$5E_S$ MODEL: EFFECT ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN CHEMISTRY IN INFORMATION COMMUNICATION AND TECHNOLOGY INTEGRATED LESSONS IN MURANG'A COUNTY, KENYA

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A RESEARCH THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS OF THE AWARD OF DEGREE OF DOCTOR OF PHILOSOPHY (*EDUCATIONAL TECHNOLOGY*) IN THE DEPARTMENT OF EDUCATIONAL COMMUNICATION AND TECHNOLOGY, SCHOOL OF EDUCATION AND LIFELONG LEARNING, KENYATTA UNIVERSITY

APRIL, 2023

DECLARATION

I declare that this thesis is my original work and has not been presented in any other university/institution for consideration of any certification. The thesis has been complemented by referenced sources duly acknowledged. Where text, data (including spoken words) graphics, pictures or tables have been borrowed from other sources, including the internet, these are specifically accredited and references cited using the current 7th edition APA system and in accordance with anti-plagiarism regulations.

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DEDICATION

This thesis is dedicated to my family for the encouragement and inexpressible support rendered to me as I endeavoured to make significance of my undertaking. First, to my dear wife Grace Wanjiru for her endless support and encouragement. Second, to my children Cynthia Wambui, Brian Charagu and Victor Kamande, for the silent but earnest hope they had in me as I made meaning of this work. Lastly, to my mum Elizabeth Wambui for inculcating the virtue of hard work which has always postulated the sky as the limit.

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ABBREVIATIONS AND ACRONYMS

5Es	Engagement, Exploration, Explanation, Elaboration, and Evaluation
ANOVA	Analysis of Variance
BSCS	Biological Sciences Curriculum Study
CEMASTEA	Centre for Mathematics, Science and Technology Education in Africa
CFSK	Computers for Schools Kenya
ICT	Information Communication and Technology
KCSE	Kenya Certificate of Secondary Education
CUE	Commission for University Education
KESSP	Kenya Education Sector Support Programme
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examinations Council
MOEST	Ministry of Education Science and Technology
NI_3C	National ICT, Innovation and Integration Centre
SCAT	Science Chemistry Achievement Test
SQ	Student Questionnaire
STEM	Science Technology, Engineering and Mathematics

SHSSA Scale of High School Students' Attitudes

TOSRA Test of Science-Related Attitudes

ABSTRACT

An integration of the 5Es model in teaching Chemistry has an impact on student conceptualization. Equally, integration of information communication technology (ICT) in teaching and learning can be helpful to students. The Kenya National Examinations Council (KNEC) reports indicate that Chemistry has dominantly registered dismal achievement in Kenya Certificate of Secondary Education (KCSE) at national level. KCSE results analysis over the years show poor results in the subject within Murang'a County. KNEC report further reveal that the topic on "structure and bonding" over the years has been rated as one of the poorly achieved areas. This study aimed at examining how 5Es model impacts learner's achievement in "structure and bonding" in ICT integrated lessons in Chemistry. The specific objectives of this study were therefore to: (i) establish effect of 5Es model on learner's achievement in "structure and bonding" in ICT integrated lessons; (ii) determine the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on ability; (iii) establish the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on attitude; (iv) determine the gender difference on learners' achievement in "structure and bonding" for learners exposed to the 5Es model in ICT integrated lessons; and (v) establish the challenges encountered in teaching ICT integrated lessons using the 5Es model. A quasi- experimental design of the Solomon four type was applied to determine the impact of the instructional model used in ICT integrated lessons on students' conceptualization and consequently achievement in "structure and bonding" in Chemistry. The sample size was 197 form two students as well as teachers of Chemistry, purposively selected from four mixed gender secondary schools. This study was guided by constructivist theory of learning and the technology acceptance model. Research instruments used included students' questionnaire, pre and post achievement tests, observation schedule as well as an interview schedule. The data collected from the study was quantitatively and qualitatively analyzed. Descriptive statistics including mean, standard deviation, percentages, frequencies and inferential statistics comprising t-test and ANOVA was used to show the relationship between the identified parameters which were used in the derivation to the new body of knowledge. Findings indicated that students instructed through 5Es model in ICT integrated lessons achieved significantly better than in the conventional methods. Consequently, 5Es model in ICT integrated lessons is rated as a better instructional approach as compared to conventional methods. Further, use of 5Es model in ICT lessons has a significantly greater effect on low ability learners as compared to high ability students. Whereas 5Es model in ICT enhanced lessons seems to have an effect on the attitude of students with positive attitude towards Chemistry as well those with negative attitude, the difference in the effect was insignificant. The results show that the difference in performance between female and male students is not significant. A technology-based instructional model related to 5Es for enhancing learning in Chemistry suitable for developing countries like Kenya has been developed based on the findings of the study. It is, therefore, recommended that Chemistry teachers should be encouraged to use the 5Es model in ICT integrated lessons so as to improve achievement in Chemistry. Moreover, the findings would be significant in improving achievement in secondary school Chemistry by involving all stakeholders in the education sector.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Chemistry is the study of matter's constituents, such as atoms, molecules, and ions, as well as their characteristics, structure, behavior, and interactions. (Johnson, 2021). It is an important field of study .since most Science Technology, Engineering and Mathematics (STEM) careers depend heavily on the subject. Chemistry provides learners with opportunities to be critical thinkers. On the other hand, Chemical technologies provide solutions to problems in health and in energy usage making Chemistry an extremely significant field of study. (Mater, Hussein, Salha, Draidi, Shaqour, Qatanani, & Affouneh, 2022). Among the topics tough in Chemistry at high school level is “structure and bonding” .This is a broad topic thus carries more marks than other areas. Consequently, the topic has been frequently examined all through the years. Documented evidence shows that the topic has persistently registered poor results thus rated among the poorly performed topics by the Kenya National Examinations Council (KNEC), KNEC Reports (2014 to 2019).

There are diverse inquiry-based learning models which guide teaching and learning process. All these have emanated from the search for methodologies and procedures that can enhance effective pedagogy. The 5Es instructional model is among these dominant models. The 5Es model was developed by an American organisation known as the Biological Sciences Curriculum Study (BSCS) (Bybee 2009). The 5E Model stimulates active and co-operative learning where learners work in partnership to investigate new concepts and find solutions to problems by observing, probing questions, examining, and coming up with logical deductions. It provides learners’ with an ample space for hands-on or rather, putting into practise on what they are learning. The 5Es instructional model is founded on the “constructivist theory of learning”. The constructivist advocates that knowledge and meanings are derived from experiences.

New knowledge and previous ideas are reconciled through understanding and reflecting on the learning process. In the 5Es instructional model, every part has a definite role and purpose. Each phase contributes to the improved instructions that in-turn help learners improve on achievement as well as attitude (Bybee, 2009). The 5Es instructional model comprises the following five (5) sequential levels: Engagement, Exploration, Explanation, Elaboration, and Evaluation.

At the Engagement level, the teacher needs to establish what the learners already know. The teacher engages learners by introducing targeted concepts through related tasks that stimulate interest and prompt previous knowledge. Learners make a link between past experiences and present experiences. They also get organized for the learning activities ahead. At this stage students’ prior knowledge is a significant factor that guides in identifying knowledge gaps. Therefore, the teacher aims at gaining an understanding on the learners’ entry characteristics. The teacher may define a problem or ask probing questions that will involve the students and focus them on the lesson objectives or interrogate on what they had previously known about the content or topic under study. It is at this stage when the concept or skill to be learnt is presented to learners in an interesting way to capture learner’s attention.

During the Exploration, phase learners are given a chance to explore current concepts, processes and skills. Learners are involved in hands-on activities that help them develop first-hand experiences with the intended learning content. Learners also work together in teams which help them in the process of sharing as well as communicating. The teacher plays a very crucial and significant role of facilitation, provision of instructional materials and gives guidance on the intended instructional objective. Learners raise questions and identify ambiguous areas in tandem with their existing knowledge at this stage. New ideas and concepts are primarily introduced by the teacher but ventilated by both teacher and learners. They are equally provided with opportunities to apply the newly learnt ideas, skills and concepts in novel contexts. It is at this phase where learners basically explore on the new concept, skills and ideas through hands –on way by going through the diverse teaching methodologies.

During the Explanation phase learners are provided with opportunities to demonstrate their conceptual understanding through explanations. This phase is directed by the teacher but focuses on prior experience from learners as demonstrated during the exploration phase. It is in this phase where learners describe their understanding about the concepts they have been exploring. The teacher also makes clarification of any emerging misconceptions. Learners make further clarification through asking questions as they synthesize on the new knowledge acquired. To enhance effectiveness at this phase the teacher is necessitated to ask learners to share the concepts learnt during the exploration phase before introducing any other new concept as guided by the lesson objectives.

In the Elaboration phase, the teacher aims at improving learners' conceptual understanding. The learning activities during this phase should help learners to apply and reinforce the concepts and skills learnt. Learners are also encouraged to conduct group discussions. To achieve this, the teacher may task learners to present or conduct further investigations aimed at reinforcing the new skills. This phase is aimed at developing deeper conceptual understanding.

In the Evaluation phase, learners' understanding toward achieving the set educational objectives is assessed. Both formal and informal assessment are used. Formal assessment is based on empirical data that measure what the learners have achieved after learning process. It aims at evaluating learners' mastery of the content. Formal assessment is also used for comparisons against certain standards. Informal assessment on the other hand is spontaneous form of evaluation that measure the learners' achievement and progress. It is more content oriented and driven by achievement. At the evaluation phase, the teacher observes the learners and see whether they have a clear understanding of the concepts taught besides self-assessment, peer-assessment, writing assignments, and sitting for an exam. The learner's ability to approach problems in a diverse manner based on what they learnt is assessed at this stage.

Globally, use of 5Es instructional model and the positive effect on achievement in Chemistry, is well documented. For instance, Opara and Waswa (2013) in a study on "enhancing students' achievement in Chemistry through the 5E model" pointed at an improved achievement. A case study by Skamp and Peers (2012) that elucidated on "insights from teachers' feedback on the impact of 5Es instructional model at the primary school level" registered similar findings. The obtained results revealed that 5Es model positively influenced on science achievement. Moreover, it was observed that the 5Es model allowed learners to be self-directed. A notable level of engagement which led to an improved learning outcome was eminent.

Kolomuc, Ozmen, Metin, and Acisli (2012) who studied "physical and chemical properties" found that the group that was exposed to the 5Es model achieved better. Cheng and Chu (2016) in a related study established a statistically significant difference in favour of the experimental group. Likewise, in a study investigating the 5Es instructional model and dubbed as "effectiveness of 5Es instructional model on students learning in Physics, statistical results indicated that learners instructed via 5Es model had significantly higher score than the learners instructed via traditional method (Khan, Aurangzeb & Tahir, 2020). Furthermore, Hokkanen (2011) examined the implications of presenting a lesson by integrating the 5Es model. The research aimed at exploring how the model can influence the academic achievement, confidence and arouse interest. Findings established that 5E model enhanced the three domains confidence in science education.

