feel about each of the following statements.

| | Statements | 1 | 2 | 3 | 4 | 5 |
|---|---|----------|----------|----------|----------|----------|
| a | Chemistry practicals increase understanding of chemistry | | | | | |
| b | Chemistry practicals increase enjoyment | | | | | |
| c | Chemistry practicals are an obstacle to syllabus coverage | | | | | |
| d | School timetable is an obstacle to chemistry practicals | | | | | |
| e | Chemistry practicals increase achievement of good grades | | | | | |
| f | Chemistry practicals reduce syllabus coverage | | | | | |
| g | Chemistry practicals are humdrum (monotonous) and routine, rather than engaging or inspiring. | | | | | |
| h | Chemistry practicals drills and practices only for passing examinations | | | | | |
| i | Gender of students is an obstacle to chemistry practicals | | | | | |
| j | Large numbers of students are obstacles to chemistry practicals | | | | | |

Thank you



**NATIONAL COMMISSION FOR SCIENCE,
TECHNOLOGY AND INNOVATION**

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9th Floor, Utalii House
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NAIROBI-KENYA

Ref: No.

Date:

16th April, 2015

NACOSTI/P/15/5333/5779

John Thiongo Mwangi
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on “*Effects of practical work on students’ performance in chemistry in Kenyan Public secondary Schools*” I am pleased to inform you that you have been authorized to undertake research in **Machakos and Nairobi Counties** for a period ending **31st August, 2015**.

You are advised to report to **the County Commissioners and the County Directors of Education, Machakos and Nairobi Counties** before embarking on the research project.

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


**DR. M. K. RUGUTT, PhD, HSC.
DIRECTOR-GENERAL/CEO**

Copy to:

The County Commissioner
Machakos County.

The County Director of Education
Machakos County.

National Commission for Science, Technology and Innovation is ISO 9001:2008 Certified

CC

The County Commissioner
Nairobi County.

The County Director of Education
Nairobi County.

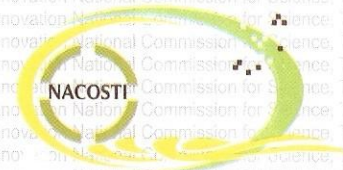
CONDITIONS

- 1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit**
- 2. Government Officers will not be interviewed without prior appointment.**
- 3. No questionnaire will be used unless it has been approved.**
- 4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.**
- 5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.**
- 6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice**

A. M. S.



REPUBLIC OF KENYA



**National Commission for Science,
Technology and Innovation**

**RESEARCH CLEARANCE
PERMIT**

Serial No. A 4914


**THIS IS TO CERTIFY THAT:
MR. JOHN THIONGO MWANGI
of UNIVERSITY OF NAIROBI, 0-100
Nairobi, has been permitted to conduct
research in Machakos , Nairobi
Counties**

**on the topic: EFFECTS OF PRACTICAL
WORK ON STUDENTS' PERFORMANCE IN
CHEMISTRY IN KENYAN PUBLIC
SECONDARY SCHOOLS**

**for the period ending:
31st August, 2015**


**Applicant's
Signature**

**Permit No : NACOSTI/P/15/5333/5779
Date Of Issue : 16th April, 2015
Fee Received :Ksh. 2000**


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