EFFECTS OF MASTERY 5Es CONSTRUCTIVIST TEACHING APPROACH ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT AND MOTIVATION TO LEARN CHEMISTRY NAKURU COUNTY, KENYA.

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Master of Education Degree in Curriculum and Instruction of Egerton University

EGERTON UNIVERSITY
AUGUST, 2023

DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and it has not been presented for any diploma or degree in this or any other university.

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DEDICATION

I dedicate this work to my loving husband Prof Alfred K. Chingi, our children; Brian, Gideon and Ruth and also to my mother who are a great inspiration to my life.

ACKNOWLEDGEMENTS

I thank God for His grace, divine guidance and provision throughout my post graduate studies. I also appreciate and sincerely thank my supervisors, Dr G.C.W. Ndeke and Dr Patriciah Wambugu for their professional guidance, constant encouragement, patience and their generous contribution to the development of my thesis. I will not forget to acknowledge and appreciate posthumously Prof S. Wachanga for the significant contribution and guidance during my proposal development. I won't forget to thank Mr. Ogolla for his professional guidance during analysis of data.

Special appreciation goes to my loving husband Prof Alfred. K. Chingi for his moral and financial support and encouragement throughout my studies. My sincere gratitude goes to NACOSTI, Rongai Sub-County Educational Office for granting me permission to carry out my research in Rongai Sub-County Schools. I also acknowledge and thank the principals, the teachers and the students who accepted to be involved pilot testing of SMQ and CAT, and also those who were involved in my actual study.

ABSTRACT

Chemistry as a science subject equips learners with knowledge and science process skills necessary for industrialization. Kenya's vision 2030 aims to transform the country into an industrialized, middle-income country providing a high quality of life to all its citizens. Therefore, there is need to offer quality education that would lead to graduates with relevant skills, knowledge, and values to industrialize and transform the country. Critical analysis of Chemistry performance in Kenya since 2013 indicates a trend of below average performance. This may be attributed to the conventional teaching methods that are mainly teacher centered. The poor performance negatively impacts the attainment of Kenya's vision 2030. Learner centered and constructivist-based teaching approaches such as Mastery learning and 5Es learning cycles have been found to promote students' achievement in science subjects. Mastery 5Es constructivist teaching approach (M5EsA) is an inquiry-based learning approach that is a hybrid of Mastery learning and 5Es constructivist learning cycle. M5EsA may help address the problem of poor performance in Chemistry though its effects have not been determined in Rongai Sub-County. Therefore, this study investigated the effects of using Mastery 5Es constructivist teaching approach on students' achievement and motivation to learn chemistry in Rongai Sub-County, Nakuru County, Kenya. Quasi experimental research was employed in which Solomon Four Non-Equivalent Control Group Design was used. Target population and accessible population were 6,762 and 3,780 respectively. Both purposive and stratified sampling techniques were used to obtain a sample of 303 students in co-educational schools. Chemistry Achievement Test (CAT) and Students' Motivation Questionnaire (SMQ) were used to collect data. Validation of the instruments was done by experts from the Department of Curriculum, Instruction and Educational Management of Egerton University. Piloting of the instruments was done in Njoro co-educational schools and reliability coefficients of 0.857 and 0.701 were obtained for CAT and SMQ respectively using KR 20 method and Cronbach's coefficient alpha. Data collected was analyzed using SPSS version 21 computer software. Hypotheses were tested using t-Test, ANOVA and ANCOVA at critical alpha value of 0.05. The findings of this study indicated that M5EsA led to increased students' achievement and motivation to learn Chemistry. This implies that if incorporated into teaching, M5EsA enhance students' achievement and motivation to learn Chemistry. Therefore, it is recommended that secondary teachers', Kenya Institute of Curriculum Development (KICD), Ministry of Education (MOE), Teacher education institutions and other education agencies should encourage the incorporation of this approach in teaching to enhance achievement in and motivation to learn Chemistry.

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LIST OF ABREVIATIONS AND ACRONYMS

BSCS	Biological Sciences Curriculum Committee
CAT	Chemistry Achievement Test
CTM	Conventional Teaching Methods
DV	Dependent Variable
INSET	In-Service Education and Training
IV	Independent Variable
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examination Council
M5EsA	Mastery 5Es Constructivist teaching approach
MLA	Mastery Learning Approach
MOE	Ministry of Education
OERs	Open Educational Resources
RSC	Royal Society of Chemistry
SMQ	Students' Motivation Questionnaire
TESSA	Teacher Education in Sub-Sahara Africa

CHAPTER ONE
INTRODUCTION

1.1. Background to the Study

Chemistry is one of the branches of science that is taught in secondary school level in Kenya. It plays a critical role in the production of human capital which is the most important resource for any nation (Aniodoh & Egbo, 2013). The quality of human resource in the field of science for instance doctors, engineers, scientists, science teacher educators and science teachers, is directly pegged on the quality of science education offered. Highly qualified personnel equipped with scientific, technical and intellectual capabilities have a great impact in propelling a nation to the desired levels of development. Chemistry education equips learners with scientific knowledge, skills and attitudes towards science and technology, therefore an essential tool for economic and technological development of any society (Abungu, 2014).

According to Wachanga (2002); Bakhshi and Rarh (2012), Chemistry occupies a central position among science subjects. This is because its knowledge helps in the learning of other subjects. For instance, the knowledge of chemicals and chemical processes aids in the understanding of various physical and biological phenomena (Bakhshi & Rarh, 2012). Chemistry also plays an important role in industrial and technological development of a nation. According to Wachanga (2005) and Royal Society of Chemistry [RSC] (2015), Chemistry has played important role in the field of medicine especially in drug discovery and pharmaceutical productivity. They further noted that chemistry knowledge has led to reduced dependence on natural material, increased efficiency in industrial processes, created efficient electronics and has enabled zero emissions of energy production. Chemistry also inculcates scientific attitudes and thought in the learners and prepares them for further vocations and specialization at higher levels of learning (Wachanga, 2005).

Although Chemistry is important for scientific and technological development and in the learning of the Physics and Biology, the trend of the students’ achievement in the subject at the Kenya Certificate of Secondary Education (KCSE) level is below average. Gender disparity also characterizes the students’ achievement in the subject since 2013 as indicated in Table 1.

Table 1: K.C.S.E National Students' Achievement in Chemistry by Gender (2013-2020)

Year	2013	2014	2015	2016	2017	2018	2019	2020
Overall % Mean score	24.57	32.55	34.36	23.71	24.05	26.88	26.09	22.51
Male % mean score	26.30	34.15	35.56	24.65	25.45	28.02	27.16	23.38
Female % Mean score	23.08	30.95	33.16	22.69	22.55	25.68	24.98	21.60

Source; Kenya National Examination Council (KNEC, 2018)

Given that the expected maximum mean score is 100%, the results shown in Table 1 indicate a continuous below average percentage mean scores in Chemistry for the years 2013 to 2020. The performance of both males and female students in chemistry is not satisfactory. It is noted from Table 1 that gender disparity in achievement in Chemistry exists in favour of the male students. The trend of poor students' achievement in Chemistry at KCSE level is not only exhibited at the national level but also in Rongai Sub-County. Table 2 indicates the performance of students in Chemistry and the other science subjects in Rongai sub-county since 2013.

Table 2: Rongai Sub-County KCSE Mean Grades in Science Subjects (2013-2021)

Subject	2013	2014	2015	2016	2017	2018	2019	2020	2021
Chemistry	2.67	3.21	3.79	4.71	4.68	3.98	4.20	4.19	4.29
Biology	3.17	3.67	4.50	4.20	3.98	4.30	3.98	4.12	4.20
Physics	3.96	3.77	3.98	4.01	4.69	4.69	3.22	4.69	4.67

Source: Rongai Sub-County Education Office, (2021)

The indicated performance in all sciences in Table 2 is below average since the maximum mean grade according to Kenya National Examination Council (KNEC) is 12 points. Table 2 indicates that performance in Chemistry for the nine years is low since 2013 with the highest average score of 4.71. The below average achievement in Chemistry by students in KCSE both at the National and Rongai Sub-County levels as indicated in Tables 1 and 2 may be attributed to inappropriate and ineffective teaching approaches employed by teachers in teaching Chemistry. This among other factors may have led to poor achievement of learners in chemistry which in turn may have led to low motivation of the students to learn chemistry.

Teaching approaches employed by teachers in classroom may affect students' academic achievement (Galaj, 2011; Wambugu, 2006). This is because a teaching approach used may affect students' motivation towards learning thereby affecting their achievement. Based on a meta-analysis of 165 research papers, Yilman et al. (2017) concluded that teaching methods affect students' motivation. Other studies have also revealed that there is significant positive relationship between students' motivation and students' academic achievement in Chemistry. Ajaja et al. (2007); Vu et al. (2022); Yong and Chow (2013) found out that Motivation greatly influenced Science achievement; motivated science students performed significantly better than the unmotivated science students. The recorded below average achievement in Chemistry by students as indicated in the Tables 1 and 2 may be due to low students' motivation to learn the subject. Motivation can be enhanced through teaching methods that actively involve students (Keraro et al., 2007).

The teaching of Chemistry in Kenya has continued to be teacher-centered thus have contributed to poor achievement in the subject by learners (Keter, 2017; Wachanga, 2002). This is because learners are not engaged in the teaching learning process (Kinya & Wachanga, 2015; Wambugu & Keraro, 2021) thus leading to lack of understanding of chemistry concepts. Therefore, there is need for the teachers to employ learner-centered and constructivist-based teaching approaches. Such approaches would not only capture learner's interest, enhance learners' participation and understanding, but also would inculcate in them critical thinking skills. This will enable them solve any problem encountered in Chemistry thus leading to higher achievement in the subject.

Mastery 5Es constructivist teaching approach (M5EsA) is a hybrid of Mastery learning and 5Es learning cycle model. Mastery Learning refers to a category of instructional methods which establishes a level of performance that all students must master before moving on to the next unit (Kairo et al., 2021; Slavin, 1987). 5Es (Engage. Explore, Explain, Elaborate and Evaluate) learning cycle model is a constructivist-based approach to learning (Subedi, 2021) in which students in small groups are given opportunity to learn through the five phases.

The first phase Engage helps students to make connections between past and present learning experiences, raises their curiosity thus ensuring that the learners to be thoughtfully involved in the concept, process, or skill to be learned (Mwanda, 2016). The second phase Exploration gives learners time and opportunities to work with materials provided in different ways. Thus, expressing their current ideas and demonstrating their abilities as they try to clarify puzzling elements of the engage phase (Bybee, 2014). Explain, is the third phase in which the concepts, practices, and abilities with which students were originally engaged and subsequently explored are made clear and comprehensible through discussions with the teacher. The teacher introduces scientific or technological concepts briefly and explicitly (Bybee et al., 2006). The fourth phase Elaborate is a phase in which students are involved in learning experiences that extend, expand, and enrich the concepts and abilities developed in the prior phases thereby transferring the concepts and abilities to related, but new situations (Bybee, 2014). Finally, the fifth phase is Evaluation which is an on-going assessment process throughout the learning cycle that helps is determining the effectiveness of each phase in enhancing the learning process. The phases can be represented as shown in figure 1.

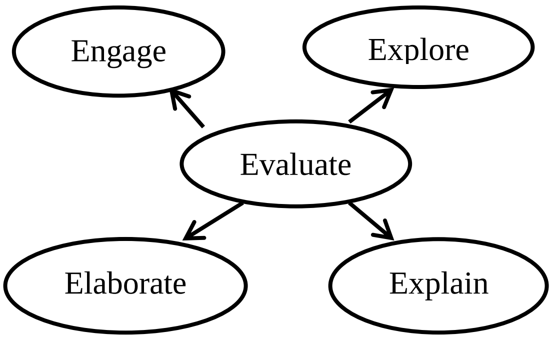

Figure 1: Bybee's 5E Learning Cycle Model

Source: (Bybee, 2002)

In an attempt to improve the teaching-learning process of Chemistry in secondary schools, several studies have been carried out to determine the effects of teaching methods and approaches on students' academic achievement. Studies have been carried out on mastery learning in order to find out its effect on students' academic achievement and motivation. Studies by Keter (2013); Damavandi and Kashani (2010); Mitee and Obaitan (2015) found out that motivation and academic levels of the students taught using mastery learning teaching approach were significantly higher than those for the students taught using Conventional Teaching Methods.

Other studies have been carried out to investigate the effects of constructivist 5Es learning cycle model on students' academic achievement. These include Uzezi (2017); Umahaba (2018); Njoroge et al. (2014). The results of these studies indicated that there was higher academic achievement when students are taught using this approach than when the Conventional Teaching Methods are used. However, there is limited documentation on studies carried out to investigate the effects of using mastery 5Es learning constructivist teaching approach on students' academic achievement and motivation.

The current study is informed by the results obtained from mastery learning and the inquiry based 5Es learning cycle studies. Therefore, M5EsA being a hybrid of the two teaching approaches may reap the benefits associated with each approach. M5EsA involved breaking down of subject matter into units with predetermined objectives to be mastered by the students. Students were given quizzes at the end of each unit where they must demonstrate mastery of a minimum score of 80%, before moving on to new material (Kulik et al., 1990). Students who did not achieve mastery received remediation through tutoring, peer monitoring, small group discussions, or additional assignments (Aggarwal, 2004; Kairo et al., 2021). Additional time for learning was prescribed for those requiring remediation and the cycle of studying and testing continued until mastery was achieved. Learning of the units was guided through 5Es learning cycle whereby students in small groups in each lesson went through activities sequenced in the five phases. Therefore, students got opportunities to create their understanding together.

The study focused on the topic "Effect of electric current on substances" in chemistry. This is a topic taught in Form Two in Kenyan secondary schools. The topic forms the foundation of Electrochemistry and has been identified to pose problems to students (Garnett & Treagust, 1992; Yilmaz et al., 2002) yet it plays important role in different types of curricula and in everyday life (Karamustafaoglu, 2015). It is also noted in KNEC council report (KNEC, 2018) that Electrochemistry question 3 in Chemistry paper 1 (233/1) was poorly performed since learners could not identify and state the uses of the different parts of a dry cell. Therefore, there is need to build a good understanding and raise students' motivation to learn the topic. This may lead to improved performance not only in the topic but also in Chemistry. This study investigated the effects of M5EsA on students' achievement and motivation to learn the topic. The results obtained would then be generalized to Chemistry.

1.2. Statement of the Problem

Chemistry is important for industrial and technological development of a nation because it equips the human capital with necessary knowledge, science process skills and values (A bungu, 2014). Chemistry also occupies a central position thus its knowledge helps in the learning of other science subjects (Wachanga, 2005). Despite its significance in the community and its role in the learning of other subjects, critical analysis of students' achievement in Chemistry in the Kenya Certificate of Secondary School Education (K.C.S.E) for the last seven years both at the national level and in Rongai Sub-County has continued to be unsatisfactory. Gender disparity in the students' achievement in Chemistry in favour of the male child has also been noted. This may have led to both male and female students' low motivation to learn Chemistry. This could be attributed to the use of Conventional Teaching Methods (CTM) which may be ineffective thus leading to students' poor motivation and low chemistry achievement. Although mastery learning approach combined with 5Es learning cycle constructivist approach use in teaching could improve students' academic achievement and motivation, its effects in chemistry achievement and motivation have not been documented. Therefore, this study investigated the effects of M5EsA on students' academic achievement and motivation to learn Chemistry.

1.3. Purpose of the Study

This study aimed at investigating the effects of M5EsA on students' achievement and motivation to learn Chemistry in Rongai Sub-County. This study also investigated whether gender had an effect on students' achievement and motivation to learn Chemistry when taught using M5EsA.

1.4. Objectives of the Study

The study was guided by the following specific objectives;

i. To determine the effects of using mastery 5Es constructivist teaching approach on students' academic achievement in Chemistry.
ii. To determine the effects of using mastery 5Es constructivist teaching approach on students' motivation to learn Chemistry.
iii. To determine whether students' achievement in chemistry when taught using M5EsA is gender dependent.
iv. To determine whether students' motivation to learn Chemistry when they are taught using M5EsA gender dependent.

1.5. Hypotheses of the Study

This study was guided by the following four hypotheses;

$H_0$1. There is no statistically significant difference in students' achievement in Chemistry between students who are taught using M5EsA and those who are taught using CTM.

$H_0$2. There is no statistically significant difference in students' motivation to learn Chemistry between those who are taught using M5EsA and those who are taught using CTM.

$H_0$3. There is no statistically significant difference in achievement in Chemistry between boys and girls who are taught using M5EsA.

$H_0$4. There is no statistically significant difference in motivation to learn Chemistry between boys and girls who are taught using M5EsA.

1.6. Significance of the Study

These findings of this study are likely to provide information to the different stake holders of education on the effects of using M5EsA on students' chemistry achievement and motivation to learn the subject. It is also likely to provide information on the effect of gender on the students' chemistry achievement and motivation when M5EsA is used. Chemistry teachers may adopt this teaching approach and therefore influence the way they will organize the content, teaching-learning activities and evaluation process. This in turn will enable learners to construct their own knowledge hence enhancing achievement and motivation in the subject. Teacher educators may incorporate the use of M5EsA in their training methodology course. The Kenya Institute of Curriculum Development (KICD) may recommend the use of this approach in the teaching of chemistry in secondary schools and may use the findings in the production and vetting of chemistry materials that will embrace M5EsA. The findings may also be used as reference for further researches in science education.