Shaheen, Alam, Mushtaq, and Bukhari (2015) in a study that was carried out in Pakistan was of a similar opinion. Findings from the research showed that 5Es model was more effective compared to lecture method. Subsequent to research findings, a conclusion was arrived at that affirmed its superiority vis-à-vis conventional teaching strategies. Mupira and Ramnarain (2018) in a study on "The effect of 5E inquiry-based learning on the achievement of grade 10 physical sciences learners in South Africa" opined that the 5Es model was more impactful.

Jack (2017) established that use of 5E model resulted to an improved the achievement in Chemistry in Nigeria. This observation is supported by findings from Ellah and Achor (2018). Similar observations are reported in a study on BSCS 5Es model on Zambian secondary schools in teaching acid s and bases in Chemistry (Chola, & Shumba, 2016). These finding are in tandem with that of Sen and Oskay (2017). In their study the group under 5Es interventions had a better achievement that was statistically significant. In a related research that sought to establish the effect of 5Es instructional model on students' understanding of the gas concept in Chemistry education, the traditional approach was used to train the control group while and the experimental group was taught by using 5Es instructional model of the constructivist approach. A statistical analysis established a significant difference (Yadigaroglu & Demircioglu, 2012).

Similar observations are reported in Nigeria by Ezugwu (2019). The study on “comparative analysis of the impact of 5Es constructivist instructional and lecture methods on learner achievement in Biology” established that 5Es instructional model was a superior approach. The research design that was in the study was quasi experimental with a total sample size of two hundred and forty learners.

The Impact of 5Es model in classroom practice in Kenyan schools is evident across a number of subjects. In Biology education for instance Mwanda, Odundo and Midigo (2017) found that the use of 5Es instructional model was more effective compared to conventional approaches. Likewise Hassan (2015) researching on a study dubbed “effect of 5Es enquiry based approach in teaching secondary schools in Kenya”, established that test group learners which used to the 5Es instructional model had a better achieved than their counterpart who used conventional strategies. These findings augers well with a study done in Physics education by Njoroge, Changeiywo and Ndirangu (2014) on “effects of inquiry-based teaching approach on secondary school Students’ achievement and motivation” . Opara and Waswa (2013) had similar findings in Chemistry education

Since 1963, Kenya education system has under gone through several educational reviews that aimed at improving teaching Ominde, 1964; Gachathi, 1976; Mackey, 1982; Kamunge, 1988; Koech, 1999). Other contributors that were notable in the rolling out of the ICT programmes in education included, Computers for Schools Kenya (CFSK) (Randerson, 2011), National ICT Innovation and Integration Centre (NI_3C) (Kadzo, 2011), Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) (Nyanchoka, 2015) and the school laptop project (Mariga, Ogenga, Shikali, & Muliaro, 2017). In 2018, the Kenyan government adopted the Competence-Based-Curriculum (CBC) with a key aim to integrate technology tools in classroom. Notwithstanding the reiterated endeavours made by Kenyan government on ICT use, students in Kenyan secondary schools still register low grades in Chemistry as reported in KNEC reports for the period 2014 to 2019 as given in Table 1.1.

Table 1:1 KCSE Chemistry Achievement by Students, from 2014 to 2019

Year	National mean score	Overall mean score for Murang'a county
2014	3.859	4.135
2015	4.123	4.242
2016	2.845	2.282
2017	2.886	2.667
2018	3.225	3.166
2019	3.130	2.914

Source: KNEC Reports from 2014 to 2019

As shown in Table 1.1, the average scores at KCSE in the years 2014 to 2019 reflects a low achievement at the national level that ranges between grades D- to D+. It is also evident that the achievement in Chemistry in Murang'a County is low since it ranges between grades D- of 2.282 points in the year 2016 to a D+ of 4.242 points in the year 2015. This raises genuine concern since the minimum grade required for a student qualify for science related courses at the Kenyan university is set at grade C+ as per the Kenya Commission for University Education (CUE, 2012). KNEC reports have further indicated that over the years the questions tested on the topic under "structure and bonding" are among the poorly achieved by candidates (KNEC, 2005-2019). This state is exemplified in Table 1.2 by KNEC report on poorly achieved questions in Chemistry at the KCSE examination by candidates.

Table 1.2: Poorly Achieved Questions in Chemistry at the KCSE Examination

Year	Questions in paper 233/1	Poorly achieved questions	Questions on "Structure and Bonding"
2005	28	4	1
2009	28	3	2
2010	27	2	1
2013	29	5	1
2016	29	4	1
2018	29	4	1
2019	29	3	1

Source: KNEC Reports 2019

In the year 2005, four questions out of the twenty-eight questions tested in paper 233/1 were poorly achieved by candidates. Out of the four questions tested one was from the topic on structure and bonding. Similarly, in the year 2009 three questions were poorly achieved out of the twenty eight tested questions. Notably two of the questions were from the topic on structure and bonding. This represented a 66.67% of the poorly achieved questions in that particular year.

In the year 2010, there were two dismally achieved questions one of which was from the topic on structure and bonding. This represents a 50% of the poorly achieved questions. As per the report this trend was evident in the year 2013 and 2016. For the two year, it represented 20 % and 25% respectively of the poorly achieved questions from the topic on “structure and bonding”. In the year 2018 a representative percentage of 25% was registered while in the year 2019 the rating was 33.33% (KNEC, 2019).

This low achievement in the topic on “structure and bonding” as indicated in the KNEC report is a matter of great concern. Studies on ICT integration in teaching and learning have shown significantly better achievement on learners exposed to ICT lessons. A meta-analysis of each show that none of them is specific on how the instructional process in teaching of the ICT lesson is carried out. In addition, a cursory analysis on studies carried out on 5Es instructional model have shown significantly better achievement on learners exposed to the 5Es enquiry-based approach.

For the studies done, none of them has ventured to research on how the instructional process that is guided by the 5Es model in ICT integrated lessons can influence learner’s conceptualization and consequently achievement. This is a key factor since the instructional process in teaching ICT integrated lessons can be methodical and a step by step approach. This approach is well guided by the 5Es model of instruction. On the converse, the instructional process can be undertaken through the conventional methods. So far from the literature reviewed there exists no information on the most efficient instructional process to employ when teaching “structure and bonding” in ICT integrated lessons precisely in Kenya.

1.2 Statement of the Problem

An instructional process that is guided by the use of the 5Es model in ICT integrated lessons may bring about a better coherence and a common systematic process. This could enhance learners’ achievement in classroom, resulting to a better outcome in achievement.

Dismal achievement in science subjects at high school level and more precisely so in Chemistry is an issue of major concern. It has thus persistently necessitated the Government of Kenya and other interested parties in education to treat it as an urgent issue that needs serious attention. This is from the realisation that low achievement in sciences threatens learners' chances for upward progression. Moreover, at the national level there is low transition into careers in science and technology due to this low achievement. The government of Kenya has adopted various interventions coming up with effective instructional intervention in the education system in an attempt to reverse this worrying trend. This dismal achievement in Chemistry (see table 1.1) is evident in Murang'a County, Kenya. The "topic structure and bonding" which is broad thus carrying more marks than other areas has been frequently examined all through the years and has persistently registered poor results (see table 1.2).

Existing literature show little information on the most efficient instructional intervention to employ when teaching "structure and bonding" in ICT integrated lessons precisely in Kenya. In order to fill this gap therefore, this study intended to investigate the effectiveness of 5Es instructional model in ICT integrated lessons on learners' achievement in Chemistry in Murang'a County, Kenya.

1.3 Purpose of the Study

The study intended to investigate the effect of 5Es model in ICT integrated lessons on learner's achievement in teaching the topic "structure and bonding" in Murang'a County, Kenya

1.4 Objectives of the Study

The study was guided by the following objectives.

a) Establish effect of 5Es model in ICT integrated lessons on learner's achievement in "structure and bonding"

b) Determine the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on ability.

c) Establish the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on attitude.

d) Determine the gender difference on learners' achievement in "structure and bonding" for learners exposed to the 5Es model in ICT integrated lessons.

e) Establish the challenges encountered in using the 5Es model ICT integrated lessons

1.5 Research Hypotheses

The following research null hypotheses were tested:

H_{O1}: There is no significant difference in achievement in "structure and bonding" between learners using 5Es model in ICT integrated lessons vis-à-vis conventional methods

H_{O2}: There is no significant difference in achievement in "structure and bonding" between learners guided by 5Es model in ICT integrated lessons vis-à-vis conventional methods based on ability

H_{O3}: There is no significant difference in achievement in "structure and bonding" between learners guided by 5Es model in ICT integrated lessons vis-à-vis conventional methods based on attitude

H_{O4}: There is no gender difference in achievement in "structure and bonding" for learners guided by 5Es model in ICT integrated lessons vis-à-vis conventional methods

1.6 Significance of the Research

The study examined the most efficient instructional process between use of 5Es model in ICT integrated lessons and the conventional instructional approach in teaching "structure and bonding". The findings may be of much important to MOEST because it may guide in the generating ICT related policies. School Administrators have to be well informed on adoption of the most efficient instructional strategy

Chemistry teachers may be encouraged to use 5Es model in ICT enhanced lessons to reduce gender disparity in Chemistry performance. The impact of 5Es model in ICT based lessons on low ability and high ability learners may be beneficial to Chemistry teachers when handling these different categories. This will play a significant role in evaluating the entry behavior of the learners. An analysis on how 5Es model in ICT enhanced lessons influences learner's attitude may benefit Chemistry teachers in giving necessary guidance and counseling. The Ministry of Education Science and Technology and school administrators will be informed of the challenges encountered when integrating 5Es model in ICT enhanced lessons. Finally, the developed ICT based instructional process model related to 5Es will be valuable to teacher training institutions in developing countries like Kenya.The teacher trainees will be familiar with an effective instructional process to follow when integrating ICT in teaching of Chemistry particularly on the topic "structure and bonding".

1.7 Limitations and Delimitation of the Research

The following section dealt with limitations and delimitations of the study as follows;

1.7.1 Limitations

A number of limitations was related to this the study. These includes:

a) The respondents were confined to schools in Murang'a County.

b) There was no random selection and assigning of the learners to the sample study groups due to nature of research design thus the entire class was involved.

c) A small number of respondents was involved due to nature of research design.

1.7.2 Delimitations

This study delimited itself to a number of issues which include:

a) It focused on the instructional process in teaching ICT integrated lessons in Chemistry regardless of the fact that there are various aspect that affects the students' achievement in Chemistry.

b) Although Murang'a county has many secondary schools, the study only targeted schools which have ICT equipment and facilities

c) In spite of a number of subjects in the curriculum this research narrowed down to instructional process used in the teaching of "structure and bonding"

d) From the KNEC report, the topic identified as the most persistently poorly achieved over the years is "structure and bonding" which is taught at form two. The study thus targeted form two students only.

1.8 Assumption of the Study

This study assumed that the implementation of 5Es model in ICT integrated lessons was implemented by teachers of equivalent competency and with the same degree of motivation. The study presupposed that the blended ICT tools with the 5Es model was carried out on learners with a similar level of aptitude and motivation The study also assumed that the sampled schools had a robust ICT policy that was either funded by the government or by the school through the various stake holders.