1.7. Scope of the Study

This study investigated the effects of M5EsA on students' chemistry achievement and motivation to learn Chemistry for five weeks in Rongai sub-county co-educational schools. Effects of gender on achievement and motivation to learn Chemistry when M5EsA was used was also investigated. The study covered a selected topic in Chemistry; "Effects of electric current on substances". This is because the topic has been identified to pose problems to students and have contributed to the poor students' achievement in Chemistry. Therefore, the study involved Form Two chemistry students in co-educational sub-county schools in Rongai sub-county, Nakuru County, Kenya. In this study the researcher was concerned with the use of M5EsA and CTM, their effects on achievement and motivation in Chemistry and whether the effects would be affected by gender.

1.8. Limitations of the Study

These refer to those characteristics of design or methodology that impacts or influence the interpretation of the findings from the research (Price & Murnan, 2004). The following are the limitations of this study;

(i) This study involved students in Rongai sub-county co-educational secondary schools. Therefore, the findings will be generalized to students in co-educational schools in Rongai sub-county and those with similar characteristics in other parts of the country.

(ii) This study determined the effects of M5EsA on students' achievement and motivation to learn the topic effect of electric current on substances. Therefore, generalization of the results will be with caution to Chemistry as a subject.

1.9. Assumptions of the Study

In this study the assumptions that were made included the following;

(i) Chemistry teachers had sincere interest to participate in this research, they were willing to cooperate with the researcher and used the guidelines, procedures, apparatus and the teaching approach given by the researcher.

(ii) The information that the students gave in the SMQ about their feelings, perceptions, and judgments were true.

1.10. Operational Definitions of Terms

The following are the operational definitions of terms used in this study.

Achievement: This refers to a thing done successfully with effort, skill, or courage (Oxford dictionary). It also refers to the ability to perform tasks in the lower and higher order skills as an outcome of an instructional process (Gronlund, 1993). In this study it means the cognitive, competences that enable a learner to perform well in chemistry and was measured by the scores attained in the CAT.

Conventional Teaching Methods (CTM): These refer to the teaching using chalk and boards for teachers; pens and papers for the learners (Mukiri & Ireri, 2018). In this study conventional teaching methods implied the teaching methods in which teacher uses such as teacher demonstration, lecture, class experiments and questions and answer methods.

Gender; refers to the role of a male or a female in a society, also referred as gender role (Newman, 2018). In this study it refers to the difference between boys and girls in socio-cultural aspects rather than physical difference only.

Effect; refer to a change that somebody or something causes in somebody or something else (Welhemeier et al., 2000). In this study effect refers to the changes that would be on students' achievement and motivation in Chemistry upon the administration of the use of M5EsA in teaching.

Mastery learning; Refer to a category of instructional methods which establishes a level of performance that all learners must master before moving on to the next unit (Slavin, 1987). This study mastery learning as an instructional method in which a level of 80% performance must be mastered before moving to the next unit.

5E Learning cycle: This is an instructional model based on the constructivist approach to learning, which says that learners construct new ideas on top of their old ideas (Bybee, 2014). In this study, this is a constructivist-based approach to learning which allows learners to create their understanding through learning activities and experiences provided by teachers through five phases denoted by 5Es; engage, explore, explain, elaborate and evaluate.

Mastery 5Es Constructivist Teaching Approach: In this study this refers to an approach of teaching in which content to be learnt is broken down into manageable units each with its own objectives. Students were tested to check on the level of mastery of the objectives, those who did not attain the expected level went through remedial learning until they achieve the required mastery of 60% (Kulik et al., 1990). The process of learning was marked by 5 phases; engaged, explore, explain, elaborate and evaluation.

Motivation; Motivation is generally understood to denote the strength of a person's desire to attain a goal" (Schmidt et al., 2010). In this study student's motivation refers to both internal and external factors that stimulate students to continually be interested and committed to learn chemistry.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

This chapter covers the review of the relevant literature to the study. It is done in four major sections which are; significance of Chemistry, common instructional methods used in Chemistry teaching, mastery learning approach, constructivist 5Es learning model, students' academic achievement and students' motivation. Theoretical and conceptual frameworks that guide this study are also discussed in this chapter.

2.2 Significance of chemistry in the society

Chemistry education equips citizens of a nation with knowledge, science process skills and values (Abungu, 2014; Mwangi & Mwangi, 2016; Njeri, 2022) which can be used in industries, factories such as breweries, bakeries, food production and preservation just to mention a few (Kamonjo, 2023). These industries do not only manufacture goods human consumption but they also create job opportunities to many people in the community.

Chemistry knowledge forms basis for research whose findings are beneficial to man. For example, researches that boost agricultural and animal productions. Availability of insecticides and herbicides has led increased food production thus has translated to improved nutrition (Kamonjo, 2023). Through improved agriculture and animal production more and diverse food materials have been availed. Thus, have led to improved health status of members of a community.

Chemical knowledge leads to appreciation of nature which leads to conservation measures such as global warming and its relationship with forest, understanding how to control population in relation to available resources (Wachanga, 2005). Exploitation of natural resources also requires understanding of chemical processes such as reduction and oxidation.

Discovery and production of germicides, medicines and vaccines for fighting diseases have led to increased life expectancy (Royal Society of Chemistry, RSC, 2015). Chemistry knowledge has led to production of diverse synthetic materials which are used for various purposes thus making life comfortable. For example, different polymers for purposes like providing shelter, clothing, and containers for domestic and industrial purposes.

In addition to its significance to the society, in education, chemistry helps in the learning of other subjects such as Physics and Biology (Bakhshi & Rarh, 2012) since its knowledge helps in the understanding of some physical and biological concepts. Chemistry is also a career subject thus plays a great role in laying the foundation upon which further specialization is built. Therefore, there is great need to ensure students' understanding and acquisition of chemical and skills in enhanced thus greater achievement and motivation to learn Chemistry.

2.3. Instructional Approaches used in Chemistry Globally

Instructional methods comprise the principles and methods used by teachers to enable student learning. The teaching methods used by the teacher are determined by; the level of the learner, the teacher's training and qualification, the environment of the school, the facilities available and the content to be covered (Wachanga, 2005; Westwood, 2008).

Generally, the teaching methods are classified under two broad approaches for teaching; teacher centered and student centered. In Teacher-Centered Approach to Learning, teachers are the main authority figure while students are viewed as "empty vessels" whose primary role is to passively receive information via lectures and direct instruction with an end goal of testing and assessment (Diepreye &Odukoya, 2019); Rodriguez, 2012). It is the primary role of teachers to pass knowledge and information onto their students. In Student-Centered Approach to Learning, teachers and students play an equally active role in the learning process. Students' interests and 'voice' are acknowledged as central to the learning experience (Hannafin & Hannafin, 2010). The teacher's primary role is to coach and facilitate student learning and overall comprehension of material.

Success of the teaching method employed is measured by the attainment of the objectives by the learners. Studies have shown that among successful countries in teaching chemistry and other science subjects like Japan, England and America, student-centered and constructivist teaching approaches have been adopted (Nourian & Ezazi, 2016). This has been advanced by the use of technology in the teaching learning process. Teachers are able to bring chemistry to life and students are able to visualize abstract concepts and test new learned concepts in chemistry (Nourian & Ezazi, 2016). A collaborative project coordinated by the Open University UK with partners in Ghana, Kenya, Uganda, and Zambia; Teacher Education in Sub-Sahara Africa (TESSA) secondary science in 2005 was developed to support science teachers in sub-Sahara Africa on the use of interactive and constructivist pedagogical skills. At the heart of TESSA is a bank of open educational resources (OER), linked to the school curriculum, and designed to support teachers and teacher educators in developing active approaches to learning. Studies have indicated that lack of ICT infrastructure such as computers, power and internet in most schools is a major drawback to the implementation of such active approaches in sub-Sahara Africa secondary schools (Gardner et al., 2018).

2.4 Conventional Teaching Methods (CTM) in Kenya

The following are the commonly used chemistry teaching methods in Kenyan secondary schools' lecture method, discussion, teacher demonstration, class experiments, projects and field work. Atandi et al. (2019); Chebii (2019) findings revealed that teachers used a blend of lecture, group work and question and answer and demonstration methods to a larger extent.

Chemistry performance in Kenya has continued to be below average indicating that the teaching approaches employed are not effective. According to Wachanga (2005) and Keter (2013), the teaching of chemistry has continued to be expository thus may have contributed to the lack of understanding of chemistry content among the students thereby resulting in poor achievement in the subject. Even though these commonly used methods have several advantages, there are disadvantages inherent in them. For instance, Baxter et al. (2000) and Maree and Frasers (2004) caution that, a method as lecture contributes little to the development of skills, nurturing of inquiry attitudes and conceptual understandings of science.

Coakley and Sousa, (2013) explains that such teacher-centered approaches cannot according to Bloom's taxonomy (Bloom, 1956) move students beyond level 1 (remembering) where they recall relevant knowledge from the long-term memory to 2 (application and analysis) where they are able to determine how parts of a concept relate to each other and finally to 3 (synthesis) where they are able to integrate concepts and generate something new. Therefore, there is need to identify ways to make them effective or other approaches such as learner centered, inquiry based and constructivist approaches should be incorporated in the teaching of chemistry for the academic success of the students.

2.5. Mastery Learning

This is a teaching approach in which this study is based. Mastery learning refers to a category of instructional methods which establishes a level of performance that all learners must master before moving on to the next unit (Slavin, 1987; Winget & Persky, 2022). Therefore, mastery learning implies an approach in which the students are not allowed to proceed to a subsequent learning objective until they demonstrate proficiency with the current one.

2.5.1. Origin of Mastery Learning

Mastery learning is an instructional strategy which was proposed by Benjamin in 1968. Mastery learning is defined as an instructional process that provides students with multiple opportunities to demonstrate content mastery (Candler, 2010). Unlike in the traditional method of teaching, in mastery learning the unit material is taught and students' comprehension is assessed before they are allowed to move on to the next unit. Students who demonstrate mastery on this test are assigned more challenging assignments so as to extend and deepen their content knowledge while those who do not pass this test at a designated level receive a corrective instruction, followed by a summative test (Winget & Persky, 2022). According to Wambugu and Changeiywo (2008) students who fail the summative test may receive further instruction until all students finally pass or the teacher decides to move to the next unit when the majority of the class masters the unit.

2.5.2. Strategies of Mastery Learning

There are two strategies under mastery learning each being derived from different theories. These are Personalized System Instruction (PSI) and Learning for Mastery (LFM). The first system is "Keller Personalized System of Instruction" which is a self-paced learning strategy in which a student has greater control over his/her learning (Keller, 1967). It involves modularization of units and use of study guides to direct learning. PSI has the following five distinguishing features. First, it is self-pacing, second; emphasizes topic mastery, whereby a student must demonstrate mastery of each topic before progressing to the next. Third; uses lectures and demonstrations as the motivational devices rather than simple delivery of learning content. Fourth; uses textual material for the delivery of course content and fifth; uses proctors for individual tutoring and assessment (Fox, 2004).

The second strategy; Learning for Mastery is applied as communal approach that requires students to proceed at a pace controlled by the teacher (Lai & Biggs, 1994; Swanson & Denton, 1977). This idea was presented in John Carroll learning model (1963-1965) and was expanded later by Benjamin Bloom (1968). In Carroll model, classroom learning is a time-based phenomenon that is, the longer the time of learning, the higher the rate of learning will be. Bloom confirming this material believed that if the students were provided with learning opportunity and quality of instruction commensurate with their personal need, about 95% of them reach mastery learning level. Bloom converted theoretical model of Carroll to a practical model for classroom learning, so that one can provide opportunity in the classroom that all students can achieve high level of academic achievement and their differences in learning can be minimized. He introduced regular formative assessments which provides feedback on students' learning progress and assists the teacher and students to identify learning difficulties thus strategizing ways to close learning gaps (Bloom et al., 1971).

2.5.3. Principles of Mastery Learning.

In order to be to achieve mastery learning, there are two basic principles that a teacher must observe while planning to teach. The principles are; achievability and flexible-time (Laska, 1985). Achievability principle maintains that a teacher should have objective(s) that can be attained by a motivated student. According to Laska (1985) a learning objective is achievable if these three conditions are fulfilled. First, the student must have innate abilities that are necessary for attainment of the objective(s). Second, it must be feasible for the teacher to structure all the learning situations required for the student to accomplish the objective and third, the objective(s) must be assessable in order to find out whether or not the objectives have been attained. The flexible-time principle requires a teacher to devote the necessary time and effort to the teaching activity. Therefore, a teacher should be willing and have opportunity to; teach and re-teach students as often as possible to acquire the required mastery, assess and re-assess the learners as often as necessary until the accomplishment of the desired learning outcome and finally allow the students as much time as they require to achieve the intended learning outcome.

2.5.4. Effectiveness of Mastery Learning

Mastery learning has been found to have resounding success globally when implemented correctly (Guskey, 2009). Bloom (1984) in his research on group instruction, showed scores of students taught through Mastery Learning Approach were around the ninety-eighth percentile, or approximately two standard deviations above the mean. However, he argued that students taught through Mastery Learning needed more time to master more advanced material. A meta-analysis by Guskey and Pigott (1988) looked at 46 studies that implemented group-based mastery learning classrooms. Results found consistently positive effects for a number of variables including student achievement, retention of learned material, and involvement in learning activities. Another large-scale meta-analysis conducted by Kulik, Kulik and Bangert-Drowns (1990) investigated 108 studies of mastery programs being implemented at the elementary, secondary, and post-secondary level. Results revealed positive effects in favour of these teaching strategies, with students also reporting positive attitudes toward this style of learning. This study also found mastery programs to be most effective for weaker students.

Wachanga and Gamba (2004), in their study effects of using mastery learning approach on secondary school students' achievement in chemistry found that mastery learning approach facilitates students' learning in chemistry better than the regular teaching method. Damavandi and Keshani (2010) in their study effects of mastery learning method on performance and attitude of the weak students in chemistry concluded that MLA is more effective on performance of weak students in higher levels of learning than common learning methods. Keter (2013) also carried out a study to investigate the effects of cooperative mastery learning (CMLA) on students' motivation and academic achievement in chemistry and noted that motivation and academic levels of the students taught using CMLA were significantly higher than those for the students taught using conventional methods. Furo (2014) carried out a study to determine the effects of mastery learning approach on secondary school students' achievement in chemistry. The researcher noted that the experimental group performed better than the control group thus was evidenced that the approach is effective in improving students' achievement. From the study effects of mastery learning on senior secondary school students' cognitive learning outcome in quantitative chemistry (Mitee & Obaitan, 2015) it was noted that MLA is a very effective method of teaching that leads to increased cognitive learning outcome.

Several other studies carried out to investigate the effectiveness of mastery learning approach found results that are consistent with the findings of those discussed in this study. These research studies include; Agboghoroma (2014), Adeyemo and Babajide (2014), Changeiywo et al., (2008) and Yemi (2018). However, there is limited documented evidence on the effects of mastery learning on students' chemistry achievement in Rongai sub-county. This study investigated how students' chemistry achievement in the sub-county would be affected by the use of M5EsA.

2.6. The 5Es Learning Cycle

This is an instructional model based on the constructivist approach to learning, which allows learners to create their understanding through learning activities and experiences provided by teachers through five phases denoted by 5Es; engage, explore, explain, elaborate and evaluate.

2.6.1. Origin of 5Es Learning Cycle

This is an instructional model that was developed in California by the Biological Sciences Curriculum Committee (BSCS) in 1980s with its origins being traced back to the philosophy and psychology of the early 20th century Johann Herbart. It is based on Herbart's psychology that connections between students' prior knowledge and new ideas slowly form concepts that lead to character building, so the best pedagogy should allow students to discover relationships among their experiences (Bybee et al., 2006). They also noted from Herbart the importance of learners' interest development based on experience with the natural world and social interactions thus the need to give learners opportunity to do explorations using objects, organisms, events and experiments and to demonstrate their understanding by discussions with their peers and their teacher. According to Bybee (2014), the BSCS 5Es model is a direct descendant of the Atkin and Karplus learning cycle proposed in the early 1960s and used in the Science Curriculum Improvement Study (SCIS) in an elementary school in California which used the terms exploration, invention, and discovery. BSCS introduced Engagement and Evaluation phases to this SCIS model. They also renamed invention phase (introduction phase) as Exploration and discovery (concept application phase) as Explanation thus the 5Es of their learning cycle.

2.6.2. The Concept of 5Es Instructional Model

This is an instructional model that consists of the following phases: engagement, exploration, explanation, elaboration, and evaluation.

Engagement; this is part of a lesson during in which a teacher tries to get the attention and interest of the learners. The aim of this phase is to; focus students' attention on the topic, assess students' prior knowledge, inform the learners about the lesson objectives, remind the learners the concepts they already know and are going to be used in the topic, pose a question to the learners to explore in the next phase of the cycle.

Activities here may be psychological or physical and may include; asking a question, defining a problem, or showing a discrepant event (Bybee, 2014).

Explore; this phase of a lesson where students have activities with time and opportunities to resolve the disequilibrium of the engagement experience. The exploration lesson or lessons provide concrete, hands-on experiences where students express their current conceptions and demonstrate their abilities as they try to clarify puzzling elements of the engage phase (Bybee, 2014). The students in groups are at the Centre of action as they explore and find answers to the questions given while the teacher's role in the exploration phase according to Bybee is to initiate the activity, describe appropriate background, provide adequate materials and equipment, and to counter any misconceptions, that is, the teacher acts as a guide by;-answering the questions asked by the learners, pointing the students to a particular direction and asking the right questions to help the students how to proceed.

Explain; the teacher in this phase helps the students to make connections between the results of the activity and other topics. Using students' explanations and experiences, the teacher introduces scientific or technological concepts briefly and explicitly. Lecture method plays an important role in this phase as the teacher explains the concepts involved and probes the learners through questions that will allow personal understanding and scientific accepted explanations (Bybee et al., 2006). The emphasis here is to let definitions, and other concepts arise out of the experience rather than from reading.

Elaborate; students here are applying the knowledge gained in new but similar or related situations. The intention is to facilitate the transfer of concepts and abilities to related, but new situations thus the key point for this phase is to use activities that are a challenge but achievable by the students (Bybee et al., 2014). Learners' creativity takes the centre stage here to solve the problems or answer the questions given by the teacher through application of the knowledge gained.

Evaluate; this is an on-going process throughout the lessons; in engagement phase it assesses the student's prior knowledge, in exploration phase it checks on the process for instance how well the learners are using the information and provided materials, their data collection and how they are coming up with new ideas, in elaboration stage it involves checking on how well the students are able to apply the knowledge and skills obtained in solving the questions and problems given. Evaluation will lead to a new topic and a new engagement to a new process or beginning of the 5e learning cycle. It may also take the form of summative assessment in form of exams at the end of the term or continuous assessment tests (Bybee et al., 2006).

2.6.3. Effectiveness of the 5Es Instructional Model

According to Bybee et al. (2006) report, several studies carried out by different researchers on different topics in science which included energy, health, ecology, change and measurement indicated that there was evidence that 5Es learning cycle increased learners' mastery of the subject matter, led to development of scientific reasoning and cultivation of interest and attitudes about science as compared to the other instructional modes.

Tegegne and Kelkay (2023) in their study on Comparative study of using 5E learning cycle and the traditional teaching method in chemistry to improve student understanding of water concept, found out that there was a significant difference between groups in favor of the experimental group in understanding of water concepts, this is because the post-test scores for the experimental groups were higher compared to control groups.

Anil and Batdi (2015) carried out a comparative meta-analysis of 5Es learning cycle and Traditional Approaches carried out in Turkey. To compare the effects of 5Es learning cycle and traditional approaches on students' academic achievement, retention and attitude scores, the researchers selected studies and theses done between 2004 and 2014, used treatment effect method to analyze data and they found out that 5Es learning cycle has positive effect on the three variables; academic achievement, retention and attitude scores. Cakir (2017) also carried out another meta-analysis study using doctoral theses and articles of 2006- 2016 to determine the effect of 5Es learning model on academic achievement, attitude and science process skills. The results of this study showed that effect of the method applied for each dependent variable was found to favour the experimental group.

Ajaja, Urhievwenjire and Eravwoke (2012), investigated the effects of 5Es learning cycle on students' achievement in Biology and Chemistry in Nigeria. Their study revealed that 5Es learning cycle had significant effect on both biology and chemistry achievement and retention of knowledge by students when taught using the cycle, but there was non-significant difference in achievement between males and females and there was also non-significant interaction between method and sex on achievement. Uzezi (2017) also carried out a study to determine the effects of learning cycle constructivist-based approach on students' academic achievement and attitude towards chemistry in secondary schools in north-eastern parts of Nigeria, using pre-test and post-test non randomized control group quasi-experimental design found out that the cycle group significantly achieved better in chemistry scores than those taught using lecture method. Umahaba (2018) investigated the impact of 5Es learning model on academic performance in chemical equations concept among secondary school students in Katsina Metropolis in Nigeria and found out that the experimental group performed significantly higher than the control group. The results also indicated that the treatment in to gender was friendly that is, there was no significant difference in performance between the male and the female students.

Researchers in Kenya have also carried out investigations to determine the effectiveness of this teaching approach and their results are in line with the other findings elsewhere. In their study Effects of inquiry-based teaching approach on Secondary School Students' achievement and motivation in Physics in Nyeri County, Kenya, Njoroge et al. (2014) noted that the inquiry-Based Teaching (IBT) approach resulted into higher students' scores in achievement in physics. Mwanda (2016) also carried out a study in Homa bay

County to determine the effects of the constructivist instructional method on learner achievement in Biology in secondary schools. Mwanda noted the following findings; the 5Es model is more effective than the conventional methods, girls learned and performed better in Biology when taught using this instructional strategy and noted also that females have a more positive attitude towards the constructivist approach than the males.

Generally, studies have indicated positive improvement of students' academic achievement when taught using 5E learning cycle. Other studies that were conducted earlier include; Pulat (2009), Cardak et al. (2008), Baser (2008), Nuhoglu and Yalcin (2006), Akar (2005), Whilder and Shuttleworth (2004), and Lee (2003). The results of these studies are consistent with those for the studies already discussed in this chapter and thus 5Es teaching approach has been recommended as an effective teaching strategy that should be incorporated in learning institutions. However, there is a research gap that this current study would like to fill; to determine the effects of M5EsA on students' chemistry achievement and motivation that has not been carried out in Rongai sub-county.

2.7. Mastery 5Es Learning Cycle Approach (M5EsA)

This is a teaching approach that is a hybrid of the two teaching approaches; mastery learning and 5Es learning cycle model. The researcher in this study combined the advantages derived from each approach by bringing together the two approaches to form an approach to learning (M5EsA).

The content to be learnt was broken down into units that has to be mastered one at a time before the learner proceeds to learn the next unit; Benjamin Bloom stated that a learner must achieve a level of mastery; that is, 80 - 90% in the pre-requisite knowledge before moving on to learn the subsequent information (Bloom1968; Kulik et al., 1990).

Learners were also allowed to create their knowledge through inquiry-based learning activities and experiences provided by the researcher in five phases; engage, explore, explain, extend/elaborate and evaluate; 5Es learning cycle that is informed by Roger By bee (2002) model. Since there are documented evidence from the researches that the two approaches improve teaching and learning process leading to significant differences in academic achievement in favour of the experimental groups, it is likely therefore that the study will improve academic achievement in and promote learners' motivation to study chemistry.

2.8. Secondary School Students' Achievement in Chemistry

Academic achievement or academic performance in this study refers to the extent to which a student has achieved their short or long-term chemistry educational goals. Globally academic achievement is commonly measured through examinations or continuous assessments but there is no general agreement on how it is best evaluated or which aspects are most important, that is, whether skills or facts (Ward et al., 1996).

Secondary school students continue to consider chemistry as difficult to learn (Sibomana et al., 2021). This is because chemistry achievement in Kenya for the last seven years has not been satisfactory as indicated earlier in the introduction in Table 1. The highest achievement of 34.36% in the year 2015 was recorded, followed by 32.55% in the year 2014 and very low achievement of below 30% in the other years. Several factors affect chemistry academic achievement of learners in secondary schools. Such factors include individual differences, which is linked to the differences in intelligences and personality, non-cognitive factors such as motivation, attitude, self- concept and self-control. Other factors exist outside the learner but affect their academic achievement immensely. Such factors include teacher related factors as qualification, experience and motivation, teaching strategies/approaches employed, availability of teaching /learning resources and school related factors such as type and culture of the school.

Studies have been done to check on the effects of teaching approaches on academic achievement of learners of different levels in teaching and learning process .Acisli and Turgut (2011); Ajaja and Eravwoke (2012); Uzezi (2012); Njoroge et al. (2014); Mwanda (2016) carried out study to establish effect of 5E learning cycle on students' academic achievement in different subjects and found out that there was meaningful difference between the groups; experimental and control groups in favor of the experimental groups.

Many other researchers have carried out studies to establish the effect of mastery learning on academic achievement. For instance, Changeiywo et al.(2008); Agboghoroma (2014); Adeyemo and Babajide (2014) and Yemi (2018), among other have found out that mastery learning as a teaching approach leads to higher students' academic achievement. The results of such studies give indication that classroom teaching approaches employed play an important role in the learning process. This role is realized in the academic achievement of the learners. There is limited documentation of researches carried out to determine how M5EsA teaching approach would affect students' achievement in Chemistry.

2.9. Secondary School Students' Motivation to learn Chemistry.

Dornyei (1998) defines motivation as a process whereby certain amount of instigation forces arises, initiates action, and persists as long as no other force comes into play to weaken it and thereby terminating action or until the planned outcome has been reached. Williams and

Burden (1997) describe motivation as a state of cognitive and emotional arousal, which leads to a conscious decision to act, and which gives rise to a period of sustained intellectual and/ or physical effort in order to attain a previous set goal. In this study motivation refers to both internal and external factors that stimulate students to continually be interested and committed to learn chemistry.

Motivation is a key element in students' education and for the success of the overall teaching and learning process regardless of the subject (Galaj, 2011). Learning is inherently hard work; it is pushing the brain to its limits, and thus can only happen with motivation (Pintrich, 2003). Highly motivated students will learn readily while unmotivated students will learn very little thus is reflected in the students' academic achievement. Ajaja et al. (2007); Cabiling and Magday (2022) and Yong and Chow (2013) revealed that there is significant positive relationship between students' motivation and students' academic achievement. Keter (2013) also found out that motivation greatly influenced achievement in Chemistry, that is, motivated science students performed significantly better than the unmotivated science students. Therefore, the poor students' achievement indicated in Table1 indicates a generally low secondary school students' motivation to learn Chemistry.

An individual's motivation may be inspired by others or events (extrinsic motivation), or it may come from within the individual (intrinsic motivation). Students are likely to be intrinsically motivated if they attribute their educational results to factors under their own control, believe they have the skills to be effective agents in reaching their desired goals, and are interested in mastering a topic, not just in achieving good grades. Extrinsic motivation comes from influences outside of the individual. Usually, extrinsic motivation is used to attain outcomes that a person wouldn't get from intrinsic motivation. Common extrinsic motivations are rewards (for example money or grades) for showing the desired behavior, and the threat of punishment following misbehavior, competition, and a cheering crowd.

Studies discussed above, for instance, Keter (2013); Njoroge et al. (2014); Mitee and Obaitan (2015); Uzezi (2017); Umahaba (2018) have indicated that students' motivation is affected by teaching strategies and approaches employed in teaching. The results are in favour of the experimental group, that is, mastery learning and constructivist's inquiry –based learning approaches increases students' motivation. There are other studies have been carried out that indicated that students' motivation greatly affects their academic achievement. Amrai et al. (2011) in their study to explore the relationship between students' motivation and students' academic achievement found out that there was a significant positive correlation between motivation and academic achievement. Ajaja et al. (2007) found out that motivated students performed significantly higher than the unmotivated students. Eymur and Geban (2011) in their study to investigate the relationship between motivation and chemistry achievement of pre-service chemistry teachers found out that academic achievement and two intrinsic motivation sub-scales (to know and to experience stimulation) have significant positive relationship. Chow and Yong (2013) also indicated that there is a significant positive association between students' motivational orientations and science achievement.

There are no documentations in research on investigation on the effects of M5EsA students' motivation to learn Chemistry. Therefore, this study investigated the effects of M5EsA and CTM on students' motivation towards learning Chemistry and determined whether learners' had the same level f motivation when taught using both M5EsA and CTM.

2.10. Gender and Secondary School Students' Achievement in Chemistry.

Gender disparity has characterized secondary school students' achievement in Chemistry in Kenya as indicated in Table1. Females have continuously been outperformed by their male counterparts for the five years. Gender difference in performance has strongly been associated with chemistry and other sciences' achievement with male students outperforming their female counterparts (Akala, 2010; Kashu, 2014). This has generated a lot of concern for science educators.

Despite the large efforts made over the past decades to narrow the gender gap in science education, major inequalities still persist (Oladejo et al., 2021; UNESCO, 2017). Girls are disadvantaged in science as a result of multiple and overlapping factors embedded in both socialization and learning processes such as social, cultural and gender norms which influence the way females and males are brought up to learn and interact with parents, family, friends, teachers and community (UNESCO, 2017). Girls are often brought up to believe that science subjects are 'masculine', that is, they are innately inferior in their ability in sciences. Mwiigi (2014) listed lack of motivation to study Chemistry among girls and gender insensitive teaching strategies to be among the factors that contribute to this difference in performance. However, Ajaja et al. (2007) and Wambugu et al. (2010) found out that motivation effects on science students tests scores are not gender related

Studies in Chemistry has continued to yield inconsistent results and it has usually been attributed to unequal exposure of females and males to learning instructions relevant to Chemistry learning (Ajayi & Ogbeba, 2017). Different learners with different characteristics may profit from one instructional approach or method than from another. This is because of treatment interaction effort (Abonyi, 2014). Some studies have indicated that boys perform better than girls in Chemistry (Gipp, 2004; Kashu, 2014). Other studies such as; Ventura (2008), Ajayi (2016), Eze (2010) and Al-Mustapha (2014) indicates that the there is no difference in chemistry achievement for both boys and girls. However, others indicated that girls' chemistry achievement is higher than that of the boys. Such studies include Calsambis (2007), Soyibo (2009) and Abe (2011). The current study seeks to fill the gap that still exists; to investigate how gender would affect students' achievement in Chemistry when taught using M5EsA.

2.11. Gender and Secondary School Students' Motivation to Learn Chemistry

Motivation to learn chemistry benefits all students by fostering their chemical literacy, which is the capability to recognize chemical concepts, define some key-concepts, identify important scientific questions, use their understanding of chemical concepts to explain phenomena, use their knowledge in chemistry to read a short article, or analyze information provided in commercial ads or internet resources (Shwartz et al., 2006).

Dole and Sinatra (1998) describe how both cognitive and motivational learner characteristics interact within a specific learning environment to support or hinder conceptual change. Therefore, learning environment provided should enhance gender parity in order to support both girls' and boys' conceptual changes. Since some studies such as Ajaja et al. (2007); Eymur and Geban (2011); Chow and Yong (2013) have indicated that there is a positive relationship between students' motivation and their academic achievement, the continued low achievement in Chemistry by female students as compared to male students points to females lower motivation to learn Chemistry as compared to the males'.

Some studies discussed earlier, have indicated that motivation is affected by the teaching approaches affect learners' motivation to learn. Motivation of the learners in the experimental groups significantly differed from that of those in the control groups. However, they found out that motivation was not gender related. Such studies include Ajaja et al. (2007); Wambugu (2006), Keter (2013); Wambugu et al. (2010). There are limited records that indicate how gender affects students' motivation to learn Chemistry when M5EsA is used in teaching.

2.12. Theoretical Framework

Behaviorism and Constructivism theories of learning guided this study.

Behaviorism is a learning theory that only focuses on objectively observable behaviors and discounts any independent activities of the mind (Danley et al., 2014). Therefore, behaviorists lay emphasis on the role of observable behavior in determining learning. Mastery learning approach can be based on operant conditioning by B.F. Skinner. According to Skinner (1984) learning is a function of an overt behavior, that is, changes in behavior are the results of individual responses to events that occur in the environment. Based on this behavioral theory, mastery learning focuses on observable behaviors that can be measured (Baum, 2017). This theory guided this study since the material to be taught was broken into units that were mastered by learners progressively. Students were required to overtly demonstrate learning by achieving level of mastery in the pre-requisite knowledge before moving on to learn the subsequent information.

Constructivism theory places emphasize on learners' active construction of their own knowledge. Both cognitive constructivist theory by Jean Piaget (1972) and social constructivist theory by Lev Vygotsky (1978) also guided this study. Cognitive constructivists view learners as active constructors of meaning from input by processing it through existing cognitive structures and then retaining it in the long-term memory (Okere, 1996). They also lay emphasis on the importance of prior knowledge in formation of the base or foundation upon which the new knowledge is built thus meaningful learning being realized.

Cognitivist constructivist theory guided this study because in M5EsA students went through the 5Es constructivist learning cycle in which learning experiences were sequenced to provide students opportunities to take an active role in constructing his own understanding rather than receiving it from someone who knows. Ideas advocated for by this theory informed the phases of learning in this study. The engagement phase provided an opportunity for the teacher to find out what students already know or think they knew about the topic and concepts to be developed (Bybee, 2002). In the exploration phase students interacted with materials and ideas through classroom and small group discussions (Llewellyn, 2005). Thus, they acquired a common set of experiences so that they could compare results and ideas with their classmates. In the explanation phase students were provided an opportunity to connect their prior experiences with current learning and to make conceptual sense of the main ideas. This phase also provided the opportunity for the introduction new scientific terms and content information. In the elaboration phase students were provided with the opportunity to apply introduced concepts to new experiences. This phase helped students to make conceptual connections between new and prior experiences, connect ideas and deepen their understanding of concepts and processes. In the evaluation phase provided continuous and summative assessment of what students know (Bybee, 2002).

Social constructivists emphasize on how meaning and understanding grows out of social interactions (Vygotsky, 1978). Bruning, Schraw and Ronning (1999) explain that knowledge is first constructed in a social context and is then appropriated by individuals. They further posit that by collaborative elaboration learners are able to construct understanding together that would not be possible alone. Social constructivist's reason that through peer interactions, students are able to process new information in a way that is understandable to them, therefore leading to higher order thinking (Kristen et al., 2017).

Social constructivists' theory guided this study because during learning process, the outlined activities required students' participation in small groups. Students' physical or psychological collaboration so as to solve the given problems or to perform particular tasks or answer the questions provided in this study enhanced peer interactions thus enable them construct understanding together.

2.13 Conceptual Framework.

This study has been conceptualized with constructivist-based M5EsA approach and Conventional Teaching Methods (CTM) as the main independent variables while students' chemistry achievement and motivation to learn Chemistry forms the dependent variables. In an ideal situation the independent variables have direct influences on the dependent variables. That is, there is a relationship between the independent and dependent variables. However, in real situations factors such as; learners' characteristics (gender, entry behavior and age), type of school (resources), and teacher's training and experience may interfere with the relationship between independent and dependent variables if they are not controlled. These factors form the intervening variables. It is paramount that such intervening variables are controlled so that there will be no interaction effect of these variables and the independent variables on the dependent variables. Figure 2 illustrates how the intervening variables affect the relationship between the independent variables and the dependent variables.