1.9 Theoretical and Conceptual Frame Works

1.9.1 Theoretical Framework

Constructivist theory of learning (Bada & Olusegun, 2015) and Technology Acceptance Model (TAM) (Davis, 1989) guided the study. Constructivism holds that knowledge creation is a fundamental aspect of learning. It postulates that learners create meanings through reflecting on past and present experiences. Further, learner's knowledge is shaped from the experiences undergone. Given the diverse carder of learners with different cognitive abilities from the sampled schools, constructivist theory was relevant to the study in establishing how knowledge is created in low ability learners as well as high ability learners. Moreover, constructivist theory proposes that the core role of the teacher is not only limited to observing and assessing but also in creating an active learning atmosphere by engaging learners through probing questions that promote reasoning. Thus, learning becomes effective when learning process actively engages learners rather than them receiving knowledge passively. The aspect of active learning, which is among the key tenets of constructivist theory would be a basis in establish how its effect on learners achievement as learners navigated though the different levels of the 5Es model. Blending constructivist theory with technology makes learning more meaningful as learners get more engaged in the learning process. Consequently learners are actively engaged and are more responsive about what they learn (Rob & Rob, 2018).

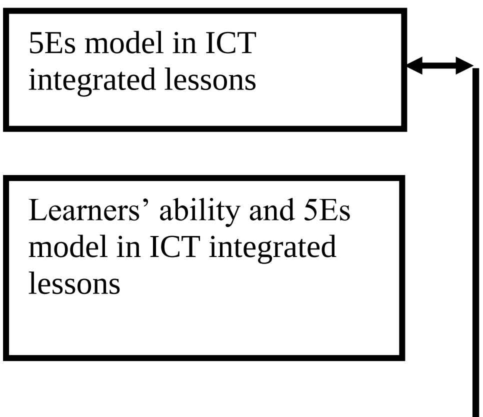
The 5Es model includes the steps of engaging, exploration, explaining, elaborating, and evaluating the entire process of learning in an attempt to promote conceptualization. Each level of the 5Es model demands that learners work together as a team. Gender disparity among the learners from the sampled schools was an area of concern that the study investigated in relation to academic achievement. Among the tenet of constructivist theory is the aspect of social collaboration in knowledge creation. Constructivist theory of learning was thus relevant to the study in establishing the effect of gender on learner's achievement when using the 5Es model in ICT integrated lessons.

Technology acceptance model (TAM) was developed by Davis (1989) and presupposes that there exist key tenets towards use of technology. These includes how users of technology perceive ease of use of any technological intervention, perceived usefulness and the harboured attitude towards using the technology. This model antedates that, for effective integration of ICT tools in pedagogy, the key players who are the teachers and the learners must appreciate the worth and ease of its use. This model would thus remain significant in guiding the study on investigating on challenges that were encountered in the use of 5Es model in ICT lessons. The attitude of teachers and learners becomes more positive when ease of use of technology is guaranteed as well as a realization of significance and importance of the used technology is arrived at. Any expedient integration of ICT tools enhances the learning process consequently resulting to a better conceptualization. Technology acceptance model (TAM) thus came in handy in the investigation on how the 5Es model would impact on learner's attitude when 5Es model in ICT lessons is used in teaching Chemistry.

1.9.2 Conceptual Frame Work

Through conceptual frame work, an inter-relationship between the key variables is depicted as shown in figure 1.1.

Independent variables. **Intervening variables** **Dependent variable**



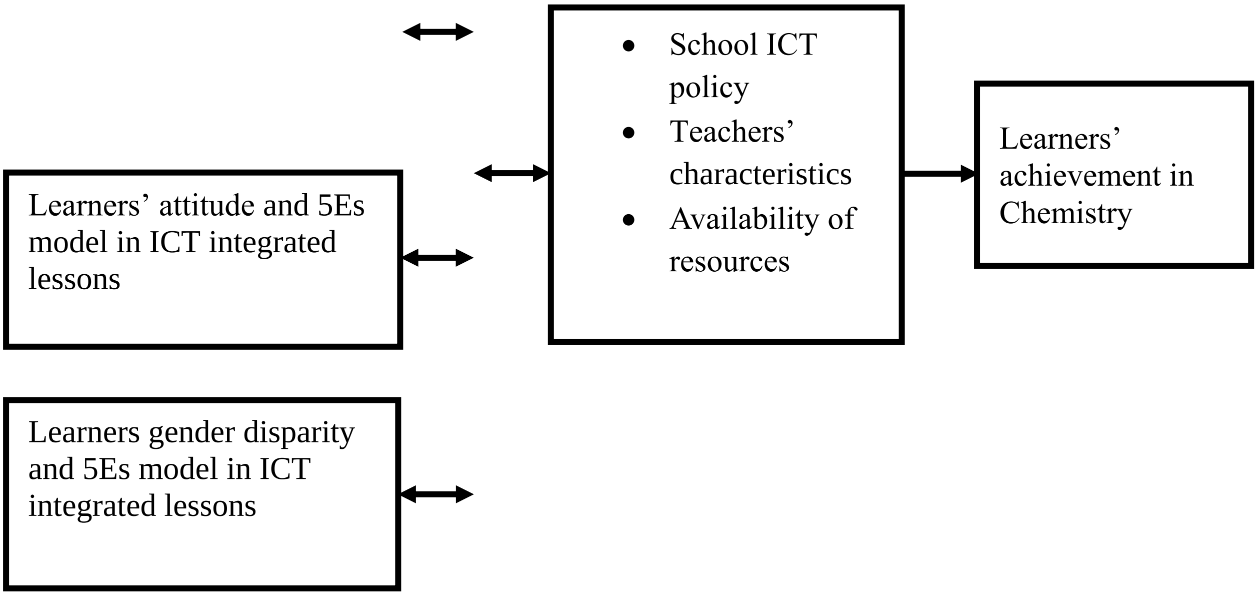


Figure 1.1 Conceptual frame work (Source**:** Adapted from Ogembo (2017).

The study conceptualized learners' achievement as dependent variable. Mastery of the content in Chemistry is perceived to be influenced by an array of independent variables including; 5Es model in ICT integrated lessons, learners' ability in use of 5Es model of in ICT integrated lessons, learners' attitude towards 5Es model in ICT integrated lessons as well as gender disparity toward use of 5Es in ICT integrated lessons. It is postulated that three key control factors which were controlled by being studied alongside the independent variables included; school ICT policy, teachers' characteristics and availability of ICT resources positively influences learners' achievement.

1.10 Operational Definition of Terms

5Es instructional process: learner centered teaching and learning approach that is sequential and methodical as guided by the steps of: engagement, exploration, explanation, elaboration, and evaluation in the delivery of curricula in ICT integrated lessons.

Achievement in Chemistry: the level of competency achieved and measurable in terms of grades scored by a learner.

Chemistry: A branch of science concerned with substances of which matter is composed.

Conventional methods: a non-sequential approach characterized by teacher demonstrations and commonly adopted in the classroom in teaching ICT enhanced lessons.

High Ability Students: These are learners who basically have a high achievement during assessment and evaluation process

ICT integrated lessons: technology-based lessons that majorly utilizes "WEB 2.0" tools to assist teaching and learning.

Low Ability Students: These are learners who basically perform lowly during assessment and evaluation process

Attitude: A mental state encompassing learners' beliefs, feelings, values and dispositions that make them behave or act in a certain way

Gender: Distinguish learners as either male or female based on their sex

Structure and bonding: A topic in Chemistry that studies how element combine to form chemical structures

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter focuses on significance of teaching Chemistry subject in secondary schools, general performance of sciences at secondary schools and the use of information communication technology(ICT) in teaching .The review also focuses on 5Es instructional model and its effects on learner's ability, attitude and gender. It also ventures on the challenges encountered while integrating 5Es instructional model in teaching and learning process.

2.2 Significance of Teaching Chemistry Subject in Secondary Schools

The goals and objectives of teaching Chemistry elucidates its significance as a subject. These goals which includes providing a foundation in Chemistry, stresses on scientific reasoning subsequently, providing learners with skills that prepare them in diverse careers such as the chemical industry and other related professionals (Musengimana, Kampire, & Ntawiha, 2021). Basic knowledge and understanding of Chemistry at secondary schools is developed in learners which is a major milestone in understanding the relationship of chemical substances, their properties and their application in life. Learners are exposed to a breadth of experimental techniques while interacting with modern instrumentation. This helps student appreciating the interdisciplinary nature of Chemistry where knowledge from Mathematics, Physics, Biology and other fields are integrated in solving chemical related problems. (Iyamuremye, Mukiza, Nsengimana, Kampire, Sylvain, & Nsabayezu, 2022).

Learners not only master laboratory skills that guides in the interpretation chemical research but explores the content, process language used in Chemistry. This facilitate in the development of effective communication of scientific information by learners. Moreover, students learn professionalism including the ability to be good team players in the application of basic ethical principles (Nainggolan, Hutabarat, Situmorang, & Sitorus, 2020). Development of consciousness in practicing Chemistry in and out of school becomes part of the day to day living of learners. Scientific values of inquiry creativity, perseverance, honesty, accuracy respect of natural products is inculcated in leraners. All this culminates in a well moulded learner who is well equipped with the requisite knowledge and skills needed in the job market (Nakum, 2022)

2.3 Teaching of Chemistry Subject in Secondary Schools in Kenya

Chemistry is taught through two instructional approaches in Kenya. The first approach examines the theoretical part of Chemistry through paper 1 and paper 2 while the second approach entails the practical aspect of Chemistry which is examined in paper 3. (Kenya National Examination Council (KNEC), 2018). Paper 1 tests content from forms 1, 2, 3 and 4 while paper 2 scrutinises in-depth understanding of the concepts studied during the four year course in the specific topics taught in secondary school Chemistry. Paper 3, on the other hand, tests the practical skills attained by students (Nzomo, Rugano, Njoroge & Gitonga, 2023).

Since 1985, when the 8-4-4- system was introduced in Kenya, Chemistry subject is no more an optional subject in Forms 1 and Form 2 . Furthermore, in many secondary schools in Kenya, Chemistry is offered from Forms 1 to Form 4. Irrespective of its undoubted significance the teaching strategies used remain inadequate on content delivery. Some of the most common teaching approaches in Kenyan classrooms includes experiments and projects (Inyega, Arshad-Ayaz, Naseem, Mahaya & Elsayed, 2021). Nonetheless, learner-based approaches would best guide the teaching process as envisaged by curriculum developers. Learning of Chemistry in Kenyan secondary schools has therefore remained largely expository as observed by Ikiao (2019)

Markedly, inquiry learning strategies in science classrooms is given slight attention. Consequently, students invariably are rendered a passive role in the dissemination of information which negatively affect their conceptual understanding. Little regard is given to how well the students understand Chemistry concepts. Therefore, teachers of Chemistry clear syllabus but poor examination results are still ringers (Waswa & Cheptinget, 2013).

2.3 Performance in Science Subjects at Secondary School Level

Low achievements in sciences is a major problem globally. In South Africa, even though there are concerted determinations in alleviating the dismal achievement at secondary school level, the results indicate the converse. This is an issue of a major concern. To counteract this dismal achievement, the South African government has not relented in training teachers through workshops and in-service programmes (Petrus, 2018). In Nigeria, sciences are a pre–requisite for the enrolment in many university courses. Careers such as medicine, pharmacy among others, demands that students should have a good mastery of concepts in sciences. However, poor teaching methods and abstract nature of science concepts and laws account for learner's low achievement in science subjects. Consequently, the Nigerian government has found it necessary to look for innovative learning approaches that give an enhanced means of instruction on science in an attempt to counteract the low achievement (Idris, Tsado, Hounveneou, Shaaba & Yusuf, 2021).