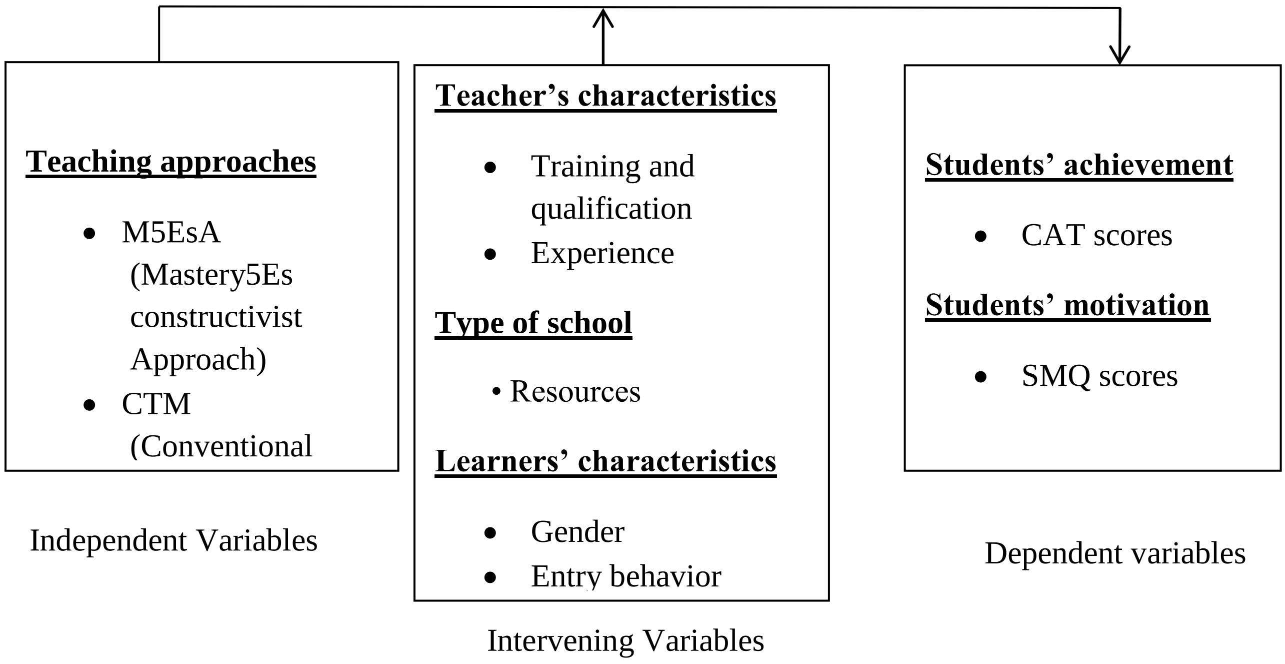

Figure 2: The conceptual framework showing the effects of M5EsA on students' achievement in and motivation to learn Chemistry

This study was carried out in public secondary schools because teachers in public secondary schools are all trained and qualified. Only schools where teachers have a teaching experience of above three years were selected for the study. Therefore, teachers' characteristics were controlled. .Chemistry teachers involved in the experimental groups were trained by the researcher on the M5EsA. In addition, they were guided by a manual that was provided by the researcher; this minimized teacher variability effect on the study. Gender could be controlled by involving boys' and girls' schools, however in this study effect of gender was studied rather than being controlled. Therefore, co-educational schools were involved in this study. Sub-County co-educational schools with similar characteristics were selected so as to minimize the effect of school characteristics such as resources on the experimental results. Learners' entry behavior was controlled since learners enrolled into Sub-County schools have approximately similar academic achievement.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1. Introduction

This chapter describes the procedures that were followed and ethical issues that were considered while carrying out the research. The research design used, target and accessible population, sampling procedures and sample size, data collection instruments and the statistical methods used in data analysis are also discussed in this chapter.

3.2. Research Design

Quasi-experimental research was used in this study in which Solomon's Four Non-Equivalent Control Group Design was used. The sampling unit used in this research was classes since there was no random assignment of students to the experimental and control groups due to the fact that secondary school classes once constituted exists as intact groups and authorities do not normally allow such classes to be broken up and reconstituted for research purposes (Gall et al., 2007; Fraenkel &Wallen, 2000). To avoid interaction of students from different groups that may contaminate the results of the study, one class from a school constituted one group hence four schools which are far apart were selected purposively in this study. The schools were randomly assigned to the control and treatment groups to control for selection and interaction (Ary et al., 1979). The conditions under which the instruments were administered were kept as similar as possible across the schools in order to control instrumentation. This was done by ensuring that the topic was covered and administering the instruments across the four schools at the same time.

The groups were organized as follows; E1 which received a pre-test, treatment (X), and then post-test, C1 which received a pre-test and post-test. On the other, E2 were not given a pre-test, but treatment(X) and post-test was given while C2 were not given a pre-test, no treatment but a post-test was given. E1 and E2 were the experimental thus were taught using M5EsA while C1 and C2 were the control groups thus were taught using CTM. This design is represented in Figure3.

E1	O_1	X	O_2
C1	O_3	_	O_4
E2	_	X	O_5
C2	_	_	O_6

Figure 3: Solomon Four Non- Equivalent Control Group Research Design.

Source: Fraenkel and Wallen (2000 p.291)

Key

O_1 and O_3 were pre-tests

O_2, O_4, O_5 and O_6 were post-tests

X was the treatment where students learn through M5EsA

E1 and E2 were the experimental groups while C1 and C2 were the control groups.

3.3. Population of the Study

The target population involved all the students in public secondary schools in Rongai Sub-County. The Sub-County was selected by the researcher because there is limited evidence of studies carried out to investigate on the effects of M5EsA on students' academic achievement and motivation in chemistry in the Sub-County. The accessible population was the form two students in public Sub-County co-educational schools in Rongai Sub-County. This accessible population constituted the sample frame from which the samples for the research were drawn. Co-educational schools were selected so as allow the researcher investigate the effect of the treatment on boys and girls learning under similar conditions. Form two students were involved because the selected topic (Effect of electric current on substances) is taught at this level in Kenyan secondary schools.

3.4. Location of the Study

This study was carried out in Rongai Sub-County in Nakuru County in Kenya. Rongai is a vast Sub-County with 52 secondary schools. There are there are four boys' and six girls' boarding schools. The rest forty-two are co-educational day/boarding secondary schools, out of which twenty-eight are public schools. Analysis of KCSE results for the last eight years for these public co-educational schools indicates very poor students' achievement in Chemistry as indicated in Table 2. There is no evidence of studies done in the Sub-County to investigate the effects of teaching approaches on students' achievement and motivation in chemistry.

Therefore, this study aimed at determining the effects of M5EsA students' achievement in chemistry and motivation to learn chemistry in this Sub-County.

3.5. Sampling Procedures and Sample size

The unit of sampling in this study was secondary school rather than individual learners because secondary schools operate as intact groups (Gall et al., 2007). The list of the Sub-County co-educational schools constituted the sampling frame. The researcher after obtaining permission from NACOSTI, Nakuru county and Rongai Sub-County educational offices visited co-educational schools.

Purposive sampling technique was used in selecting four public Sub-County co-educational secondary schools that had functional laboratories in which learners carried out the suggested activities/experiments. And also, schools with trained teachers of chemistry with a teaching experience of a minimum of three years. This was done so as to control teacher characteristics. To minimize experimental contamination (Fraenkel & Wallen, 2000), stratified sampling technique was used to select four schools from different educational wards within the Sub-County. This was to ensure that they were not close to each other.

Simple random sampling was used to assign the four schools to treatment and control groups. The schools that had more than one form two streams were taught using similar approach because of ethical reasons (Wambugu & Changeiywo, 2006). Random sampling technique was then be used to pick one stream whose data was used for analysis. The sample size for this research was 303students from the four sampled schools as shown in Table 3.

Table 3: Sample size, N per School

Group		Sample size, N
1	Experimental group (E1)	67
2	Control group (C1)	83
3	Experimental group (E2)	79
4	Control group (C2)	74
	Total	303

3.7. Instrumentation

In this research data was collected using two instruments; Chemistry Achievement Test (CAT) and Students' Motivation Questionnaire (SMQ). The two instruments were used to measure students' achievement and motivation to learn chemistry before and after the treatment.

3.7.1. Chemistry Achievement Test (CAT)

The CAT (Appendix A) was done in one hour. It measured learners' acquisition and mastery of the content taught in Chemistry. This CAT was constructed by the researcher using Secondary Chemistry students' Book 2 (2009), Secondary Chemistry Book Two teachers' guide (2009) published by the Kenya Literature Bureau (KLB), Secondary Chemistry Book 2 by Longhorn publishers and items from KCSE past papers. The test was administered as CAT 1 before the treatment. The items in the CAT1 were rearranged and administered as CAT 2 after the treatment. The CAT contained 12 items which measured concepts and principles in the sub-topics of conductors and non-conductors, electrolytes and non-electrolytes, electrolysis, and applications of electrolysis with scores allocated as indicated in Table 4.

Table 4: CAT scores allocation per sub-topic

Sub-topic	Number of items	Scores per sub-topic	Maximum scores	Minimum Scores
Conductors and Non-conductors	4	10	10	0
Electrolytes and Non-electrolytes	4	14	14	0
Electrolysis	3	24	24	0
Application of electrolysis	1	2	2	0
TOTAL	12	50	50	0

The minimum and maximum score of the CAT were 0 and 50 marks respectively. The items in CAT measured the different levels of learning in the cognitive domain such as knowledge, comprehension, analysis, synthesis and evaluation. The items were scored dichotomously as either correct or wrong.

3.7.2. Students' Motivation Questionnaire (SMQ)

The Students' Motivation Questionnaire (SMQ) appendix B was used to measure learners' motivation to learn chemistry. The researcher adapted the students' motivation questionnaire that was used by Keter (2013). The SMQ contains items on students' socio-background and psychological concepts of motivation such as curiosity, persistence, learning and performance (Deci & Ryan, 2020). The SMQ was divided into two parts; the first part captured participants' demographic information like gender, age, and name of the school while the second part contained 23, 5-point Likert scale items that were used to generate data on students' motivation to learn Chemistry. Scoring was done as Strongly Disagree; SD (1), Disagree; D (2), Neutral; N (3), Agree; A (4), and Strongly Agree; SA (5). A higher number on the scale will represent agreement with the item and a more favorable disposition of that item. The minimum and maximum score for SMQ were 23 and 115marks respectively. It was administered to E1 and C1 Groups as pre-test. The items were rearranged and administered to all the Groups as post- test.

3.7.3. Validity of Research Instruments

Validity is defined as the accuracy and meaningfulness of inferences which are based on the research results (Cohen et al., 2007). Validity refers to the degree to which results obtained from the analysis of the data actually represent the phenomena under study. Face and content validity for the instruments (CAT and SMQ) was ascertained by three experts in the Department of Curriculum, Instruction and Educational Management of Egerton University. Comments from these experts were used to improve the instruments.

3.7.4. Reliability of Research Instruments

Reliability refers to how consistently a method measures something. A measure is said to have a high reliability if it produces similar results under different conditions (Trochim, 2006). To estimate the reliability of these instruments, pilot study was conducted in a co-educational school in Njoro sub-county with similar characteristics to those in which the study was conducted.

The reliability of the SMQ was determined by computation of Cronbach's coefficient alpha. This is because the items were on a 5-point Likert scale and thus yielded a range of scores. The coefficient determines how items correlated among themselves, and hence tested the internal consistency of the instrument in measuring the construct of interest (Nkapa, 1997). Reliability coefficient of CAT was calculated using Kuder-Richardson formula 20 (KR-20). This method is suitable when test items can be scored as correct or incorrect and are of different difficulty level (Gronlund, 1993). Reliability coefficients of 0.857 and 0.701 were obtained for CAT and SMQ respectively. Thus, the two instruments' reliability coefficients were accepted because according to Fraenkel and Wallen (2000) a reliability coefficient of alpha value 0.7 and above is considered suitable to make possible group predictions that are sufficiently accurate.

3.7.5. Data Collection

The researcher obtained an ethical clearance the Egerton University Research Ethics Committee secretariat. This enabled the researcher obtain an introductory letter from Egerton University Graduate School through which a research permit from the National Commission for Science, Technology and Innovation (NACOSTI) was obtained. The researcher sort permission also from the Rongai Sub-County Director of Education. The principals and chemistry teachers of the participating schools were requested by the researcher to allow their schools to be involved in the study and their co-operation was appreciated. The researcher trained chemistry teachers in the experimental schools on the expectations and procedures of M5EsA and gave them an instructional manual (Appendix C) specifically designed for the topic "Effects of electric current on substances". To ensure that the content was covered uniformly by all the groups, teachers in the four groups adopted a common scheme of work (Appendix D) developed by the researcher. Before the treatment, data was collected using CAT1 and SMQ1 as pre-test that was administered to the experimental group I and the Control group I. The students in the experimental group I and Experimental Group II were taught using M5EsA while those in the control group I and Control group II were taught using CTM. After six weeks the post-test was administered to all the groups as CAT2 and SMQ2. Post-test provided data for all groups after the administration of the treatment.

3.8. Data Analysis

Both SMQ and CAT generated quantitative data which was analyzed with the help of Statistical Packages for Social Science (SPSS) computer program. Pre-test analysis was done using t-Tests to determine if there are differences in the students' achievement and motivation between the two groups before administration of the treatment. t-Tests were also used to determine if there was gender difference in academic achievement and motivation both before and after the treatment. t-Test was used to test differences between two means because of its superior quality in detecting differences between two means (Gall et al., 2007). ANOVA was used to analyze whether there are significant differences in the mean scores of the Groups' post-test results. ANCOVA was also used so as to take care of any initial differences in the treatment and control groups. It reduces experimental error by statistical rather than by experimental procedure (Gall et al., 2007). KCPE scores of the participants were used as a co-variate. To make reliable inferences from the data, all statistical tests were tested at threshold alpha values of 0.05. Table 5 summarizes the variables and the statistical procedures which were used in the study.

Table 5: Summary of the Variables and Statistical Tests of the study

Hypothesis	**Independent variable**	**Dependent variable**	**Type of test**
$H_0$1; There is no statistically significant difference in students' achievement in Chemistry between students who are taught using M5EsA and those who are taught using CTM.	M5EsA CTM	CAT Scores	t-Test ANOVA ANCOVA
$H_0$2; There is no statistically significant difference in students' motivation to learn Chemistry between those who are taught using M5EsA and those who are taught using CTM.	M5EsA CTM	SMQ Scores	t-Test ANOVA ANCOVA
$H_0$3; There is no statistically significant difference in achievement in Chemistry between boys and girls who are taught using M5EsA.	Gender	CAT Scores	t-Test
$H_0$4; There is no statistically significant difference in motivation to learn Chemistry between boys and girls who are taught using M5EsA.	Gender	SMQ Scores	t-Test

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter deals with presentation and discussion of the data analysis findings on the effects of Mastery 5Es Learning Cycle Teaching approach (M5EsA) on Students' Achievement and Motivation to learn Chemistry. Gender differences on students' achievement and motivation to learn chemistry when taught using M5EsA is also covered in this chapter. The results of data analysis are presented in tables and conclusions drawn indicating whether the hypotheses were accepted or rejected at a stated significance α level of 0.05.

4.2 Pre-test Results

Analysis of the pre-test enabled the researcher to assess the homogeneity of the groups before the administration of the treatment to the experimental groups as recommended by Borg and Gall (2006) and Wiersman and Jurs (2005). To find out whether there was significant difference in achievement of the two groups, descriptive statistics and an independent sample t-Test were carried out on CAT1.The results obtained on CAT1 analysis are as recorded in Table 6.

Table 6: t-Test results of Students Means Scores on CAT 1

Teaching approach	**n**	**Mean**	**SD**	df	**t-value**	**p-value**
E_1	67	1.40	1.326	148	.123	.902
C_1	83	1.37	1.552			

df = 148, t-critical = 1.984, p > 0.05

The results in Table 6 reveal that the mean score of the experimental group E_1 was higher than that of the control group $C_{1,}$ though the difference between the means of the two groups was not statistically significant at the 0.05 level, t (148) = .123, *p* =.902. Therefore, the level of achievement of the learners in chemistry before the administration of the treatment was similar, the groups had similar entry behavior thus were suitable for the study.

Gender is a factor that may affect students' achievement in chemistry. Therefore, students' CAT1 scores were analyzed by gender in order to determine the entry behavior of both male and female students before the administration of the treatment. The results obtained were as indicated in Table 7.

Table 7: Results of t-Test of CAT1 by Gender

Gender	N	Mean	SD	Df	t-value	P-value
Male	80	1.30	1.409	148	-.781	.436
Female	70	1.49	1.501			

df =148, t-critical = 1.984, p > 0.05

The results obtained in Table 7 reveals that the female mean score was above that of their male counterparts. However, the p = .436 obtained indicates that there is no significant difference in achievement of boys and girls. This means that both the male and the female students were at the same level of achievement before the administration of the treatment.

To assess the homogeneity of students' motivation before the administration of the treatment, SMQ1 scores were analyzed using t-Test statistical technique. The results of the analysis of SMQ1 are as indicated in Table 8.

Table 8: Results of t-Test of SMQ 1

Teaching approach	N	Mean	SD	df	t-value	p-value
E_1	67	69.2836	17.9704	148	.147	.883
C_1	83	69.8795	15.7034			

df = 148, t-critical= 1.984, p > 0.05

The results in Table 8 reveals the difference between the means of the two groups was not significant at the 0.05 level, t (148) = .147, p = .883. This means that the students in both E_1 and C_1 groups were at the same level of motivation to learn Chemistry before treatment thus they were suitable for study.

Gender is a factor that may affect students' motivation to learn Chemistry. In order to determine whether or not the male and the female students had the same level of motivation to learn chemistry before the administration of the treatment, the SMQ1 scores were also analyzed per gender. The results of the analysis are as indicated in Table 9.

Table 9: Results t-Test of SMQ 1 by Gender

Gender	N	Mean	SD	Df	t-value	p-value
Male	80	68.9500	18.27560	148	-.087	0.931
Female	70	69.1857	14.82096			

df = 148, t-critical = 1.984, p > 0.05

The results in Table 9 reveal that there was no statistically significant difference in the level of motivation to learn chemistry between male and female students before the administration of the treatment. This implied that both the male and female students were equally motivated to learn chemistry at the beginning of the study.

4.3 Post-test analysis on CAT2 results

4.3.1 Effects of M5EsA on Students' Achievement

The first objective of this study was to determine whether there is a significant difference in students' achievement in chemistry when taught using M5EsA and CTM. To achieve this, objective analysis of post-test scores on CAT2 was carried out using descriptive and one way ANOVA statistical techniques. Table 10 shows the results obtained on the mean scores and the standard deviations of the four groups.

Table 10: Summary of CAT2 Mean Scores and Standard Deviations

Teaching approach	N	Mean	SD
E_1	67	22.9403	10.4923
C_1	83	12.4337	10.2888
E_2	79	19.9367	9.6521
C_2	74	11.9865	8.8045

The results indicates that the highest mean score was attained by E_1 (22.94) followed by E_2 (19.94) then C_1 (12.43) and finally C_2 (11.98). This implies that students in the experimental groups had higher scores on CAT2 compared to those students in the control groups who had lower scores. In order to the determine whether the noted difference in achievement in Table 10 was statistically significant one-way ANOVA statistical technique was used to analyze the post-test scores on CAT2. The results obtained were as shown in Table 11.

Table 11: One way ANOVA Post- Test Scores Results of CAT2 Students' Scores

	Sum of squares	df	Mean square	F	Sig
Between Groups	6588.658	3	2196.219	22.744	.000
Within groups	28871.817	299	96.561		
Total	35460.475	302			

The results in Table 11 show that the difference in the mean scores among the four groups was significant at the .05 level, $F\ (3,299) = 22.744$ p = .000. To find out where the differences existed, *Tukey post-hoc* analysis was carried out. Tukey post-hoc analysis was preferred because of the unequal number of students in the groups. The results of this analysis are presented in Table 12.

Table 12: Tukey post-hoc Pair-Wise CAT2 Groups' Comparisons

(I)Teaching approach	(J)Teaching approach	Mean Difference(I-J)	Std. Error	Sig.
E_1	C_1	10.50656*	1.61388	.000
	E_2	3.00359	1.63203	.257
	C_2	10.95381*	1.65713	.000
C_1	E_1	-10.50656*	1.61388	.000
	E_2	-7.50297*	1.54457	.000
	C_2	.44725	1.57107	.992
E_2	E_1	-3.00359	1.63203	.257
	C_1	7.50297*	1.54457	.000
	C_2	7.95022*	1.58971	.000
C_2	E_1	-10.95381*	1.65713	.000
	C_1	-.44725	1.57107	.992
	E_2	-7.95022*	1.58971	.000

*. The mean difference is significant at the 0.05 level.

Table 12 reveals that there was statistically significant difference in the means of post-test CAT2 scores between the pairs of groups E_1 and C_1, E_1 and C_2, E_2 and C_1 and E_2 and C_2 at 0.05 level of significance. The significant difference noted was in favour of the experimental groups. However, there was no statistically significant difference between $E_1$and E_2 as well as C_1 and C_2. These results suggest that M5EsA led to improved students' achievement in the experimental groups.

The entry behavior of students into secondary school is a factor that may influence the students' achievement in this level. Though this intervening variable was controlled through purposive sampling of sub-county schools, its effects may still exist among the learners in the same group since they were admitted to the schools with different marks in their Kenya Certificate of Primary Education (KCPE). Therefore, ANCOVA test analysis was carried out in order to minimize such effects. KCPE marks were used as a co variate during the analysis of CAT 2 post-test scores. The adjusted means obtained are as shown in Table 13.

Table 13: Actual and Adjusted CAT2 Mean using KCPE as a Co variate

Teaching approach	N	Mean	Adjusted Mean
E_1	67	22.9403	22.561[a]
C_1	83	11.7108	11.007[a]
E_2	79	19.9367	20.325[a]
C_2	74	11.9865	12.706[a]

Table 13 indicates that the adjusted means scores of CAT2 for the four groups were different from each other. The students in the experimental groups had their adjusted CAT2 means higher than those of the students in the control groups. In order to determine whether or not the noted differences in the adjusted means were statistically significant, ANCOVA analysis was carried out and the results were as recorded in Table 14.

Table 14: ANCOVA of the CAT2 post-test Means Scores with KCPE mark as a Co variate

Source	Sum of Squares	Df	Mean Squares	F	Sig	Partial Eta Squared
Contrast	7179.696	3	2393.232	28.985	.000	.226
Error	24605.443	299	82.569			

The results in Table 14 shows that the differences in the adjusted mean scores of the groups were statistically significant at the 0.05 level, F (3,299) = 28.985, P= 0.000. This confirms that students' achievement in the four groups differed significantly. Partial eta squared= .226

indicates that the relationship between KCPE marks of the students and their achievement after the treatment was weak, that is, the effect of co variate on the students' CAT 2 marks was not significant. This implies that the noted significant difference noted in Table 11 was confirmed. In order to determine where the differences were, a *Tukey* post-hoc test was carried out. *Tukey post-hoc* was preferred because of the unequal number of students in the groups (Schlegel, 2018). The results of the analysis are recorded in the Table 15.

Table 15: Tukey Post-Hoc Pair-Wise Comparisons of the Adjusted CAT2 Scores

(I)Teaching approach	(J)Teaching approach	Mean Difference(I-J)	Std. Error	Sig.
E_1	C_1	10.820*	1.579	.000
	E_2	2.263	1.606	.160
	C_2	9.893*	1.641	.000
C_1	E_1	-10.820*	1.579	.000
	E_2	-8.557*	1.533	.000
	C_2	-.927	1.574	.846
E_2	E_1	-2.263	1.606	.160
	C_1	8.557*	1.533	.000
	C_2	7.630*	1.555	.000
C_2	E_1	-9.893*	1.641	.000
	C_1	.927	1.574	.557
	E_2	-7.630*	1.555	.000

Table 15 reveals that there are significant differences between the experimental and control groups in all the pairs are in favour of the experimental groups. There are no significant differences between; the experimental groups; E_1 and E_2, p=.160 and also between the control groups; C_1 and C_2, p= .557. This means that M5EsA led to increase in students' achievement in the topic. Therefore, the null hypothesis (H_01) was rejected. This is because the students in the experimental groups attained higher scores as opposed to those students who were in the control groups who attained lower scores.

4.3.2 Students' Achievement Mean Gain analysis

The analysis of post-test scores on CAT2 indicated that there was significant difference in students' achievement between those using M5EsA and those taught using CTM in favour of those who were facilitated using M5EsA. However, to determine whether all the students benefited from the two approaches, achievement gain analysis was carried out after the study. This was done by comparing students' achievement scores in CAT1 before the study and their respective achievement scores in CAT2 after the study. The results obtained were as indicated in Table 16.

Table 16: Comparison of Students' Achievement Mean Scores with their Mean Gain

	Group 1(Experimental)	**Group 2(control)**
Pre-test Scores	1.40	1.37
Post-test Scores	22.9403	12.4337
Mean Gain	21.5403	11.063

CAT Maximum Score = 50

The results in Table 16 indicate that both groups gained from the two learning approaches. However, the experimental group had a higher mean gain (21.5403 than the control group (11.063). To determine whether there was a significant difference in students' achievement gain, groups' achievement gain means were compared using t-Test. The results obtained from the analysis are as recorded in Table 17.

Table 17: Achievement gain t-Test results

Teaching approach	N	Mean	SD	df	p-value	t-value
E_1	67	21.5403	10.18663	148	7.368	.000
C_1	83	11.0637	7.95303			

Table 17 indicates that there was significant difference in mean achievement gains for the two groups in favour of the experimental group. This implies that M5EsA is a more effective approach to learning because it led to increased achievement in the topic "Effect of electric current on substances" compared to CTM.

The results obtained above leads to the rejection of the null hypothesis ($H_0$1) upon which objective number one was based. This may be attributed to learners taught using M5EsA being engaged in discussion groups while constructing knowledge through the five phases; engagement, exploration, explanation, extrapolation and evaluation of the constructivist 5Es learning cycle. Based on both cognitive and social constructivists view on learning, the five stages gave peers great opportunities to interact with each other's views on different concepts involved in the subject matter. They got chance for peer collaborative elaboration of the concepts thus construction of understanding together which led to learner's deep understanding of the concepts. M5EsA also ensured good mastery of the concepts. This is because subject matter was divided into smaller units which were mastered by the learner. This was done by learners being given exams after every unit and those who do not attained the minimum set score must were given remediation until they achieved target then were allowed to proceed and learn the next unit.

These results are in agreement with those obtained by Noureen et al. (2020) in their study "Effect of Constructivist Teaching Approach on Student's Achievement in Science at Elementary Level". From their study they concluded that constructivism renovates the student from a passive learner to an active participant in the teaching learning process, thus enhancing achievement. Adeniji et al. (2018); Kainua et al. (2014); Mayanchi and Anya (2021) in their studies on mastery learning the researchers found out that the learners taught using mastery learning approach achieved higher scores than those taught using contemporary methods of teaching. Njoroge et.al. (2014); Olaoluwa & Olufenke (2015); Umahaba (2018); Jack (2017) also noted that the students in the experimental groups who were taught using the inquiry-based 5Es learning cycle achieved higher scores than those taught using CTM in the control groups. A literature review on masters, doctoral thesis and articles for the years 2006-2016 on the effects of the inquiry-based approach on performance of the learners done by articles on the effects of the inquiry-based approach on the performance of the learners done by Cakir (2017) revealed that the 5Es learning cycle is indeed an effective learning and teaching strategy and has a positive effect on the performance of the students. M5EsA is a hybrid of mastery learning and constructivist-based 5Es learning cycle reaps the benefits of both approaches to learning. Therefore, there is combined positive effect of the approaches in M5EsA which is realized in the achievement of learners in the experimental groups expressed through the higher scores achieved than of those in the control groups.

4.4 Post-test analysis results on SMQ 2

4.4.1 Effects of M5EsA on students' motivation to learn Chemistry

This study investigated whether learners had the same level of motivation to learn Chemistry when taught using M5EsA and CTM. In order to determine this, analysis of post-test scores on SMQ2 was done. The results obtained are from the descriptive analysis are as tabulated in Table 18.

Table 18: Means and Standard Deviations results of SMQ 2 Students' Scores

Teaching approach	N	Mean	SD
E_1	67	76.1791	17.1172
C_1	83	69.0361	14.9923
E_2	79	75.9114	19.6294
C_2	74	67.7297	14.8262

The results in Table 18 indicated E_1 and E_2 groups had higher mean score compared to C_1 and C_2 groups. This signifies that the students in the experimental groups were highly motivated compared to those in the control groups. To determine whether there was significant difference in the mean scores one-way ANOVA test was carried out on post-test scores on SMQ 2. The results obtained were as recorded in Table 19.

Table 19: Results of One Way ANOVA of SMQ 2 Post-test Scores

Scale	Sum of Squares	df	Mean Square	F	Sig
Between Groups	4454.877	3	1484.959	5.294	.001
Within Groups	83869.717	299	280.501		
Total	88324.594	302			

The results in Table 19 shows that the difference in the mean scores among the four groups based on the teaching approach is statistically significant at the .05 level, $F(3,299) = 5.294$ $p=.001$. This implies that M5EsA had a significant positive effect on students' motivation to learn Chemistry. To investigate where the significant differences were *Tukey post-hoc* analysis was carried out since the groups involved in the study did not have the same number of students (Schlegel, 2018). The results were as indicated in Table 20.

Table 20

Tukey Post-Hoc Pair-Wise SMQ2 groups' Comparisons

(I)Teaching approach	(J)Teaching approach	Mean Difference(I-J)	Std. Error	Sig.
E_1	C_1	7.14296*	2.75294	.043
	E_2	.26771	2.78390	1.000
	C_2	8.44937*	2.75294	.016
C_1	E_1	-7.14296*	2.75294	.043
	E_2	-6.87525*	2.63471	.041
	C_2	1.30641	2.67993	.971
E_2	E_1	-.26771	2.78390	1.000
	C_1	6.87525*	2.63471	.041
	C_2	8.18166*	2.71172	.015
C_2	E_1	-8.44937*	2.82673	.016
	C_1	-1.30641	2.67993	.971
	E_2	-8.18166*	2.71172	.015

Table 20 results indicate that the significant differences existed between the experimental groups and the control groups only. The noted differences are in favour of the experimental groups. The Table 20 further indicates that there were no significant differences between the experimental groups ($E_1$and E_2) and also between the control groups (C_1 and C_2). These results reveal that M5EsA improved students' motivation to learn chemistry as opposed to CTM. The null hypothesis ($H_0$2) was therefore rejected since there was significant difference in students' motivation to learn when taught using the M5EsA and CTM.

To determine whether or not students' entry behavior had influence on students' motivation to learn during the study, ANCOVA test was carried out using KCPE marks as a co variate because it is the last common exam that was done by the learners in the four groups before joining the different co-educational Sub- County secondary schools. Results of the actual and adjusted SMQ2 mean scores from ANCOVA analysis are as shown in Table 21.

Table 21: Actual and Adjusted SMQ2 Scores using KCPE as a co variate

Teaching approach	N	Mean	Adjusted Mean
E_1	67	76.1791	75.497[a]
C_1	83	69.0361	67.771[a]
E_2	79	75.9114	76.608[a]
C_2	74	67.7297	69.022[a]

The results in Table 21 indicate that the adjusted means for the four groups differ from each other. The adjusted means for the experimental groups are higher than those of the control groups. To determine whether or not the differences noted in the adjusted means of the four groups is significant, ANCOVA analysis of SMQ2 scores was done. The results obtained are recorded in Table 22.

Table 22: ANCOVA analysis results of the SMQ 2 Post-test scores

Source	Sum of Squares	Df	Mean Squares	F-ratio	p-value	Partial Eta Squared
Teaching approach	4704.043	3	1540.980	5.814	.001	.055
Error	79215.103	299	265.033			

The results in Table 22 shows that the differences in the mean scores of the groups were statistically significant at the 0.05 level, $F(3,299) = 5.814$, p= 0. 001.The partial eta squared= .055 was not significant indicating there is a weak relationship between the student's motivation (SMQ2) scores and their respective KCPE marks. To determine where the significant differences existed a *Tukey post-hoc* analysis was done. *Tukey post-hoc* was preferred because of the unequal number of students in the four groups (Zach, 2020). The results were recorded in Table 23.

Table 23: **Tukey Post-Hoc Pairwise Comparisons of adjusted SMQ2 Means**

(I)Teaching approach	(J)Teaching approach	Mean Difference(I-J)	Std. Error	Sig.
E_1	C_1	7.726*	2.681	.004
	E_2	-1.098	2.727	.688
	C_2	6.475*	2.788	.020
C_1	E_1	-7.726*	2.681	.004
	E_2	-8.837*	2.603	.001
	C_2	-1.251	2.674	.615
E_2	E_1	1.111	2.727	.688
	C_1	8.837*	2.603	.001
	C_2	7.586*	2.641	.004
C_2	E_1	-6.475*	2.788	.020
	C_1	1.251	2.674	.615
	E_2	-7.586*	2.641	.004

Table 23 results indicate that the significant differences were between the experimental and control groups (E_1andC_1, E_1andC_2, E_2andC_1, E_2andC_2) in favour of the experimental groups. Therefore, the null hypothesis ($H_0$2) was rejected since there was significant difference in students' motivation to learn chemistry when taught using M5EsA and CTM.

4.4.2 Students' Motivation Gain analysis

Mean gain analysis on students' motivation to learn was carried out in order to determine how students' motivation was affected by the teaching approaches employed during the study. This was done by comparing students' SMQ1 and SMQ2 mean score. The results obtained are as recorded in Table 24.

Table 24: Comparison of Students SMQ1 and SMQ2 Mean Scores.

	Group 1(Experimental)	**Group 2(control)**	**Overall (150)**
Pre-test Scores	69.28	68.88	69.08
Post-test Scores	76.18	69.04	72.61
Mean Gain	6.9	0.16	3.53

Table 24 shows that students in both groups had their motivation level increased after the administration of the treatment. However experimental group students had their motivation level increased higher (mean gain = 6.9) than for those in the control group (mean gain = 0.16). To determine whether the difference noted in Table 22 between the experimental and control group was significant, t-Test analysis was done on students' motivation gain. The results are recorded in Table 25.

Table 25: t-Test results on Motivation Mean Gain Analysis

Teaching approach	**N**	**Mean**	**SD**	**Df**	**t-value**	**p-value**
E_1	67	6.8955	13.91221	148	3.775	.000
C_1	83	.1807	4.77581			

The results in Table 25 indicates that difference in students' motivation gain analysis recorded in Table 24 was statistically significant; p=.000. The students in the experimental groups were more motivated compared to those in the control groups. This means that M5EsA had significant positive effect on students' motivation to learn chemistry.