A study done in Zimbabwe and aimed at investigating contributors of low science achievement indicated at some key aspects. Some of the factors that have resulted to this low achievement include among others teaching strategies and the learners' attitude towards science subjects (Makawa, 2018).

In Kenya, according to a study by Ogembo, Otanga, and Yaki (2015) that investigated on how attitude by learners and teachers' influence achievement in Chemistry, similar findings were established. The study further purports that low achievement emanated from a number of factors with some being related to learners' attitude. They include among others poor teaching approaches, learners' attitude towards Chemistry and teachers' attitude towards learners' abilities.

2.4 Use of Information Communication and Technology (ICT) in Teaching

Information communication and technology (ICT), on the other hand, refers to processes that are commensurate with computing technologies (Peng, Su, Chou, & Tsai 2009). Various reasons are put forth with regard to integration of ICT tools in classroom practice. Notable is the capability enshrined in ICT tools that allows for information to be presented in diverse lines of approach and dimensions. This embraces tactics such as videography, graphics, pictorial presentations, texts and audio-visuals. These dimensions have the capability to stimulate learning through hands on activities besides creating a conducive and an interesting learning atmosphere for the learners. (Sung, Chang & Liu 2016). Learners' individual differences are put on focus. Opportunities for own pacing, control over time and at their convenience is conveniently created for leaners (Majumdar, 2015).

Globally, it has been proven that use of ICT tools can be useful in pedagogy. For instance, in Pakistan, Hussain, and Suleman, (2017) found that ICT tools improves learners' achievement particularly so on the retention and achievement in Chemistry. Akram, Athar and Ali (2011) in study that focused on ICT tools in teaching Chemistry and their impact on achievement, ascertained of their significant input.

A research done in Turkey Özmen, (2008) had similar findings. Learners were assigned into groups of twenty five students. Further, the groups were categorised into two, one being experimental while the other was the control group. Research findings indicated a statistically significant difference in achievement. An empirical based conclusion was thus arrived at that established that teaching of "chemical bonding" is harnessed through ICT tools. In India, Agrahari and Singh (2013) had a similar finding.

In Norway, Røkenes and Krumsvik (2016) in a study that focused on geography education in relation to ICT integration in learning geography concepts at senior secondary stage pointed out at a higher and better achievement. Achievement by the learners was significantly better in the geography education. Study finding indicated that integration of ICT in teaching geography has provided two major opportunities for learners. As it was established, learners are provided with self-learning where they learn at their own pace. Moreover, they are able to self-evaluate themselves conveniently making the entire learning process more flexible as well as catering for learner's individual differences which is a key pedagogical component. This finding corroborates with a study in Singapore by Reyes and Tan (2013) where integration of ICT in pedagogy offered better learning prospect and provided learners with new learning experiences. The study concluded that integration of ICT improves learners' achievement besides making learning an interesting undertaking. Moreover, use of ICT on learners with learning difficulties in science subjects has been found to be more effective where abstract idea and concepts are made simpler and easy to comprehend .In a nutshell the learners' level of comprehension and mastery of science concepts is raised which results to an improved achievement in sciences.

In Asia, Kareem (2018), established that there exists a significant difference when ICT tools are used in learning Biology. Learners under ICT instructions registered improved results in comparison to their counterparts who used conventional learning strategies. Superiority of ICT tools in classroom is evident more so in the development of high order thinking and problem solving skills in learners (Koh, Chai & Lim, 2017). Similarly, in China, Skryabin, Zhang, and Zhang (2015) asserts that integration of ICT in classroom is a significant positive forecaster for improved learners' achievement especially so in Mathematics as well as in sciences. Comparable findings on use of ICT at secondary school level is also evident in the Middle East and more precisely in Saudi Arabia (Al-Mansour, 2012) as well as in the United Arab Emirates (Almekhlafi 2006).

In an attempt to address learners' improvement, use of ICT tools has taken a central role in America. Sciences, Technology, Engineering and Mathematics (STEM) which focused on strengthening ICT integration in schools was established. Under it the integration of ICT in pedagogy has been found to be beneficial to learners in improving their academic achievement (McDonald, 2016).

In Africa, a study done in Zimbabwe had a similarity on the outcome from the established findings. The impact of use of ICT on learners in relation to their achievement in the subject significantly improved. Results findings showed that integration of ICT in learning resulted to a higher student achievement for the group that treatment was administered. This was after the two groups were statistically compared. The difference in achievement was statistically significant (Oyedele, 2014). In secondary school Mathematics correlating results were established as opine by Perienen (2020).

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Studies carried out in West Africa on ICT usage in pedagogy have given correlating evidence. More precisely, a study done in Nigeria that ventured on investigating whether there exists a significant difference in teaching “metal work technology” while using ICT tools confirmed that learners in the group that was exposed to the tools achieved significantly better (Chado, 2014). Pepple (2015) concurs with the findings. The investigations attempted to unearth significance of ICT tools on senior secondary in relation to achievement in Chemistry of “chemical equilibrium” in Nigeria which showed a statistical difference in the achievement. This was in favour of experimental group after the treatment. More precisely, Alhaji and Dan (2015) ventured on usage of ICT tools in Physics in Niger state, Nigeria. Research by Udo and Etiubon (2011) had comparable outcomes.

A focus on Chemistry education in Nigeria reviewed the positive effects of ICT integration in different topics within the subject. Statistical indications from scientific research pointed at an improved outcomes on learners mean score. A survey on influence of ICT tools on secondary school learners’ achievement in the topic on “chemical reaction and equilibrium” opined similarly. Evidently, learners on CAI registered better results **(**Achor, 2014). Moreover, study by Udu (2018) purports that use of ICT in Nigerian enhanced mastery of concepts by learners. Similar observations are reported in a research on learners' perceptions in implementing ICT in Ghana schools. Other studies done in Africa with similar school of thoughts include Charles and Issifu (2015), Olakanmi (2017) and Mushipe (2016)

For East Africa, research on the ICT usage has indicated a significantly better achievement. A typical example is a study done in Tanzania on Mathematics that found that ICT tools enhanced performance. Findings of the study established that use of ICT in pedagogy is beneficial to the learners since it enhanced a better mastery of the concepts taught (Kafyulilo, Fisser, Pieters & Voogt 2015). Equally Rusanganwa (2013) observed that use of ICT improves conceptualization in Rwandan schools. Likewise study by Saminathan (2012) attempted to find out how effective it could be if ICT tools were integrated in Learning Chemistry at higher secondary level. Through this study, it was established that the learning Chemistry through use of ICT tools is an effective means of delivering learning content.

In Kenya, similar findings have been established. For instance, a study on how achievement in sciences in secondary schools may be enhanced through the use of modern instruction established that use of ICT tools in teaching sciences culminates into an improved achievement in sciences. The study established that the learners taught through use of ICT tools had an improved achievement that had a statistical significant difference in comparison to learners instructed using the conventional practices in science (Jesse, 2015). Additionally, Muchiri, Hillary and Kathuri (2018) noted that ICT tools on agriculture in Kenyan secondary schools resulted to better achievement on the subject. In Biology education and in a study dubbed "the effect of ICT on students' academic achievement in Biology" established that it yields into a significantly better outcome (Cheruiyot, 2019). These findings corroborate well with that of Birgen (2013) in a study that investigated how computer aided learning on Chemistry in Kenyan impacts on learners. Findings of the study established that ICT tools enhances learners' achievement.

Similarly, a study by Thiong'o and Okere, (2013) in Nyeri County, Kenya that aimed at establishing the effects of ICT on "electric current" in Physics subject purported that the mean scores showed a great improvement that was statistically significant between the two test groups. These findings correlated with similar study dubbed "the effect of use of computer simulations on academic achievement of form two learners in Physics" by Chumba, Omwenga and Atemi (2020).The study had sampled four teachers teaching Physics in a mixed gender secondary schools. Two hundred form two learners who were purposively sampled. From the data analysis it was concluded that the test group register an improved achievement. Moreover, statistical tests proved a difference that was significant. The study suggested while learning Physics in secondary schools, integration of computer simulations is paramount since it improves and develops positive attitude in learners besides realising an improved academic achievement

On the whole, ICT tool has taken a centre stage in enhancing achievement of learners across the various the subjects offered at high school level. Integration of ICT in pedagogy is even more likely to flow in the future with the advancement in instructional technology. In a nutshell, the 5Es instructional model is a step by step, sequential flow, which interlinks all the five levels during the instructional process making learning more meaningful. An intertwined approach where 5Es instructional model of instruction and ICT integrated lessons are blended for instruction in classroom may address the persistent low achievement in sciences in general and Chemistry in particular at high school level.

2.5 The 5Es Instructional Model

The 5Es model which was developed by an American organisation, known as the Biological Sciences Curriculum Study (BSCS), has had a significant input in pedagogy. In the 5Es model every part has a definite role and purpose (Bybee 2009) entailing the following five sequential levels in learning, Engagement; where entry characteristics of the learners is determined, Exploration; where learners are given a chance to explore concepts, processes and skills, Explanation; a phase that offers an opportunity to show case the level of understanding, Elaboration; where clarifications are made, and finally the Evaluation phase that assesses learners' understanding toward achieving the set educational objectives.

5Es instructional model efficacy is supported by studies done at global level. For instance Tuna and Kacar (2013) established that the 5Es instructional model resulted to improved achievement. The 5E model was found superior in teaching abstract ideas in Mathematics. This observation corroborates that of Qarareh (2012) that established that the use of 5Es instructional model for teaching sciences resulted to better achievement. Similarly, the findings concurs with that of Anil and Batdi (2015) who found that 5Es instructional model was a better way of instruction in as far as achievement in learner's academic work is concerned. Coherent to these findings, subsequent submissions were put forward that pointed out that 5E model can lead to learners experiencing a more effective teaching and learning process. Similarly in a study that adapted a quasi-experimental design, 5Es instructional model proved to be statistically effective when compared to the traditional approaches in teaching "gases and gas laws" (Karsli, Ayas & Çalik, 2020).

Low achievement in Biology subject in Nigeria necessitated an exploration on the 5Es instructional model. Similar findings were established. Results obtained showed statistical difference that was significant between the groups. The differences in achievement was attributed to students constructing own knowledge thereby mastering the biological procedures applied. Learners were also actively involved in diverse hands-on activities. In so doing, it resulted to learners developing interest on the content being learnt, consequently, getting the best intellectual capacity of the subject matter. (Ezugwu 2019).

The superiority of the 5Es model is replicated in a study conducted by Osawaru and Eravwoke (2012). The study verified the impacts of 5E model on learner's achievement in Biology and Chemistry. This was after it was found that learners taught using the 5Es instructional model had greater attainment in Biology and Chemistry in comparison to learners in the control group. Moreover, finding by Kinqir and Akqemer (2013) in a research on impact of the 5Es in teaching gas concepts had similar outcomes. Findings from the study indicated that learners' level of comprehension on concepts both in the experiment and the control groups was higher. The difference was however, statistically significant in favour of experimental group. This when interpreted meant that learners in the experimental group learnt the concept under study in a more meaningful and more interrelated way than learners in the control group. For these reasons, recommendations were put forward that teachers should endeavour to use the 5Es instructional model. This would make learning more meaningful besides developing a better retention ability in learners.