The results obtained from both descriptive and inferential statistics were carried out on post-test SMQ2 scores indicated that the learners in the experimental groups were more motivated than the learners in the control groups. The results further indicated that there was significant difference between the experimental groups and the control groups in favour of the experimental groups. This implies that M5EsA had a positive significant effect on the motivation of the learners. This may be attributed to how learners worked together in groups through the 5es learning cycle in which many activities and inquiry questions are placed for them to do in the engagement, exploration, explanation, extrapolation and evaluation phases. This enabled them to inquire into concepts, manipulate apparatus, discuss and draw conclusions together as the teacher guides them through these phases. This created a stimulating environment for learning thus enhancing learners' motivation to study chemistry. Since the topic was divided into small units that learners must master before moving to the next unit, learners' understanding was promoted from one unit to another. This motivated them to move to the next unit since they were able to answer the questions from the previous unit well.

These results agree to those obtained by Keter (2013), Birhan (2018), and Suhartini et al. (2018) who found out that mastery learning approach had significant positive effect on the learners' motivation to learn writing skills, in Islamic religious studies and Chemistry respectively. However, Cetin (2012) did not find significant difference in motivation to learn Chemistry between students who were taught using the learning cycle and those taught using CTM.

4.5 Effects of gender on students' achievement in chemistry

Gender is an intervening variable that was not be controlled in this study. Therefore, its effect on students' achievement when exposed to M5EsA was the third objective of the study. To determine this effect, post test scores on CAT2 of the experimental group were analyzed by gender using t-Test statistical technique. Mean scores of males and females in treatment groups were as recorded in Table 26.

Table 26: t-Test results of CAT 2 Means per gender

Gender	N	Mean Score	SD
Male	81	21.8272	10.78632
Female	65	20.6818	9.20227

The results in Table 26 reveals that male students achieved slightly higher (M= 21.83) than the female students (M= 20.68). To determine whether there was significant difference in the Mean Scores an independent sample t-Test was carried out. The results obtained were as recorded in the Table 27

Table 27: t-Test Results of Experimental Group Students' CAT 2 Mean Scores by Gender

Gender	N	Mean Scores	SD	Df	t-value	p-value
Male	81	21.8272	10.78632	144	.683	.495
Female	65	20.6818	9.20227			

The results of Table 27 indicates that there is no significant difference in achievement between male and female students when taught using M5EsA (t (144) = .683, p=.495 which is > .05. Therefore, the null hypothesis ($H_0$3) which stated that there is no significant difference in students' achievement between male and female students when taught using M5EsA is accepted. This means that M5EsA is an effective approach in facilitating learners understanding of Chemistry concepts regardless of their gender. This implies that the constructivism theories of learning apply to all students regardless of gender. For example, collaborative elaboration of concepts by learners enabled each member of the group to create their own meaning of the subject matter. This enhanced deep understanding by both the male and the female students. Further understanding of concepts was enhanced when the subject matter is broken into small units to be mastered.

Adeniji et al. (2018) found out that when students are taught circle geometry through mastery learning gender difference gap in performance in maths was leveled. Khan, et al. (2020) in their study using learning cycle model found that the experimental group outperformed the control group. Ajaja et al. (2012), Abakpa and Iji (2013) and Isamareiya et al. (2018) studies agreed that both male and female students benefited equally when taught using mastery learning. Shaheen et al (2015), Olaoluwa and Ofufunke (2015) found out that inquiry-based 5Eslearning cycle enabled learners to perform better than those taught using traditional methods.

Although Twumasi et al. (2021) in their study on effect of 5es instructional model on physics academic achievement based on gender and students' ability found out that the use of the inquiry-based learning cycle improved learners' academic achievement, their results unlike those of this study found out that there was significant difference in the achievement by gender in favour of the male students. Udo and Udofia (2014); Kainuwa et al. (2021) studies also disagree with the results of this study because their results indicated that the male students performed significantly higher in chemistry than the female counterparts when taught using Mastery learning. Calsambis (2007), Soyibo (2009), Abe (2011) and Mwanda (2016) on the other hand found out that the female students performed better that the male students.

4.6 Effects of gender on students' motivation to learn Chemistry

SMQ 2 scores were also analyzed per gender in order to determine whether male and female students had the same motivation level when exposed to M5EsA. Table 28 compares the male and female students mean scores and standard deviations.

Table 27: Results of SMQ2 Mean Scores and standard deviations per gender

Gender	N	Mean Scores	SD
Male	81	76.0494	19.20150
Female	65	75.4308	17.66438

Table 27 indicates that the male students attained a higher mean score (M= 76.05) compared to the female students (M = 75.43). An independent sample t-Test analysis was carried out on these means scores to determine whether there was a statistically significant difference between the male and the female students. Table 28 shows the results obtained from the analysis.

Table 28: t-Test results of experimental group SMQ 2 Students' Scores per gender

Gender	N	Mean Scores	SD	Df	t-value	p-value
Male	81	76.0494	19.20150	144	.200	.841
Female	65	75.4308	17.66438			

The results in Table 28 indicate that there was no significant difference between male and female mean scores (t (144) = .200, p=.841 which is > .05. The results indicate that there is no significant difference in motivation of the male and of the female students to learn Chemistry when taught using M5EsA. Therefore, the null hypothesis ($H_0$4) is accepted. This implies that M5EsA motivated both the male and the female learners to learn the topic "Effect of electric current on substances. Given that learning was done through a constructivist approach and working together in small groups through the 5Es phases, learners freely exchanged their views on their understanding of the different concepts. They also engaged in discussions from different viewpoints as they tried to manipulate the apparatus and solve the various problems. This enhanced critical thinking, creativity and higher achievement. This led to increased motivation to study. The results further indicate that both male and female students were motivated to learn Chemistry when the content is broken into small units because few concepts were introduced at a time. Repeated testing and remediation enhanced mastery and retention of the content by all learners thus enhancing their motivation regardless of gender.

The results obtained in this study agree with those obtained by Hagos and Andargie (2022) in their study, "Gender Differences in Students' Motivation and Conceptual Knowledge in Chemistry Using Technology-Integrated Formative Assessment". They found out that there was no interaction effect of treatment and gender on the conceptual and motivational test scores when students were taught using technology-integrated formative assessment. Changeiywo et al. (2010) in their study effect of gender on learners' motivation to study physics when facilitated through mastery learning found out that gender had no significant effect. Keter et al. (2014) using cooperative mastery learning found that student's motivation to study chemistry increased but there was no significant difference in the motivation of the male and the female students. Cetin (2012), Keter (2013) and Birhan (2018) also noted that there was no gender difference in motivation to learn when mastery learning and the 5Es learning cycle are used to facilitate learning.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter discusses summary of the findings of the study guided by four objectives upon which the study was based. The conclusions drawn from, the implications of and recommendations based on the findings are discussed in this chapter.

5.2 Summary of the findings

The following are the four major findings based on the four objectives of this study.

i. There was a significant positive effect of M5EsA on students' achievement in Chemistry. This is because there was a statistically significant difference in students' achievement Chemistry when taught using M5EsA and CTM. The noted difference was in favour of the experimental groups.

ii. There was a significant positive effect of M5EsA on students' motivation to learn Chemistry. This is because there was a significant difference in students' motivation to learn Chemistry when taught using M5EsA and CTM. The noted difference was in favour of the experimental groups.

iii. The constructivist approach had a positive effect on the achievement of both male and female students. This is because there was no statistically significant difference in achievement between male and female students when taught using M5EsA.

iv. There was no significant difference between males' and females' motivation to learn chemistry. This means that M5EsA has positive effect on the motivation of both the males' and the females' motivation to learn chemistry.

5.3 Conclusions

Four major conclusions drawn from this study based on the findings obtained. These conclusions are as follows;

i. Both CTM and M5EsA approaches led to increase in students' achievement in chemistry but those who are taught using M5EsA had higher achievement compared to those who were taught using CTM. This indicates that M5EsA has a higher positive significant effect on learners' understanding of chemistry concepts compared to CTM.

ii. Both CTM and M5EsA approaches led to increased motivation of learners' motivation to learn chemistry but the students who were taught using M5EsA were more motivated than those who were taught using CTM. This indicates that M5EsA more effective in motivating learners to study chemistry.

iii. Gender does not affect students' achievement when they are taught using M5EsA. This is because there was no significant difference in achievement of male and female students when taught using M5EsA. Therefore, M5EsA enhances achievement of both the male and the female students equally. M5EsA may help in bridging the gender difference gap that has existed for a long time in chemistry achievement in favour of the male students.

iv. M5EsA motivates both the male and the female students equally. This is because there was no significant difference in motivation of boys and girls to learn chemistry. Therefore, M5EsA is an effective approach to boosting students' motivation to learn chemistry regardless of their gender.

5.4 Implications of the study

The findings of this study indicate that M5EsA led to enhanced achievement in chemistry. Therefore if this teaching approach is incorporated into the teaching of chemistry in secondary schools it may lead to higher students' achievement in chemistry in secondary schools. The findings indicated also that achievement of both male and female students was improved therefore may led increase in students' achievement regardless of gender thus may narrow the gap that has existed for a long time in the achievement in chemistry in favour of the male students.

M5EsA led to enhanced students' motivation to learn Chemistry regardless of their gender. Therefore, if embraced in the teaching of Chemistry it may lead to increased learners' motivation to learn chemistry regardless of their gender.

5.5 Recommendations

Based on the findings of this study, the following recommendations are made.

i) M5EsA leads to improved motivation and higher achievement in chemistry. Therefore teachers, MOE and KICD may encourage the use of this approach so as to enhance achievement in chemistry and boost learners' motivation to study chemistry. This can be done through regular teacher-induction seminars and workshops that may be organized by the ministry.

ii) M5EsA may be incorporated into the teaching / learning approaches used in teacher training institutions, colleges and universities, M5EsA may lead to increased motivation and performance of the teacher trainees. They in turn may also be able to facilitate their teaching in secondary schools using the approach thus leading to effective learning in their subjects.

5.6 Recommendation for further research

In order to have more information on the effect of M5EsA on students' achievement in and motivation to learn chemistry and also to enrich the present findings, further research is recommended to find out effect of M5EsA on other topics in chemistry other than the topic used in this study. There is need also to carry out more research to find out effect of M5EsA learners' achievement in and motivation to study other subjects.

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APPENDICES

APPENDIX A: CHEMISTRY ACHIEVEMENT TEST (CAT)

NAME……………………………………ADM.NO…………….CLASS………………

SCHOOL…………………………………….

TIME 1HR

Instructions

Attempt all the questions in the spaces provided

1. Define the following terms

a) Conductor…………………………………………………………………………………

…………………………………………………………………(1mk)

b) Electrode…………………………………………………………………………………

……………………………………………………………………(1mk)

c) Electrolysis………………………………………………………………………………

…………………………………………………………………… (1mk)

2. Which particles are responsible for electrical conductivity in

a) Solids

………………………………………………………………………………… (1mk)

b) Aqueous solutions

………………………………………………………………………….. (1mk)

3. Aluminium is a better conductor of electricity than magnesium. Explain (1mk)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………

4. Distinguish between the following substances

a) Anode and cathode (2mk)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………

b) Electrolyte and non-electrolyte (2mk)

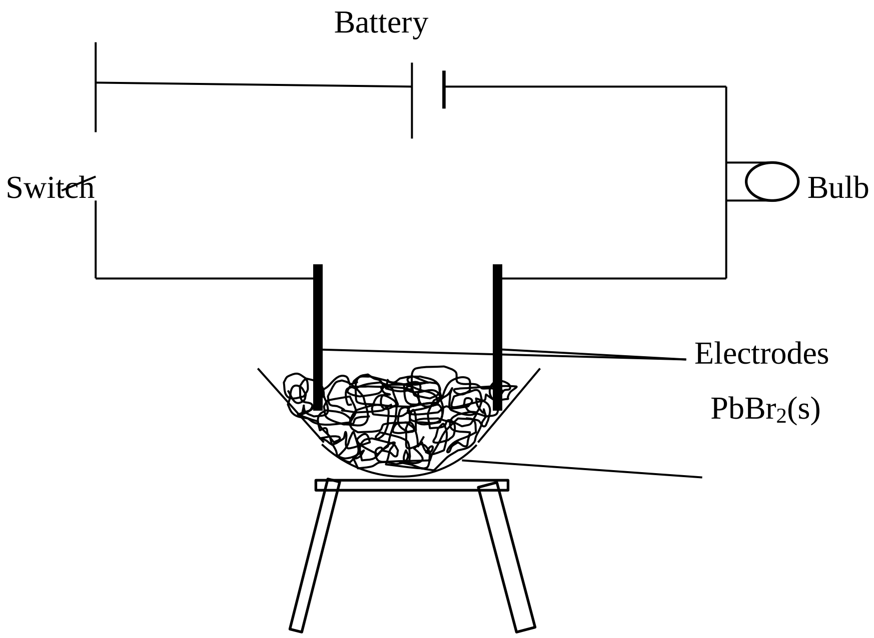
……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………

5. In an experiment to investigate the electrical conductivity of substances, a student used the set-up shown below.



The student noted that the bulb did not light

a) What mistake did the student do in the set-up that led to this observation? (1mk)

………………………………………………………………………………

b) Explain why the bulb lights when the mistake is corrected (2mk)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………

6. Molten calcium chloride is a binary electrolyte.

a) What is a binary electrolyte? (1mk)

…………………………………………………………………………………………………

………………………………………………………………………………

b) Give any two other examples of binary electrolytes (2mk)

…………………………………………………………………………………………………

………………………………………………………………………………

7. State the particles responsible for electrical conductivity in (3mk)

a) Magnesium

……………………………………………………………………………………

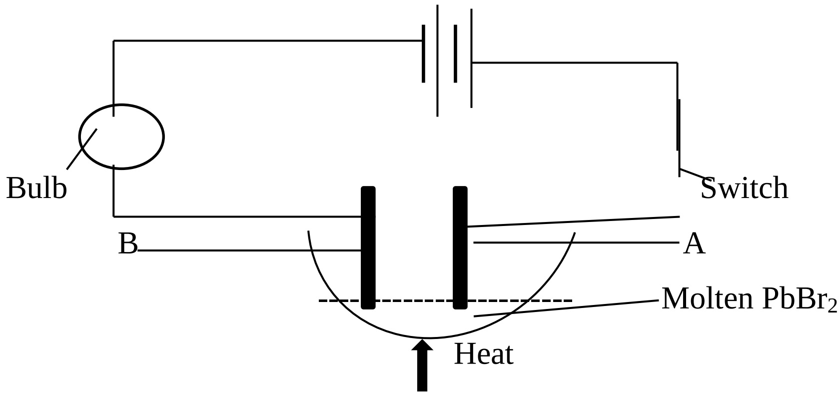
b) Magnesium chloride liquid

……………………………………………………………………………………………

c) Graphite

……………………………………………………………………………………………

8. The set-up below was used to investigate the products that would be formed during electrolysis of molten lead (II) bromide. Study it and answer the questions that follow.



a) Identify the electrodes (2mk)

A……………………………………………………………………………………….

B……………………………………………………………………………………….

b) Explain why solid lead (II) bromide does not allow the passage of electric current (2mk)

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

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

………………………………………………………………………………………….

c) State the observations made when the switch is closed and the circuit is completed (2mk)

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

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

…………………………………………………………………………………………

d) Write the equations to show the reactions that occur at the (2mk)

(i) Anode……………………………………………………………………………………

…………………………………………………………………………….

(ii) Cathode……………………………………………………………………………………

…………………………………………………………………………...

e) Why is it necessary to carry out the experiment in the fume chamber? (2mk)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………

f) On the diagram above indicate the direction of electron flow (1mk)

9. Apart from electroplating of metals such as iron, state any other two applications of electrolysis (2mk)

……………………………………………………………………………………………

…………………………………………………………………………………

10. Sugar and table salt solids dissolve readily in water to form solutions. Explain why sugar solution does not conduct electricity while table salt solution does (2mk)

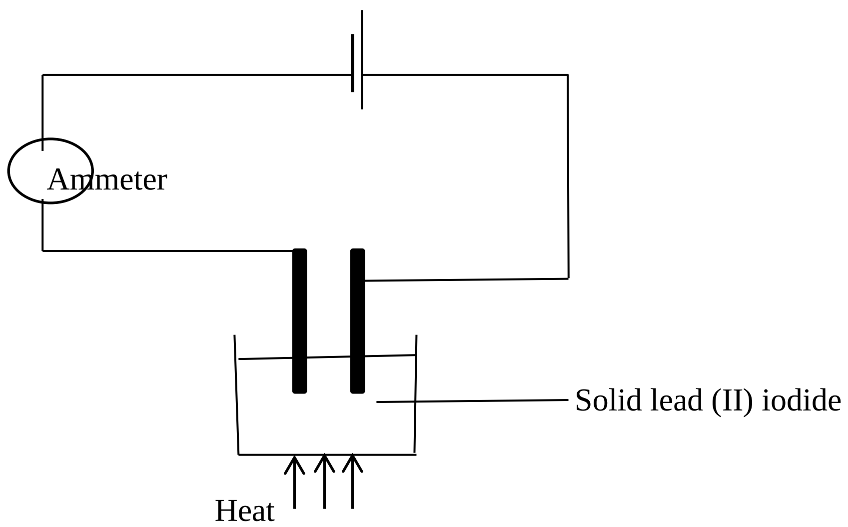
……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………

11. The set-up below was used during electrolysis of molten lead (II) iodide. The crystals were being heated until all were molten.



a) State the observation in the ammeter (2mk)

(i) At the beginning of the experiment

……………………………………………………………………………………………

……………………………………………………………………………

(ii) As lead (II) iodide was melting

……………………………………………………………………………………………

……………………………………………………………………………

(iii) Explain your answer in (a) (ii) above (2mk)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………

b) State the observation made at the anode during electrolysis (2mk)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………

c) Explain your answer in (b) above (2mk)

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………..

12. Complete the table below. (8mk)

Binary electrolyte	Observations made during electrolysis	Anode reaction equation	Cathode reaction equation
Lead (II) Bromide ($PbBr_2$)	1 2		
Copper (II) Chloride ($CuCl_2$)	1 2		

APPENDIX B: STUDENT’S MOTIVATION QUESTIONAIRE (SMQ)

Introduction

1. This questionnaire is NOT A TEST. The purpose of this questionnaire is to find out what you think about Chemistry as a subject. Please indicate what you think about each item. The information obtained will be used for research, which aims at improving the learning of Chemistry in schools. Only the researcher will have an access to the information about your responses.
2. THERE ARE NO RIGHT OR WRONG ANSWERS to the questionnaire. What is required is your PERSONAL FEELINGS OR OPINIONS ON EACH STATEMENT OR QUESTION. Please answer ALL the questions as sincerely as possible.
3. NO NAMES REQUIRED.
4. Read the items carefully and try to understand before choosing what truly agrees with your thought.
5. Use pencil to circle the letter/ choice that corresponds to your feelings towards chemistry course. Circle ONLY ONE of the choices. If you agree your change your opinion on any statement or question, clearly erase the response before making the necessary adjustments.

SECTION 1

DEMOGRAPHIC DATA

1. Sex. [ ] Male [ ] Female [ ]
2. Age (years) [ ]
3. K.C.P.E Total Marks [ ]

SECTION II

PERSONAL OPINION ON THE LEARNING OF CHEMISTRY

For this section, please indicate the extent to which you agree with the statement in each of the following statements. Indicate whether you Strongly Agree, Agree, Undecided, Disagree, or Strongly disagree by CIRCLING the letters that best describe your level of agreement. Your level of agreement will be rated at a scale of 1-5, that is, 1= SD, 2=D, 3=U, 4=A, 5=SA.

For example: Learning Chemistry is;

Fun SD D U A SA

KEY

SD = STRONGLY DISAGREE. **D**= DISAGREE. **U** = UNDECIDED. **A** = AGREE and **SA** = STRONGLY AGREE

4	I do not feel nervous at all in learning chemistry	SD D U A SA
5	Learning chemistry in class is frustrating	SD D U A SA
6	I feel that it is my choice to learn chemistry	SD D U A SA
7	I think I am very good in chemistry	SD D U A SA
8	I feel tense while learning chemistry	SD D U A SA
9	I think I do very well in chemistry activities compared to other students	SD D U A SA
10	Doing chemistry tasks is fun	SD D U A SA
11	I feel relaxed while learning chemistry	SD D U A SA
12	I enjoy learning chemistry	SD D U A SA
13	I don’t really have a choice in learning chemistry	SD D U A SA
14	I am satisfied with my performance in chemistry tasks	SD D U A SA
15	I am anxious while learning chemistry	SD D U A SA
16	I think learning chemistry is boring	SD D U A SA
17	The hours I spend learning chemistry are the ones I enjoy most	SD D U A SA
18	I feel I am doing what I want to do while I am learning chemistry	SD D U A SA
19	I feel very skilled in chemistry activities	SD D U A SA
20	I find learning chemistry to be very interesting	SD D U A SA
21	I feel pressured while learning chemistry	SD D U A SA

22	I always look forward to chemistry lessons	SD D U A SA
23	I feel I have to learn chemistry	SD D U A SA
24	I can describe chemistry lessons as very enjoyable	SD D U A SA
25	I believe I have a choice in learning chemistry	SD D U A SA
26	Having learnt chemistry for a while, I feel am very competent	SD D U A SA

APPENDIX C: MANUAL FOR TEACHERS OF CHEMISTRY

1.0 Introduction

This guide is intended to assist the teachers to plan and implement a teaching –learning program based on M5EsA. Students will be taught through an inquiry based 5Es learning cycle and they should be able to acquire a given level of mastery in a unit before proceeding to the next unit. The instructional materials to be used in this study will be based on the revised chemistry syllabus (KLB, 2013). This manual will be used throughout the treatment period.

1.1 The Mastery 5Es learning cycle Approach (M5EsA)

M5EsA is an instructional method in which subject matter to be studied will be divided into units that have predetermined objectives. Students in groups will be guided to work through the units in following a 5Es learning cycle made up of five steps of Engagement, Exploration, Explanation, Elaborating and Evaluation. As in any cycle there is really no end to the process. As elaboration ends, the engagement of the next learning cycle begins. Evaluation is not really the last stage but it occurs in all four stages of the learning cycle. The descriptions of the events that take place at each stage are shown below:

Engagement: Engagement is a time when the teacher is on centre stage. The teacher poses the problem, pre-assesses the students, helps students make connections, and informs students about where they are heading. Evaluation's role in engagement revolves around the pre-assessment. Find out what the students already know about the topic at hand. The teacher could ask questions and have the students respond orally and/or in writing.

Exploration: Now the students are at the centre of the action as they collect data to solve the problem. The teacher makes sure the students collect and organize their data in order to solve the problem. The students need to be active. The purpose of exploration is to have students collect data that they can use to solve the problem that was posed. In this portion of the learning cycle, the evaluation is primarily focused on process, i.e., on the students' data collection, rather than the product of the students' data collection.

Explanation: In this phase of the process, students use the data they have collected to solve the problem and report what they did and try to figure out the answer to the problem that was presented. The teacher also introduces new vocabulary, phrases or sentences to label what the students have already figured out. Evaluation here focuses on the process the students are using - how well can students use the information they have collected, plus what they already knew to come up with new ideas? Using questions, the teacher can assess the students' comprehension of the new vocabulary and new concepts.

Elaboration: The teacher gives students more information that extends what they have been learning in the earlier parts of the learning cycle. At this stage, the teacher also poses problems that students solve by applying what they have learned. The problems include both examples and non-examples. The evaluation that occurs during elaboration is what teachers usually think of as evaluation. Sometimes teachers equate evaluation with "the test at the end of the chapter". When teachers have the students do the application problems as part of elaboration, these application problems are "the tests".

Subject matter will be divided into small units and instructional objectives will be developed for these units. At the end of each unit the students will be given quizzes. They must demonstrate mastery on unit exams, typically a minimum score of 80%, before moving on to new material Students who do not achieve mastery will receive remediation through tutoring, peer monitoring, small group discussions, or additional assignments. Additional time for learning is prescribed for those requiring remediation. Students continue with the cycle of studying and testing until mastery is achieved.

By the end of the topic, the learner should be able to;

1. Define the terms conductor, non-conductor, electrolyte, non-electrolyte, current, and electrode
2. Classify solutions and molten substances as electrodes and non-electrolytes
3. Differentiate electrolyte from non-electrolyte in terms of the particles they contain
4. Explain the process of electrolysis and define the terms anode and cathode
5. State the products of binary compounds
6. State some applications of electrolysis.

1.2 Guide on the topic effect of electric current on substances

The subject matter will be divided into small units.

1.Conductors and non-conductors
2. Electrolytes and non-electrolytes
3. Electrolysis
4. Applications of electrolysis

After each unit an exam will be administered, marked and remediation done to the students who did not achieve the prescribed mastery level. In every lesson, students are expected to learn following 5Es learning cycle.

1.21 Electrical conductivity of solids

By the end of this lesson the learner should be able to;

-Define current, conductors and non-conductors

-Classify solid substances into conductors and non-conductors

-Explain the difference between conductors and non-conductors

-Describe an experiment that can be used to distinguish between conductors and non-conductors

Engage activity

- Students to state what electric current is according to them

- Students in groups are provided with an electric circuit material; copper wires, switch, light bulb, dry cells, and crocodiles clips. **Note;** the teacher ensures that one of the provided materials is faulty/ not working

-They learners are required make an electric circuit and test whether electricity is passing through the circuit by connecting the two crocodile clips at the ends of the circuit. They write down reasons as to why the bulb is not lighting. With teacher's guide they look for solutions to the problem(s) and ensure that the circuit is working.

Explore Activity; Carry out experiment to classify solids into conductors and non-conductors

Questions to guide exploration;

-Name the function of the bulb in the experiment

-Name the substances used in the experiment which;

conduct electricity

do not conduct electricity

-What type of substances;

Conduct electricity

do not conduct electricity

-Suggest a reason for electrical conductivity in solids.

Students in groups carry out the experiment as guided in the **worksheet A** provided

Explanation phase

Through the guidance of the teacher;

-Students should answer the guiding questions through discussion. The teacher at this phase corrects the misconceptions noted in the first two phases, guides the learners to develop correct definitions of the concepts encountered.

Elaboration phase

Students to answer the given questions through discussion

-Explain why metals conduct electricity while non-metals do not

-Explain why graphite conducts electricity yet it is a non-metal

-Explain why some metals are good conductors while others are poor conductors

Evaluation

This occurs through all the phases, for the teacher to ascertain that objectives of the phases are achieved. In engage phase evaluation reveals students' prior knowledge, misconceptions about the topic. In explore and explain phases, evaluation help in monitoring students to complete experiment and work out the given questions.

1.22 Electrical conductivity of molten liquids

Lesson objective(s);

By the end of the lesson the learner should be able to;

-Define electrolytes and non-electrolytes

-Classify the given molten liquids into electrolytes and non-electrolytes

-Explain the difference between electrolytes and non-electrolytes

-Describe an experiment that can be carried out to distinguish between electrolytes and non-electrolytes

Engage activity.

Question; explain how common salt/ sugar crystals can be changed from solid into liquid

(Use think-pair and share method): -each student to think

- get a partner, discuss and write down brief answers

-give responses to the teacher

The teacher then after going through the responses clarifies to the difference between molten and aqueous liquids. He/she then goes ahead to introduce the aim of the current lesson based on the previously learnt concepts in the last lesson.

Exploration activity

Experiment: To investigate what type of substances conduct electric current when in molten state

Questions that will guide exploration are:

-Name the substances in the experiment which do not conduct electricity when in solid state but conduct when melted

-Name the substances in the experiment which do not conduct electricity when in both solid and melted state

-Why this experiment should be carried out in a fume chamber/ in the outside classroom.

-Why should care be taken to prevent the graphite rods from coming into contact?

-Explain why substances named in (ii) above do not conduct electricity whether in the solid or molten state.

Students carry out the experiment as guided in the **worksheet B** provided.

Explanation phase

Through the guidance of the teacher, students should answer the guiding questions through discussion. The teacher at this phase corrects the misconceptions noted in the first two phases, guides the learners to develop correct definitions of the concepts encountered.

Elaboration phase

Students to discuss and answer the questions given;

-Explain why ionic compounds do not conduct electricity in solid state but when in molten state they conduct.

-Why are metals good conductors of electricity both in the solid and molten state?

-What is a binary electrolyte? Give examples of binary electrolytes

Evaluation

This occurs through all the phases, for the teacher to ascertain that objectives of the phases are achieved. In engage phase evaluation reveals students' prior knowledge, misconceptions about the topic. In explore and explain phases, evaluation help in monitoring students to complete experiment and work out the given questions.

1.23 Electrical conductivity of substances in aqueous state

Lesson objectives;

By the end of the lesson, the learner should be able to;

-Classify aqueous solutions into electrolytes and non-electrolyte

-Identify the type of compounds that conducts electric current when in aqueous state and those that do not conduct electric current when in aqueous state.

Engage activity

1. Learners are asked to explain why their elders always caution them against touching any electrical appliance with wet hands.

2. Measure about $15cm^3$ of distilled water and of tap water into two separate 25 ml beakers and investigate their electrical conductivity using an electrical circuit. Record the observations made and state whether or not both distilled and tap water are conductors of electric current. Briefly explain the observations made.

Teacher collects learners' responses, goes through and shares them with the class. Using these responses teacher guides them to clearly get the difference between the two liquids. The teacher also introduces the aim of the experiment that they are going to investigate the electrical conductivity of solutions.

Exploration phase

Experiment: What type of substances conduct electric current when dissolved in water?

Questions to guide exploration are;

-Name the substances in the experiment which do not conduct electricity in the solid state but conduct when dissolved in water.

-What do these substances which conduct electricity when dissolved in water have in common?

-Which substances do not conduct electricity either in the solid state or when dissolved in water?

Students carry out the experiment as guided in the **worksheet C** provided.

Explain phase

Through the guidance of the teacher, students should answer the guiding questions through discussion. The teacher at this phase corrects the misconceptions noted in the first two phases, guides the learners to develop correct definitions of the concepts encountered.

Elaboration phase

Activities to enhance elaboration,

-On the set-up of the experiment on the worksheet, indicate the direction of electrons flow and explain why.

-Explain why sugar and urea solutions do not conduct electricity.

Evaluation

This occurs through all the phases, for the teacher to ascertain that objectives of the phases are achieved. In engage phase evaluation reveals students' prior knowledge, misconceptions about the topic. In explore and explain phases, evaluation help in monitoring students to complete experiment and work out the given questions.

1.24 Electrolysis

By the end of the lesson, the learner should be able to;

-Explain the process of electrolysis

-Draw and label a set up that can be used to carry out electrolysis of molten liquids

-Name the products of the process of electrolysis of selected molten liquids.

Engage activity

Students to answer the question given on a piece of paper

-What is your understanding about electrolysis?

They discuss what they have written down with a partner and the teacher calls out on them to forward their responses. After receiving, the teacher discusses them briefly with the class and introduces the aim of the lesson's experiment.

Exploration phase

Experiment: What products are formed when an electric current is passed through molten lead (II) bromide?

Questions that guide exploration;

-Identify the anode and the cathode electrodes in the experiment

-What is observed at each of the electrodes during the experiment?

-Suggest an explanation for each of the observation made

With teachers guide the students carry out the experiment as guided in the **worksheet D** provided.

Explanation phase

Through the guidance of the teacher, students should answer the guiding questions through discussion. The teacher at this phase corrects the misconceptions noted in the first two phases, guides the learners to develop correct definitions of the concepts encountered.

Elaboration phase

Students to discuss and fill in the table provided.

Binary electrolyte	Observations made	Anode equation	Cathode equation
Lead (II) bromide ($PbBr_2$)	Red vapour of bromine gas at the anode Grey solid deposited at the cathode	2Br- (l) $\longrightarrow$ Br2(g) + 2e	Pb^{2+}(l) $\longrightarrow$ +2e Pb(s)
Lead (II) Iodide (PbI_2)			
Sodium Chloride (NaCl)			
Copper (II) Chloride ($CuCl_2$)			
Aluminium Oxide (Al_2O_3)			

Evaluation

This occurs through all the phases, for the teacher to ascertain that objectives of the phases are achieved. In engage phase evaluation reveals students' prior knowledge, misconceptions about the topic. In explore and explain phases, evaluation help in monitoring students to complete experiment and work out the given questions.

1.25 Application of electrolysis

By the end of the lesson, the learner should be able to;

-State and explain some applications of electrolysis process.

Engage activity

Using Think-Pair- Share strategy

-Briefly explain the role electrolysis plays in the real world.

Exploration phase

Three stations created in the lab with; 1- A chart on purification of impure copper

2- A chart on electroplating of iron

3 - Other applications of electrolysis statements & references to read.

Students divided into 3 groups and send to the stations 1, 2 &3 stations to discuss the subject matter placed in the station. The groups spent about 10 minutes in each station and moves to the next through rotation.

Explain phase

Through the guidance of the teacher, students should answer the guiding objective of the lesson through discussion. The teacher at this phase corrects the misconceptions noted in the first two phases, guides the learners to develop correct definitions of the concepts encountered.

Evaluation

This occurs through all the phases, for the teacher to ascertain that objectives of the phases are achieved. In engage phase evaluation reveals students' prior knowledge, misconceptions about the topic. In explore and explain phases, evaluation help in monitoring students to complete experiment and work out the given questions.

APPENDIX D: STUDENT'S WORKSHEETS

Worksheet A

NAME…………………………………………ADM. NO…………………….

CLASS....................

TOPIC: EFFECT OF ELECTRIC CURRENT ON SUBSTANCES

SUB-TOPIC: Electrical conductivity of solids

EXPERIMENT 1: To find out whether all kinds of solids conduct electricity

Requirements:

Switch

Connecting wires

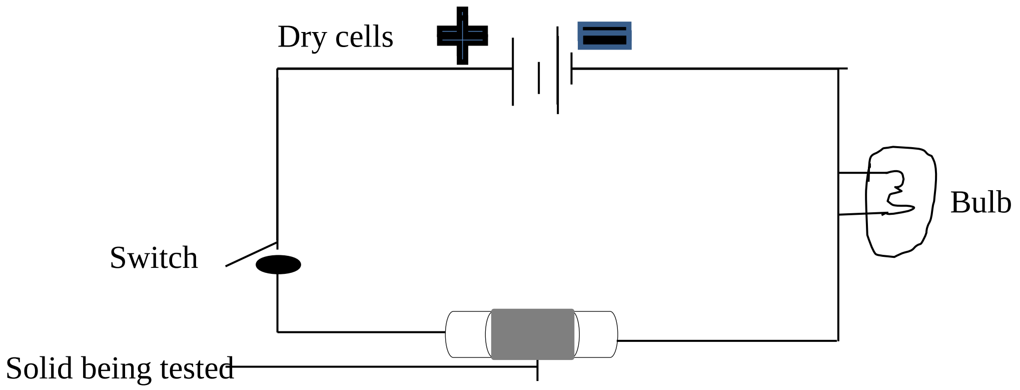
Crocodile clips

Dry cells

Solids to be test

Procedure;

Set-up the apparatus as shown in the figure below. Connect a piece of Aluminium strip to the circuit using crocodile clips. Close the switch and record your observations.



Repeat the experiment using the following instead of aluminium: magnesium, zinc, graphite, wood, sugar, sulphur, sodium chloride, lead (II) bromide, lead (II) iodide, and urea. Record the observations in the table below.