Olaoluwa and Olufunke (2015) in a study that compared on 5Es instructional model as contrasted with the inquiry-teaching methodology in Physics found that use the 5Es instructional model had greater attainment. Moreover, the efficacy of the instructional approaches in improving retention was sought. It was evident that the model was effective in improving learners' attitude towards Physics subject. The study concluded that the 5Es model of instruction produce significantly better achievement as well as an improved retention level of Physics concepts by learners. It was thus concluded that 5Es model can be embraced in teaching Physics due to its effectiveness. The study thus advanced to recommend that training of teachers on 5Es instructional model would be paramount in developing positive attitude towards Physics and make learn meaningfully.

Oludipe and Oludipe (2013) studied the "effectiveness of constructivist-based teaching strategy on academic achievement in integrated science". An experimental design was adopted which had a sample population of 120 learners. The group of learners who were instructed using the 5Es instructional model had a higher score that was significant on testing. Various empirical studies on effectiveness of 5Es cycle found that learners improved in achievement after learning various concepts using the constructivist 5Es instructional model. (Kauts & Sikand, 2019; Sakalli, 2015; Wegayehu, 2019)

Wegayehu (2019) specifically in a study that main purpose was to investigate the 5E model of constructivist approach and its impact "muscular and skeletal system concepts" reported that there were changes that were deemed significant on comprehension. The test group developed higher reasoning ability and with ease they could explain the learnt concepts. From the study findings a conclusion that 5Es model is more effective learning model was arrive at. Based on these findings a recommendation was put forward that 5Es learning model should be incorporate in teaching Biology.

Madu and Ezemagu (2013) probed the efficacy of 5Es instructional model of instruction concluded that learners in the test group achieved significantly higher on the topic on "fraction" than the control group. These observation corroborates that of Richard, Samuel and Johnston (2015), in a study on "effects of constructivist teaching approach on students' achievement in Chemistry" in Baringo, Kenya. The findings pointed out that the 5Es instructional model of learning gave significantly higher achievement. Similarly, Chowdhury (2016), in a research on "effect of 5Es instructional model on the achievement in Mathematics" is of a similar opinion. Findings from the study pointed out that 5Es instructional model of learning advances significant achievements on learners in Mathematics. However, the registered difference in achievement was not significant between males and females. This finding implied that the model is not gender-biased.

A study on effect of 5Es instructional model found out that using the 5Es constructivist approach in learning expands learners' level of achievement in Mathematics vis-à-vis conventional instructional methods (Pangat 2017). In Kenya, Mwanda, et al., (2017) in a study on "use of 5Es instructional model in learning Biology in secondary school students" found that use of 5Es instructional model is effective in learning Biology. Similarly, a research by Njoroge, et al., (2014) that investigated on how 5Es model influences on motivation and achievement in Physics, it was evident that 5Es model approach resulted into a significantly better achievement by the learners in the subject.

In Biology education, a study on "effect of 5Es enquiry-based approach in teaching secondary schools in Kenya" established similar findings after an analysis on the mean scores. The test group which used to 5Es model registered better results (Hassan 2015). This assertion corroborates that of Maonga (2015) that sought to find the influence of the 5Es model on learners' achievement in teaching high school geography on the topic "map work"

While empirical data show that 5Es model of instruction results to better achievement in various subjects, a gap exist in studies in ascertaining its effectiveness in guiding the instructional process while teaching ICT integrated lessons in Chemistry and in particular the topic on "structure and bonding" in Kenyan secondary schools. This study sought to help in bridging of this gap.

2.5.1 Chemistry and the 5Es Instructional Model

A comparison between 5Es model and traditional approach on learner's academic achievement and attitude in Nigeria, Jack (2017) found that the 5Es model was significantly better. Consequently a conclusion was arrived at that 5Es model is an appropriate model that can be used in promoting learning in Chemistry since the experimental group had significantly better results. For east Africa, a study done in Tanzania that compared the 5Es instructional model to conventional methods found that the 5Es enquiry-based model resulted to a better achievement in sciences (Athuman 2017). There is limited data on how ICT integrated lessons that is instructed through the 5Es model could mitigate the low achievement in Chemistry which have been a challenge to many secondary school students in Kenya. Scarceness in research particularly as regards the instructional process that is guided by the 5Es model in ICT integrated lessons in abstract topics such as "structure and bonding" demand that research be undertaken to ascertain the effectiveness of this instructional process towards improving learner's achievement in Chemistry. This research therefore, sought to ascertain the efficacy of an instructional process that is guided by the 5Es model in ICT integrated lessons on learner's achievement in teaching the topic "structure and bonding" in an effort to bridge the knowledge gap that exists.

2.6. 5Es Instructional Model and Learners Ability Level

In education, students are categorized into high ability and low ability levels. (Othman, Shahrill, Mundia, Tan & Huda 2016). Student ability influences learner's achievement when 5Es instructional model is used as a teaching strategy. For example, a research carried out by Manzo, When, Liets, Torre, and Gomez (2016) to examine how 5Es instructional model influences low ability and high ability learners. A significant difference was established between the two categories of learners. Low ability learners recorded a better achievement. These findings are in contrary to that of a study on "learning environments as basis for cognitive achievements of students" in Nigeria. Study findings showed that 5Es instructional model resulted to better achievement for both high and low ability grade 8 learners. Further findings indicated that high ability learners had significantly better achievement than low ability students. In conclusion the study showed low ability students had minimal improvement in achievement in comparison to high ability learners (Atomatofa & Ajaja, 2017).

A study conducted by Kauts and Sikand (2019) to evaluate 5Es instructional model on achievement of IX grade learners revealed that high ability learners had a higher score than low ability learners. It was also found that high ability learners instructed through the 5Es instructional model had a higher score at various domains of cognitive ability than the learners using the conventional strategies. The assertions agrees with a similar research by De Castro, Prenda, Laguador and Pesigan (2015) on first year computer engineering student where it was established that high ability learners registered better outcomes in comparison to low ability group. Han (2015) in STEM related research came to a conclusion that low ability learners showed a significant improvement in Mathematics scores. However, Alhaji and Dan (2015) is of a contrary opinion and his school of thought concludes that high ability learners exhibits a significant improvement in the overall mean score.

In a similar study by Agarwal and Agarwal (2018) that ventured in science education and 5Es constructivist learning approach, Contrary findings were arrived at. Learners were randomly assigned into different groups namely high ability, average ability and low ability founded on the scores of pre-test given. After a four weeks instruction using the 5Es instructional model of constructivist approach, no significant difference was found amongst the groups.

With many studies carried out in respect to learner's ability and use of 5Es instructional model, none of them has focused on how learner's ability is affected by the instructional process that is guided by the 5Es model in teaching ICT integrated lessons. So far there no research-based evidence concerning how low ability and high ability learners perform in the topic on "structure and bonding" while using ICT integrated lessons that are guided by the 5Es instructional model globally, regionally and specifically in Kenya.

2.7. 5Es Instructional Model and Learners Attitude

Evidence from empirical data postulates that integration of 5Es instructional model has an influence on learner's attitude towards learning. A valid example is a study by Ibe (2017). The study revealed that the attitude of scholars trained with 5Es instructional model was more positive than on lecture method. In a similar study on use of 5Es instructional model on student achievement, results indicated at an attitude rated as positive towards 5Es instructional model. The test group made of 6th grade students achieved significantly well. An evaluation on attitude of the test group showed a positive development toward science than in the control group (Kassir & Forawi, 2017).

Additionally, a study by Muhammad, Omwirhiren and Abubakar (2019) on “influence of 5Es teaching cycle on attitude and academic, achievement of Chemistry” had similar findings. Learners exposed to intervention while learning Chemistry of the “mole concepts” had higher mean scores. Moreover, the attitude of the learners in the test group improved significantly after the treatment. Consequently, recommendation was put forward that use of 5Es model should therefore be incorporated in teaching science subject. This was from the realization that learning becomes more meaningfully and help in developing positive attitude towards Chemistry.

A study by Ellah and Achor (2018) on “effect of 5E constructivist instructional approach on students’ achievement and attitude to Physics in senior secondary schools” revealed neither male nor female students had a statistically significant positive attitudes towards 5Es instructional model. These assertion are supported by Jack (2017) in a study that compared the effects of 5Es instructional model and traditional approach on learner’s academic achievement and their related attitude towards high school Chemistry. Findings indicated that although the 5Es instructional model was found to be significantly better there existed no statistical difference in the achievement of learners with negative and positive attitude. Similarly finding from a study by Sen and Oskay (2017) in high school Chemistry were in concurrence with the outcomes from related studies.

Contrariwise Mwanda, et al., (2017) in a study that investigated how the constructivist approach influences learning Biology in Kenya discovered that learners at the high school level developed a positive when the 5Es instructional model was used as an instructional strategy. Further, it was established that girls were more positive in regard to the 5Es instructional model in comparison to boys. Likewise, a study on “effect of 5Es instructional model on learner achievement in Biology in secondary schools in Kenya,” revealed a variation in moulding up of attitudes. Females had a positive attitude towards 5Es instructional model than males (Magak, 2016). Irrespective of the research done in respect to learner’s attitude and use of 5Es instructional model, none has focused on how learner’s attitude can be influenced by 5Es model in teaching ICT enhanced lessons.

To date there exists sparse information on whether learner’s attitude is influenced positively or negatively on teaching “structure and bonding” while using ICT integrated lessons that are instructed through the 5Es instructional model globally, regionally and specifically in Kenya.

2.8. Learner’s Sex and 5Es Instructional Model

Umahaba (2018) investigating on gender in relation to 5Es instructional model in “chemical equations” in Nigeria demonstrated an improved performance. However, between males and females a significant difference was not registered. These findings are in agreement with that of Ibe (2017). 5Es model used in teaching Biology did not yield to a statistical difference that was significant between the two genders.

Additionally Ellah and Achor (2018) in a study that correlated 5Es constructivist approach, learners’ attitude and academic in Physics in secondary schools had similar findings. The treatment duration took four weeks. Physics achievement test was administered in collecting data. Findings revealed that 5E model was superior approach however, the difference was insignificant in the scores of females and males. Coherent with the findings, 5Es constructivist model was recommended as an effective approach in teaching Physics since it was gender friendly.

Chinwe and Chinyere (2010) observed no significant gender difference on achievement in “basic ecological concepts” on using the 5Es instructional model. Similarly in a study on “effect of 5Es constructivist instructional model on students’ achievement and attitude to Chemistry”, it was found that, on the bases of the mean scores attained, the difference arrived at was no significant between gender. A conclusion was made that gender is not a factor that may be rated as in as far as achievement by learners is concerned (Tagbo 2017).Likewise, in a study that was intended to establish gender differences in using 5Es instructional model, a similar conclusion was arrived at (Ibe, Nwosu, Obi & Nwoye, 2016). Chowdhury (2016) is of a similar opinion in the field of Mathematics.