Name	Type of substance	Observation
Aluminium		
Magnesium		
Zinc		
Graphite		
Wood		
Sugar		
Sulphur		
Sodium chloride		
Lead (II)bromide		
Lead (II)iodide		

Answer the following questions;

-Name the function of the bulb in the experiment

-Name the substances used in the experiment which;

-do not conduct electricity

-What type of substances;

-Conduct electricity

-do not conduct electricity

-Suggest a reason for electrical conductivity in solids.

Worksheet B

NAME……………………………………………ADM.

NO……………………CLASS........

TOPIC: EFFECT OF ELECTRIC CURRENT ON SUBSTANCES

SUB-TOPIC: Electrical conductivity of molten liquids

EXPERIMENT 2: To find out whether all molten liquids conduct electricity

Requirements:

Switch

Connecting wires

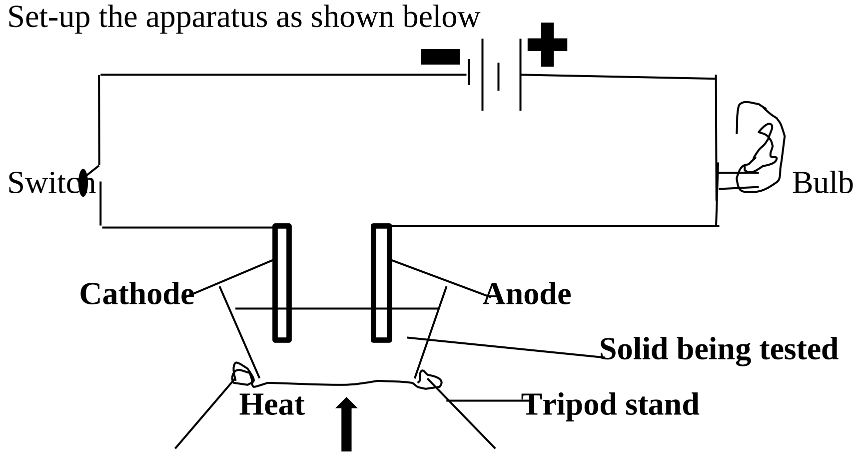
Crocodile clips

Dry cells

Solids to be tested and source of heat

Procedure:

Set-up the apparatus as shown below



Fill the crucible up to a third with lead (II) bromide. Ensure that graphite rods do not come into contact with each other. Close the switch and heat the bromide until it melts. Repeat the procedure with the other provided substances and record your observations in the table below.

Substance	Type of structure	Observation
Lead(II) bromide		
Sugar		
Sulphur		
Wax		

Answer the following questions

-Name the substances in the experiment which do not conduct electricity when in solid state but conduct when melted

-Name the substances in the experiment which do not conduct electricity when in both solid and melted state

-Why this experiment should be carried out in a fume chamber/ in the outside classroom.

-Why should care be taken to prevent the graphite rods from coming into contact?

-Explain why substances named in (ii) above do not conduct electricity whether in the solid or molten state.

Worksheet C

NAME……………………………………………ADM.

NO……………………CLASS........

TOPIC: EFFECT OF ELECTRIC CURRENT ON SUBSTANCES

SUB-TOPIC: Electrical conductivity of aqueous solutions

EXPERIMENT 3: To find out the type of substances that conduct electricity when dissolved in water

Requirements:

Switch

Connecting wires

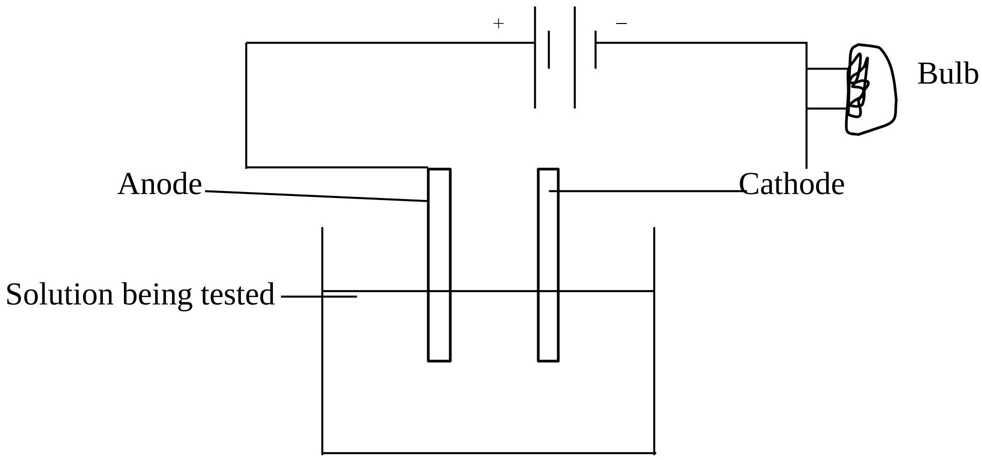
Crocodile clips

Dry cells

Solutions to be tested

Procedure

Half fill a 100ml beaker with distilled water. Add a spatula of sodium chloride crystals. Stir with a clean glass rod to dissolve the sodium chloride completely. Using graphite electrodes, set-up a circuit as shown in the figure below



Close the switch and record the observations made. Discard the solution and rinse both electrodes and the beaker. Repeat the experiment using solutions provided and record your observations in the table below.

Substance	Type of Structure	Observation
Sodium chloride		
Copper (II)chloride		
Copper (II)sulphate		
Hydrochloric acid		
Sulphuric acid		
Sodium hydroxide		
Ammonia		
Sugar		

Answer the questions that follow

-Name the substances in the experiment which do not conduct electricity in the solid state but conduct when dissolved in water.

-What do these substances which conduct electricity when dissolved in water have in common?

-Which substances do not conduct electricity either in the solid state or when dissolved in water?

Worksheet D

NAME……………………………………………ADM.

NO……………………CLASS........

TOPIC: EFFECT OF ELECTRIC CURRENT ON SUBSTANCES

SUB-TOPIC: Electrolysis

EXPERIMENT 4: What products are formed when an electric current is passed through molten lead (II) bromide?

Requirements:

Switch

Connecting wires

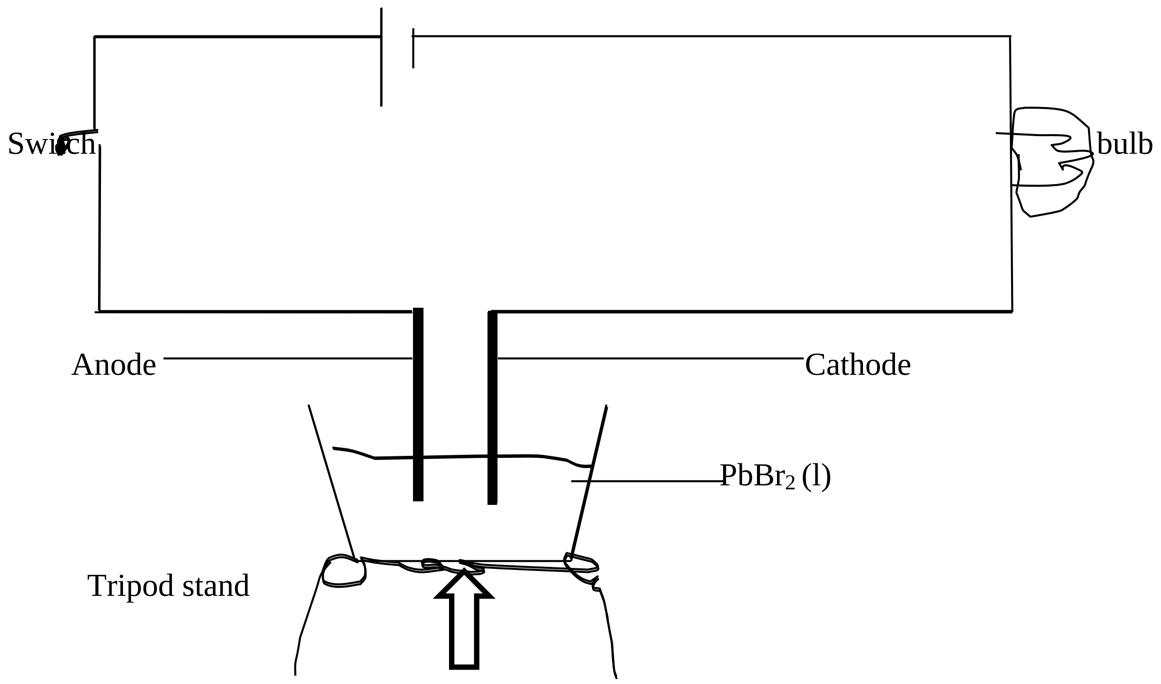
Crocodile clips

Dry cells

Solid lead (II)bromide

Procedure

Caution: This experiment should be done in the fume chamber or in the open air. Fill a crucible up to a third with Lead (II) bromide. Set up the apparatus as shown below.



Close the switch. Heat the lead (II) bromide until it melts. Record your observations

Answer the questions that follow;

-What is observed at each of the electrodes?

-Suggest an explanation for the observations made.

Worksheet E

NAME……………………………………………ADM.

NO……………………CLASS……..

TOPIC: EFFECT OF ELECTRIC CURRENT ON SUBSTANCES

SUB-TOPIC: Electrolysis

EXPERIMENT 5: What products are formed when an electric current is passed through molten copper (II) chloride?

Requirements:

Switch

Connecting wires

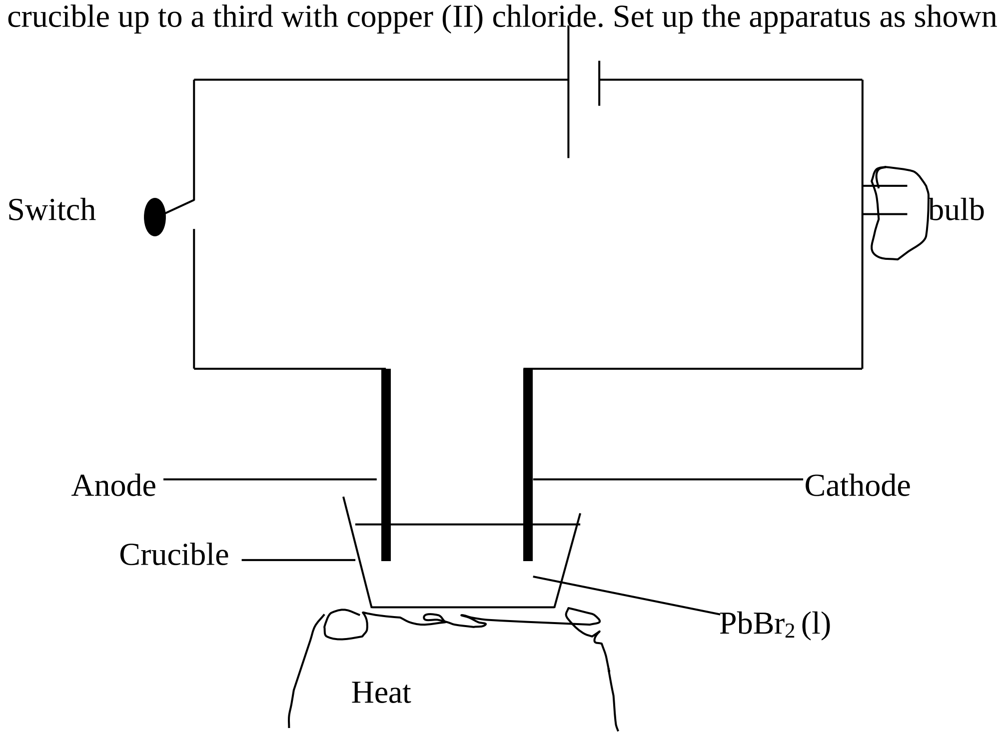
Crocodile clips

Dry cells

Solid copper (II)chloride

Procedure

Caution: This experiment should be done in the fume chamber or in the open air. Fill a crucible up to a third with copper (II) chloride. Set up the apparatus as shown below.



Close the switch. Heat the lead (II) bromide until it melts. Record your observations

Answer the questions that follow;

-What is observed at each of the electrodes?

-Suggest an explanation for the observations made.

APPENDIX E: SCHEME OF WORK

CHEMISTRY FORM 2, TERM 2, 2019

TOPIC: EFFECT OF ELECTRIC CURRENT ON SUBSTANCES

WK	LSN	SUB-TOPIC	OBJECTIVES	L/ACTIVITIES	L/AIDS	REFERENCES	REMARKS
1	1	Administration of PRE-TEST					
	2	Electrical conductivity of solids	**By the end of the lesson, the learner should be able to;** -Define current, conductors and non-conductors -Classify solid substances into conductors and non-conductors -Explain the difference between conductors and non-conductors -Describe an experiment that can be used to distinguish between conductors and non-conductors	-Experiment to investigate electrical conductivity of solids -Discussion	-Dry cells -Torch bulb -Connecting wires -Several solids	-KLB Chemistry students' book 2, Pg 105-107 -Teacher's guide book2, Pg 99 -Explore Chemistry students' book2, Pg 130	
	3	Electrical conductivity of Molten liquids	**By the end of the lesson, the learner should be able to;** -Define electrolytes and non-electrolytes -Define binary electrolyte -Classify the given molten liquids into electrolytes and non-electrolytes -Explain the difference between electrolytes and non-electrolytes	Experiment; to investigate which molten liquids conduct electricity -Discussion	-Dry cells -Torch bulb -Connecting wires -Lead (II)Bromide, Sugar, salt, Wax, Sulphur	-KLB Chemistry students' book 2, Pg 107-108 -Teacher's guide book2, Pg 100 -Explore Chemistry students' book2, Pg 131	
	4	QUIZ 1					
2	1	Revision and Remediation of QUIZ 1					

	2&3	Electrical conductivity of aqueous solutions	**By the end of the lesson, the learner should be able to;** -Classify aqueous solutions into electrolytes and non-electrolyte -Identify the type of compounds that conducts electric current when in aq state and -Identify the type of compounds that do not conduct electric current when in aq state.	-Experiment to classify aq. Solutions into electrolytes and non-electrolytes	-Dry cells -Torch bulb -Connecting wires -NaCl, $CuCl_2$, $CuSO_4$, HCl, H_2SO_4, NaOH, NH_4OH, Urea, and Sugar	-KLB Chemistry students' book 2, Pg 108-110 -Teacher's guide book2, Pg 100 -Explore Chemistry students' book2, Pg 133	
	4	QUIZ 2					
3	1	Revision and Remediation					
	2&3	Electrolysis	**By the end of the lesson, the learner should be able to;** -Explain the process of electrolysis -Draw and label a set up that can be used to carry out electrolysis of molten lead (II) bromide liquid -Name the products of the process of electrolysis of selected molten liquids.	-Experiment to investigate the products formed upon electrolysis of $PbBr_2$	-Dry cells -Torch bulb -Connecting wires -Crucible and source of heat - $PbBr_2$	-KLB Chemistry students' book 2, Pg 111-112 -Teacher's guide book2, Pg 100 -Explore Chemistry students' book2, Pg 135	
	4	QUIZ 3					
4	1	Revision QUIZ 3 and Remediation					

	2&3	Electrolysis	**By the end of the lesson, the learner should be able to;** -Name the products of the process of electrolysis of copper (II) chloride molten liquid. -Write ionic equations for the reactions that occur at the electrodes	-Experiment to investigate the products formed upon electrolysis of copper (II)chloride	-Dry cells -Torch bulb -Connecting wires -Crucible and source of heat -$CuCl_2$	-KLB Chemistry students' book 2, Pg 111-112 -Teacher's guide book2, Pg 101 -Explore Chemistry students' book2, Pg 137	
	4	Electrolysis	**By the end of the lesson, the learner should be able to;** -State and explain some of the applications of electrolysis	-Discussion	Charts on purification of impure copper, electroplating of iron using reactive metals,	-KLB Chemistry students' book 2, Pg 113 -Teacher's guide book2, Pg 102 -Explore Chemistry students' book2, Pg 139	
5	1	QUIZ 4					
	2&3	Revision of QUIZ 4 and Remediation					
	4	Post-test					

APPENDIX F: RESEARCH PERMIT

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Ref No: 771478

Date of Issue: 06/December/2019

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APPENDIX G: ABSTRACT PAGE OF THE PUBLISHED PAPER

Effects of Mastery 5Es Constructivist Teaching Approach on Secondary School Students' Achievement in Chemistry in Rongai Sub-County, Nakuru County, Kenya

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Abstract
Analysis of chemistry performance in Kenya since 2013 indicates a trend of below average performance. This may be attributed to the conventional teaching methods that are mainly teacher centered. Mastery 5Es constructivist teaching approach (M5EsA) may help address the problem of poor performance in chemistry though its effects have not been determined. This study investigated the effects of using M5EsA on students' achievement in chemistry in Rongai sub-county. Solomon Four Non-Equivalent Control Group Design under Quasi experimental research was used. Sample size of 303 students. Chemistry Achievement Test (CAT) with reliability of 0.701 was used to collect data. Hypothesis was tested using t-Test, ANOVA and ANCOVA at critical alpha value of 0.05. The findings indicated that M5EsA led to increased students' achievement in Chemistry.

Keywords: Mastery 5Es Constructivist Learning Approach, Secondary School Students', Achievement in Chemistry

1. Introduction

Chemistry is one of the branches of science that is taught at secondary school level in Kenya. It plays a critical role in the production of human capital which is the most important resource for any nation (Aniodoh & Egbo, 2013). The quality of human resource in the field of science for instance doctors, engineers, scientists, science teacher educators and science teachers, is directly pegged on the quality of science education offered. Highly qualified personnel equipped with scientific, technical and intellectual capabilities have a great impact in propelling a nation to the desired levels of development. Chemistry education equips learners with scientific knowledge, skills and attitudes towards science and technology, therefore an essential tool for economic and technological development of any society (Abungu, 2014).

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