On the contrary, Oludipe and Oludipe (2013) tend to differ. Male students had statistically significant differences when compared to female. Sakalli (2015) also opines similarly. Males achieved better than female in science subjects. Similar outcomes were reached at in a study on “effect of 5Es constructivist instructional approach on students’ achievement and attitude towards Physics in senior secondary schools” (Ellah & Achor, 2018).

Irrespective of the studies done in respect to learner’s gender and use of 5Es instructional model, none has focused on how learner’s gender is affected by the instructional process that is guided by the 5Es model in teaching ICT integrated lessons. So far there exists no empirical data on how learners gender relates with academic perform and more precisely in the topic on “structure and bonding” while using ICT integrated lessons that are guided by the 5Es instructional model globally, regionally and specifically in Kenya.

2.9. Challenges of use of 5Es Instructional Model

As per the available empirical data, use of 5Es instructional model faces a number of challenges. According to the survey that was designed to investigate the challenges teachers face when implementing 5Es instructional model indicated that there were difficulties with the "explain" and the "elaborate”. Time management also was difficult while mapping the lessons through the sequential step of the 5Es instructional model (Enugu & Hokayem, 2017). Similarly, Mdolo (2010) in a study on “factors that affect the use of 5Es instructional model approach on Biology curriculum in Malawi” found that teachers encounter challenges such as pressure due to incomplete syllabus, lack of enough text books, poorly equipped laboratory and inadequate incentives among learners. Other cited factors included unfavourable backgrounds and language barriers. Further, knowledge content on the subject matter and comprehensive understandings of the model also was a challenge.

Wilson (2012) established that maintaining classroom control and transiting from one phase of the 5Es model to another were major challenges obstructing 5Es instructional model integration for most instructors besides inadequate activities due to time constraints. As observed by Richards, Birbal and Ramdass (2020) in a study on “constructivist blended approach to teaching geography in a secondary school”, a number of challenges exist in the integration of the 5Es model of learning. There was notable minimal participation by learners in online discussions.

Furthermore, only a few learners read online support materials. Moreover, classroom discussions were teacher centred. Notably, majority of the learners feared to do presentations in the classroom due to anxiety. An over reliance on teacher was also evident. Other challenges faced by learners during the learning process where the 5Es instructional model was integrated included unreliable internet access that resulted to limited browsing of the websites. Additionally learners found it challenging to adapt to the independent learning style besides some learners remaining dormant in the assigned discussion groups.

Regardless of the research done in respect to challenges on use of 5Es instructional model, sparse information exists on the challenges emanating from use of the 5Es model in teaching ICT enhanced lessons. So far there exists no information on challenges of teaching “structure and bonding” while using ICT integrated lessons that are guided by the 5Es instructional model in Kenya. This research attempted to find out the challenges encountered when teaching “structure and bonding” in ICT integrated lessons that are guided by the 5Es instructional model in Murang’a County, Kenya.

2.10. Existing Gaps in the Literature Reviewed

Notwithstanding the numerous studies carried out in regard to integration of the 5Es instructional model in pedagogy, no specific research has been done particularly as regards to the impact of the instructional process that is guided by the 5Es model in ICT integrated lessons on learner’s achievement in “structure and bonding.” This has laid a foundation that has necessitated a research to be carried out. The study endeavoured to find out on the effects of 5Es model in ICT integrated lessons on learner’s achievement in “structure and bonding”. Whereas a meta-analysis on 5Es instructional model indicates positive impacts on learner’s achievement, information on how the 5Es model in ICT integrated lessons effects learners achievement has remained scanty and more precisely in teaching “structure and bonding.” The existing research gap is therefore, to determine the effect of 5Es model in ICT integrated lessons on students’ achievement in “structure and bonding.”

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section considers all procedures and strategies employed during collection and analyzing data so as to accomplish its objectives. It encompassed description of the research design, variables selected, study location and target population. It as well ventured into the sampling techniques, sample size, description of research instruments, pilot study to determine validity and reliability, methods that guided in collecting and analyzing data and finally the legal and ethical considerations.

3.2 Research Design

The core reason of undertaking this study was to establish the effect of 5Es model in ICT integrated lessons on learner's achievement in Chemistry. Therefore, a quasi-experimental research design was used to explore the relationship between variables. This research design was appropriate since the subjects were already constituted and school authorities do not allow reconstitution for research process. Moreover, Solomon's four group non-equivalent control group design was used because it is appropriate for experimental and quasi experimental studies (Ogunniyi, 1992).

Figure 3.1: Solomon's Four Group Non-Equivalent Control Group Design

Group	Pretest	Treatment	Post-test
E_1	O_1	X	O_2
C_1	O_3	⊗	O_4

E_2	X	O_5
C_2	(X)	O_6

KEY: E–Experimental groups; **C**–Control groups; **O**-Testing; **X**-Treatment; (X) - No treatment

Specifically, group identified as E_1 was subjected to a pretest before receiving any treatment. Thereafter, it was post tested upon receiving the intended interventions. The next category of respondents was identified as C_1. This entails learners who constituted one of the control groups. This assemblage of learners underwent testing before and after receiving no treatment. The subsequent group classified as E_2 was not exposed to a pretest however after the interventions it was post tested and served as the other experimental group. Another control group which has been keyed in as C_2 was tested only once through a post test. This meant that E_1 and E_2, used 5Es model in ICT enhanced lessons while C_1 and C_2 received conventional methods.

3.3 Study Variables

Learner's achievement in "structure and bonding" is dependent mainly on the instructional method used. The 5Es model in ICT integrated lessons is put on focus in this study. Therefore, the groups $E_1$and E_2 was exposed to 5Es model in ICT integrated lessons while the control groups C_1 and C_2 was exposed to the conventional methods. The instructional strategies used were the independent variables of the study (5Es model in ICT integrated lessons and the conventional methods). Learners' achievement in Chemistry was the dependent variable as hypothesised by the study. However, the dependent variable which in this case is improved achievement in Chemistry may be influenced by other parameters. These parameters include learners' ability in use of 5Es model of in ICT integrated lessons, learners' attitude towards 5Es model in ICT integrated lessons as well as gender disparity toward use of 5Es in ICT integrated lessons. Further, the study assumed some control factors, which were controlled by being studied alongside the independent variables that included school ICT policy, teachers' characteristics and availability of ICT resources.

The control variables ought to be built into a research. Their influence on the dependent variables is thus catered for thereby achieving a high level of validity from study findings. The effects of maturation and history were controlled by having two groups taking pre-test. Treatment and control groups were from different schools to avoid contamination. Two groups, E_2 and C_2, did not take pre-test to control regression effect. The pre-test was treated as a normal classroom test that students write in the course of instruction while the post-test was treated a normal test after a topic is covered (Mugenda & Mugenda, 2003).

3.4 Location of the Study

The accomplished study location was Murang'a County, Kenya. It is bordered to the East by Kirinyaga, Embu and Machakos counties, to the South by Kiambu, to the North by Nyeri and to the West by Nyandarua. The county has eight sub-counties and seven constituencies. It has a population of 1,056,640 as per the 2019 census. There are 27 private secondary schools while the government secondary schools in the county are 304. Out of the 304 schools, 2 are national schools, 22 are extra county schools, 37 are county schools and the rest 243 are sub-county schools. Murang'a County was sampled mainly because when compared with the national mean score at the KNEC results, Murang'a County achievement has been consistently below the national mean score (table 1.1) and in cognisant to the reports for the Chemistry that shows questions in "structure and bonding" which is a broad topic is always achieved dismally among the candidates and therefore, affecting the overall achievement.

Moreover, the county has a number of co-educational schools whose students are of interest to the study.

3.5 Target Population

There were 42 public secondary schools with ICT infrastructure in Murang'a County. These schools were crucial to the study since they were considered to be having functioning and well maintained computer laboratory where the intended research would be carried out. About 650 Chemistry teachers who taught public schools with ICT infrastructure were targeted.

The target population for the study was 26500 students in Form two classes in the secondary schools in Murang'a County. However, mixed gender sub county schools were crucial to the study. The targeted schools were considered to be having functioning and well maintained computer laboratory where the intended research would be carried out. The study targeted students in form two since the topic under investigation is taught at form two level. This topic was singled out from the Chemistry KNEC report. The report had indicated that over the years the questions tested on the topic "structure and bonding" were among the poorly achieved (see table1.2).

The sampled size comprised Form two students drawn from four sub county schools purposively sampled. To ensure no diffusion of information amongst the sampled schools, the location of the schools was made far apart from each .The schools were randomly assigned to the experimental and control groups. Each sampled school provided a Form Two class to participate in the study. However, where a school had double or multi-streams, simple random sampling was used to select one stream. The total number of students who took part in the study was one hundred and ninety seven, approximately fifty students per sampled school. This provided a reasonable sample size. According to Mugenda and Mugenda, (2003), findings from such sample reproduce the desired characteristics of the targeted population to an acceptable level.

3.6 Sampling Techniques and Sample Size

3.6.1 Sampling Techniques

Sampling was done as follows.

a) **County**

The research locale which was Murang'a County was purposively sampled. According to Etikan, Musa, and Alkassim (2016), purposeful sampling is a selective sampling technique that identifies participants who provide information about a phenomenon under investigation thus making generalizations from the sample being studied. Murang'a County was sampled mainly due to the low achievement in Chemistry replicated over the years. Furthermore, the county had a number of mixed gender schools whose students were targeted in the study.

b) **School Type**

The schools selected were co-educational schools with functioning ICT infrastructure. Students from sub-county schools have a comparable exam entry behavior and therefore they were best suited for the study. Further, in Murang'a County, most schools are found in this category. On the other hand, the Sub county schools within Murang'a County admit learners with an average mark of 250 marks at KCPE level. This category of schools was opined to have a cohort of leaners with the desired abilities that would be termed as mixed. Through simple random sampling, a small portion of the entire population was randomly taken to represent the entire data set. Individuals who constituted the subset of the larger group were randomly chosen. This random assignment of each individual in the large population set ensured an equal selection probability (Taherdoost, 2016). Simple random sampling undertaken did not only ensure that results obtained from the sampled set approximated findings to the entire population but also allowed equal chances to entire entities in the population of being nominated (Wu & Thompson 2020).

Out of the possible twenty four mixed-sex Sub County schools with robust ICT infrastructure, simple random sampling was employed to select four schools. Moreover, four (4) schools were picked for the reason that the Solomon 4 group design involves four groups. Random lottery was used to select the schools where the 24 schools were assigned numbers then the numbers were randomly selected by picking without viewing from a container. Samples were assigned to either experimental or control groups through random lottery. Table: 3.1 shows the sampled schools:

Table: 3.1 Sampled Schools

Type	**Total number of schools**	**Schools with ICT infrastructure**	**Sampled schools**
Mixed-Sex Sub County Schools	243	24	4

c) Streams/students

A majority of the schools at the sub county level had two or three streams per form two class. Simple random was used to identify one form two class. This was achieved through simple random sampling

Table: 3.2 Students Sampling Grid

Type of the school	Schools with ICT infrastructure	Sample schools	Number of learners in total
Mixed Sub County	24	4	197

d) Teachers

The teachers teaching Chemistry in the sampled streams participated in the study. The test groups were trained on effective implementation of the 5Es model in ICT integrated lessons and the ones in the control group used conventional methods. (Appendix VIII.)

3.6.2 Sample Size

The study engaged four form 2 classes with a population of 197 learners.

3.7 Research Instruments

3.7.1 Students' Questionnaire (SQ)

The attitudes of the learners towards Chemistry was measured using a questionnaire. Questionnaires offer a quick and effectual means of collecting huge information from sampled sets. They are particularly effective for measuring subject behavior such as learner's attitudes and opinions besides being appropriate in protecting privacy of the participants (Sharma & Kumar 2022). The questionnaires were administered to all the four sampled schools at the beginning of the study. This helped asses the harbored attitude towards Chemistry as at the commencement of the study (See appendix I). After a four weeks period of intervention using the 5Es model, the same questionnaire was administered to all the four schools. This helped asses any discrepancies on the harbored attitude towards Chemistry as at the end of the intervention after learner were exposed to the 5Es instructional model. (Appendix I). The Scale of High School Students' Attitudes towards Chemistry (SHSSA) was used in adopting questionnaire items (Demircioglu, Aslan, & Yadigaroglu, 2014). The instrument makes use of Test of Science-Related Attitudes (TOSRA) which measures science-related attitudes among learners.

3.7.2 Interview Schedule for the Chemistry Teachers

According to Ruslin, Mashuri, Rasak, Alhabsyi and Syam (2022) interview schedules increases the reliability through face-to-face interviews that helps in capturing verbal and non-verbal aspect of communication as well as emotions of the participants. Additionally, questionnaires provide room for gathering more in-depth information and clarifications by asking related follow-up questions (Taherdoost, 2022). For this study, the interview schedule for the chemistry teachers aimed at unearthing the experiences that the teachers who integrated the 5Es model in ICT integrated lessons underwent. This aided in capturing the impediments to a smooth implementing 5Es model in ICT integrated lessons. The instrument was also used to gage their attitude towards implementing the 5Es model in ICT integrated lessons (Appendix II).

3.7.3 Chemistry Achievement Test (Pre-Test)

Solomon's four group design guided groups in undertaking a pre-test. A pre-test guides the study in weeding out the drop outs. Furthermore, the pre-test acts as a basis of examining similarity of the sampled groups at the commencement of the study. Pre-tests also provide the ability to independently gage impact of intervention on learner's knowledge thus giving the needed directionality of the research (Grohs, Knight, Young, & Soledad, 2018). Groups subjected to a pre-test in this study were two. These included one control group and one test group. Pre-test was adopted from test items from KNEC. The test covered the Chemistry content taught in form one but also included some form two topics. However it excluded the sub-topic “structure and bonding” since it was the topic under investigation and would be captured in the post-test. From the set questions the stated learning outcomes were evaluated. The pre-test helped in ascertaining ability of learners in Chemistry subject before intervention. (Appendix IV)

Blooms taxonomy was used in setting the questions as shown in table 3.3

Table: 3.3 Table of Specification for the Chemistry achievement test items (Pre-Test)

Topic	**Level of difficulty**					**No of items**
	Easy	Average	Difficult			
	Knowledge	**Comprehension**	**Application**	**Analysis**	**Evaluation**	
Introduction to Chemistry	1a(i),1a(ii) 4a	1b(i),1b(ii)	4b,	4c	4d	**8**
Simple classification of substances	2a ,8a,	8b		2b,6a	6b(i)(ii)	**6**
Acids bases and indicators			11a	11b	11c	**3**
Air and combustion		3a	5a	5b	3b,5c	**5**
Water and hydrogen	14a		10a(i),14b	10a(ii),14c	10b	**6**
“Structure of		13a(i),13a(ii)	13a(iii),13	7,13c	9	**7**

atom and the periodic table			b			
Chemical families	12a	12b,12c	12d		12e	**5**
Number of items	**7**	**8**	**8**	**9**	**8**	**40**

3.7.4 Chemistry Achievement Test (Post-Test)

The four (4) sampled classes were assessed through the post-test. Post-test Chemistry achievement test had 14 questions with total score of 50 marks (Appendix VI).The test items were on the topic "structure and bonding" and was adopted from the Kenya National Examination Council (KNEC). According to Peters (2014), a post-test is usually administered immediately after an intervention. It serves as a measure on whether learners gained the intended knowledge as a result of the treatment given. Any difference that is statistically significant between pretest and posttest would thus be pegged on the intervention.

The following table of specification was used in setting post- test items

Table 3.4 Table of Specification for Post-Test Items

Topic	**Level of difficulty**					**No of items**
	Easy	Average	Difficult			
	Knowledge	Comprehension	Application	Analysis	Evaluation	

Structure and Bonding	5a,7a,7b,9a,11f,14f	1a,2a,6a,6b,7c,8a,11a,12a,14a	1b,2b,5b,6c,7d,11b,11c,14b,14c,14d	4,7e,8b,9b,11d,11e,12b,13,14e	3,7f,9c,10a,10b,10c	**40**
Total no of Items	**6**	**9**	**10**	**9**	**6**	**40**

3.7.5 Observation Schedule

In order to ascertain seamless execution of 5Es model is as per the training given to the teachers implementing it, an observation schedule was developed. This coding sheet is filled out by researchers through observation that are deliberately structured to aid in data collection. It specifies the various categories of comportments to be put under scrutiny. Observation schedule not only give a basis for an observation but also serve as a guide on targeted feedback. Moreover, it gives room to high levels of flexibility in terms of generating the needed information (Lindorff & Sammons, 2018). The drafted observation check list mainly focused on how the five levels of the models were integrated in the ICT based lessons (Appendix III).

3.8 Pilot Study

The focus of piloting work was to assess the viability of study. It helps in refining the research questions , testing the proposed study design and process besides determine the feasibility the entire study (Doody& Doody 2015).For this study two co-educational sub county schools that sampled 84 students were chosen purposively for piloting from the County. Schools chosen however were not among the sampled for the main study. The pretest and posttest SCAT as well as the questionnaire, were piloted to affirm their validity and reliability before commencement of the study. As pertaining the interview schedule, interview questions were reviewed in line with the language used, wording and relevance .The observation schedule was as well piloted, revised or modify accordingly.

3.8.1 Validity of the Instruments

To achieve the desired validity of the instrument four types of validity were instigated. The face validity was achieved through a face validation by the two Chemistry teachers who are experienced besides being trained KNEC examiners. For the criterion validity, the SCAT items for the pretest and posttest items, were adopted from KNEC. The main reason for adopting KNEC examination items is that the criteria used by KNEC in setting the national examinations is considered as valid. Content validity was realized by developing a table of specification for all the test items in the pretest and posttest SCAT as dictated by the Blooms taxonomy. To ensure that construct validity was attained, the questionnaire draft, interview schedule and the observation schedule were consequently assessed at the piloting stage with an intent to gauge their applicability to the study objectives as well as their usefulness in collecting relevant data. Moreover, Scale of High School Students' Attitudes (SHSSA) that makes use of (TOSRA) to measures science-related attitudes among learners was adopted in the piloting of the questionnaire draft.

3.8.2 Reliability of the Instruments

Internal consistency techniques were applied in estimating reliability of instruments. The SCAT instruments (pretest and posttest) were divided into two categories. Each category had items which were dichotomous. The Kuder-Richardson formula 20 (KR-20) was used to estimate the reliability of the test items.

$$\text{KR-20} = \frac{K\,(S^2 - \Sigma s^2)}{S^2\,(K - 1)}$$

Source: Mugenda and Mugenda (2003)

Data from the pilot test arrived at the following analysis.

Table 3.5: Pre-Test and Post-Test Reliability Index

Instrument	**Reliability index**
Pre-Test SCAT	0.725
Post-Test SCAT	0.794

Data results from the pre-test items indicated a coefficient of 0.725. Similarly for the post-test items, the coefficient was found to be at 0.794. The reliability level of the instruments was of the desired measure which was above the recommended thresh hold of 0.7(Amirrudin, Nasution, & Supahar, 2021; Taber, 2018). The Cronbach's Alpha coefficient was used to estimate the reliability of the Students' Questionnaire (SQ)

Table 3.6 Reliability Index (Questionnaire)

Statement	**Mean**	**SD**	**Factor loading**	**Item-total correlation**	**Alpha if item is deleted**
Learning Chemistry is fun.	3.28	1.068	.720	.681	.928
To solve daily life problems Chemistry is necessary	3.57	1.111	.666	.591	.930
I hate Chemistry.	3.93	0.950	.523	.635	.929
After finishing school, I will work and make discoveries for Chemistry.	3.92	0.960	.637	.583	.930
I'm not good at "Chemistry"	3.70	1.008	.622	.615	.930
After finishing school, I would not want to work in a laboratory	3.98	0.969	.453	.601	.930
One of the most interesting lessons is Chemistry.	3.91	0.927	.577	.669	.929
Am bored by Chemistry lessons	3.83	0.994	.450	.559	.931
Earning money while working in in a laboratory may be interesting	3.26	1.065	.612	.560	.931
Chemistry is easy for me to learn.	3.91	0.921	.459	.612	.930
I'm looking forward to an ICT integrated Chemistry lessons.	3.71	0.960	.557	.606	.930
It is boring to make career about Chemistry.	3.67	1.074	.537	.664	.929

It's fun to use ICT tools in learning	3.77	1.003	.557	.524	.931
I don't understand Chemistry even though I work hard	3.85	1.004	.612	.711	.928
After high school, I want to become an ICT expert	3.82	0.983	.578	.690	.928
Knowledge in Chemistry is key in finding a good job.	4.18	0.823	.445	.602	.930
Use of internet doesn't makes Chemistry easy	3.72	1.093	.590	.696	.928
I don't like Chemistry projects.	3.17	1.101	.708	.550	.931
I find the topic on "the periodic table" difficult	3.43	1.060	.524	.651	.929
I don't like how teachers teach Chemistry	3.64	0.973	.489	.585	.930

Cronbach's Alpha =.933,

Information in Table 3.6 shows that students rating for attitude had a Cronbach's Alpha rating of 0.933 which was high enough. Principal component analysis with Varimax rotation conducted for exploratory factor analysis revealed that all the elements had factor loadings which were above the acceptable threshold of 0.4 (the range was between 0.445 and 0.720). Their item to total correlations scores ranged from 0.524 to 0.711. The implication is that all the elements were retained for analysis since reliability and construct validity was established.

3.9 Data Collection

The study proceeded in four (4) phases.

Phase One

At the commencement of the study, permission was sought from Kenyatta University graduate school. Upon approval of authorization to undertake this study, the researcher sought for permission to carry out research from the National Commission for Science, Technology and Innovation (NACOSTI). Further the county director Teacher Service Commission (TSC) and the county director in the ministry of education we notified of the intentions to conduct the study. Upon obtaining approval from education field officers, the participating schools were visited for familiarization. The confidentiality of the respondents was assured at this stage. It also included meeting the sampled teachers handling lessons on 5Es model in ICT integrated lessons for training purposes. (Appendix VIII)

Phase Two

The pre-test SCAT instrument as well as the SQ were administered to the learners at this phase. The SQ and the Pre-test SCAT were administered simultaneously to the learners to E_1 and C_1 groups.

Phase Three

This phase involved actual teaching of learners using the 5Es model in ICT based lessons in experimental schools. However, groups under control were instructed using the conventional methods. The researcher equally observed and interviewed the sampled teachers implementing the 5Es model in ICT integrated lessons.

Phase Four

The final phase involved an evaluation on the topic under investigation using the post-test SCAT instrument and the SQ to the learners. This took place after the treatment duration that lasted for four weeks. The SQ and the Post-test SCAT were administered simultaneously to the learners

3.10 Data Analysis

Data collected was analyzed in two different ways. Descriptive statistics included parameters such as mean, frequency, the standard deviation and percentage. This described relationship between the variables while inferential statistics was used to test the hypothesis based on the study objectives.

This analysis is summarized in Table 3.7 of data analysis matrix

Table 3.7: Data Analysis Matrix

Objective	**Type of data**	**Instruments**	**Method of data analysis**
Establish effect of 5Es model in ICT integrated lessons on learner's achievement in "structure and bonding"	Quantitative	Pretest and posttest SCAT	One-way ANOVA
Determine the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on ability.	Quantitative	Pretest and posttest SCAT	Two-way ANOVA

Establish the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on attitude.	Quantitative	Student questionnaire. Pretest and posttest SCAT	Two-way ANOVA
Determine the gender difference on learners' achievement in "structure and bonding" for learners exposed to the 5Es model in ICT integrated lessons.	Quantitative	Pretest and posttest SCAT	Two-way ANOVA
Establish the challenges encountered in using the 5Es model ICT integrated lessons	Qualitative	Interview schedule. Observation schedule	Thematic analysis

3.11 Legal and Ethical Considerations

Permission to conduct research was sought after through the Graduate School' Examination Board. NACOSTI which acts on behalf of Government of Kenya to permit research was visited to request for a go-ahead. A visit to the sample schools was done to seek permission and inform the head of the institution about the study involving form two learners.

At the commencement of data collection, ethical procedures were put in place. Potential participants were inform that they were to choose freely on participate in the intended study. They were further made aware that they could withdraw from the study at any time and that the repercussions would not negatively affect their stay and studies in their respective learning institutions. Subjects were made aware about the aim for the research where issues of their Confidentiality and anonymity were guaranteed. No name of the school, respondent or personal information were to be disclosed. To the participants, a reassurance was made that the data gotten from them was exclusively destined for the research purposes only. Overly, the collected information would be treated with confidentiality.

CHAPTER FOUR

REPORTING, INTERPRETATION AND DISCUSSIONS OF THE FINDINGS

4.1 Introduction

The chapter presents the findings, interpretation and discussion of data sought to establish the relationship between study variables. Findings which are mainly quantitative in nature are presented as per research objectives.

4.2 General and Demographic Information

The study sought to establish the effects of 5Es model on students ‘achievement in Chemistry with a specific focus on students' achievement in "structure and bonding". The study objectives were as follows;

a) Establish effect of 5Es model in ICT integrated lessons on learner's achievement in "structure and bonding"

b) Determine the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on ability.

c) Establish the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on attitude.

d) Determine the gender difference on learners' achievement in "structure and bonding" for learners exposed to the 5Es model in ICT integrated lessons.

e) Establish the challenges encountered in using the 5Es model ICT integrated lessons

The study therefore used null hypotheses. The formulated null hypotheses include:

H_{O1}: There is no significant difference in achievement in "structure and bonding" between learners using 5Es model in ICT integrated lessons vis-à-vis conventional methods

H_{O2}: There is no significant difference in achievement in "structure and bonding" between learners guided by 5Es model in ICT integrated lessons vis-à-vis conventional methods based on ability

H_{O3}: There is no significant difference in achievement in "structure and bonding" between learners guided by 5Es model in ICT integrated lessons vis-à-vis conventional methods based on attitude

H_{O4}: There is no gender difference in achievement in "structure and bonding" for learners guided by 5Es model in ICT integrated lessons vis-à-vis conventional methods

4.2.1 General Data Analysis Information

197 learners took part in the study. This was a response rate of 92.05 %. The response rates was calculated by dividing the number of completed survey responses (197) by the total number eligible in the sample chosen (214). (Fincham, 2008). Girls were slightly more compared to boys (100 girls and 97 boys). Table 4.1 provides a summary of data analysis.

Table 4.1: Study Respondents by Gender

Group	**Gender**				**Total**	
	Male		Female			
C_1	19	9.6%	25	12.7%	44	22.3%
E_1	23	11.7%	28	14.2%	51	25.9%

C_2	31	15.7%	21	10.7%	52	26.4%
E_2	24	12.2%	26	13.2%	50	25.4%
Total	**97**	**49.2%**	**100**	**50.8%**	**197**	**100.0%**

The results in table 4.1 indicate that there are slightly more female than male at 50.8% and 49.2% respectively. This disparity may be attributed to high rate of students dropping out from public secondary schools by the boy child due to parental level of education, parental income influence among other gender related factors (Kaindi, 2015). However, **C_2** registered a slightly higher number of males at 15.7 % compared to females at 10.7%.

4.3 5E Model and Learner's Achievement in Chemistry

The first objective sought to establish effect of 5Es model in ICT integrated lessons on learner's achievement in "structure and bonding". The difference in achievement of groups, one group exposed to the 5Es model in ICT based lessons (E_1) and the other group exposed to conventional methods (C_1) was sought.

4.3.1 Students' Achievement in Pre-test.

Pre-test results for control (C_1) and experimental (E_1) were generated as shown in Table 4.2

Table 4.2: Students' Achievement in Pre-test.

	Test group composition				**Total**	
	C1		E1			
	F	%	F	%	F	%
Below 20	30	31.6	36	37.9	66	69.5
20 – 45	12	12.6	15	15.8	27	28.4
Above 45	2	2.1	0	0.0	2	2.1
Total	44	46.3	51	53.7	95	100.0
Mean	18.36		18.04		18.19	
SD	13.46		11.41		12.33	

Data obtained from the pre-test presented in Table 4.2 show that generally, learners achieved poorly in the test (M=18.19; SD=12.33), more than six out of ten of the students scoring less than 20% in the test. Specifically, results show that slightly more learners in the test group, E_1 (37.9%) recorded less than 20% and thus achieved poorly compared to those in the control group C_1, (31.6%). A comparable tendency was noted with regard to learners who scored between 20% and 45%, slightly more students from E_1 having scores within this range compared to those from C_1 (15.8% and 12.6% respectively). However, all those who scored above 45% and thus could be presumed to have passed in the test were from C_1. Finding therefore illustrates that whereas the students achieved poorly in the pre-test, students in C1 achieved slightly better (M=18.36; SD=13.46) matched to learners in experimental group E_1 (M=18.04; SD=11.41).

This dismal achievement is a replica to that of Petrus, (2018) in a study carried out in South Africa that pointed at low achievement in sciences. Similarly in Nigeria where sciences are a pre–requisite for the enrolment in many university courses, low achievement in science subjects is evident. Poor teaching methods and abstract nature of science concepts accounted for the dismal results (Idris et al., 2021). Similarly in Zimbabwe empirical evidence indicates that achievement in science is also low among secondary school learners (Makawa, 2018). In Kenya the low achievement in sciences and more so in Chemistry is also evident (Ogembo, et al., 2015). This low achievement in the pre-test, as depicted in the findings, is a correlate with the KNEC report on the performance of Chemistry at the national level which is a matter of great concern. This necessitated further statistical analysis to give detailed insights on student achievement. An independent sample t-test was thus undertaken on the groups to assess their homogeneity of the test groups as regards their composition as shown in Table 4.3.

Table 4.3: Independent Sample t-Test for Pre-test Results

Group	N	Mean	SD	SE	df	F	p-value	t-value	p-value
C_1	44	18.36	13.46	2.029	93	1.120	.899	.127	.899
E_1	51	18.04	11.41	1.598					

Results obtained (F=1.120, p = 0.899) indicates an insignificant difference. There was no significant mean difference in the mean for $\mathbf{C_1}$ (M=18.36; SD=13.46) and $\mathbf{E_1}$ (M=18.04;

SD=11.41) at t(93)=.127, p = .899 when the test results were analyzed for equal variance. Thus the means for control and the experimental groups were comparable. This implied that learners within these groups could be compared in ability or character which was significant for this study. Consequently, an investigation on the impact of the 5Es model in ICT integrated lessons was carried out on the post-test administered as shown in Table 4.4

Table 4.4: Achievement in Post test Results for C_1 and E_1

	Test group composition				Total	
	C_1		E_1			
	F	%	f	%	F	%
Below 20	16	16.8	0	0.0	16	16.8
20 – 45	14	14.7	31	32.7	45	47.4
Above 45	14	14.7	20	21.1	34	35.8
Total	44	46.2	51	53.8	95	100.0
Mean	33.64		41.96		37.83	
SD	19.98		12.66		16.29	

Data obtained show that compared to their achievement in the pre-test, a remarkable improvement in the post test was noted, learners posting a mean achievement of 37.83 (SD=16.29) which is almost twice as much as their achievement in the pre-test. Based on the groups, students in experimental group E_1 posted a better achievement (M=41.96; SD=12.66) compared to those in the control group C_1 (M=33.64; SD=19.98). Specifically, findings illustrated that students who scored less than 20% in the post test were all from control group C_1 which is contrary to what was observed in the pretest in which a slightly bigger number of students had scored below 20% and were presumed to have achieved poorly. Of those who scored between 20% and 45%, there were slightly above twice as many students in E_1 (32.7%) as those from C_1 (14.7%). Similarly, amongst the students who scored above 45% and could be presumed to have passed in the post test, a majority (21.1%) were from E_1. This means that comparatively, more students in E_1 achieved better in the post test examination compared to their counterparts in C_1. Equally, was the trend noted with regard to achievement in E_2 and C_2 as shown in Table 4.5

Table 4.5: Achievement in Post test Results for C_2 and E_2

	Test group composition				Total	
	C2		E2			
	F	%	F	%	F	%
Below 20	17	16.5	0	0.0	17	16.5
20 – 45	27	26.2	29	28.2	56	54.4
Above 45	8	7.8	21	21.3	30	29.1
Total	52	50.5	50	49.5	103	100.0
Mean	30.54		48.71		39.65	
SD	16.90		18.55		17.74	

Consistent with the findings of the post test results for students in C_1 and E_1, was the achievement of students in C_2 and E_2. Table 4.5 points at student achievement in the two groups that was equally high, the students posting a mean achievement of 39.65 (SD=17.74) slightly higher than the post test results of students in C_1 and E_1. Based on the groups, students in experimental group E_2 posted a better achievement (M=48.71; SD=18.55) vis-à-vis control group C_2 (M=30.54; SD=16.90).

Specifically, findings illustrated that more than half of the students (70.9%) scored 45% or less in the test. Of these, slightly less than a third (28.2%) were from E_2 while the remaining majority (42.7%) were from C_2. This implies that of those who either failed or scored averagely in the post test, a majority were from the control group. Amongst those who scored above 45% and could be presumed to have achieved well in the post test, those from the E_2

were approximately three times as many (21.3%) as those from the C_2 (7.8%). This finding which shows that more students in the E_2 had an enhanced achievement in the post-test examination when a comparison is made with group (C_2) is similar with that of C_1 and E_1.

Descriptive findings on the post-test SCAT compared to pre-test SCAT, students in the experimental group in the post-test was better than that of students in the pre-test SCAT. In regard to levels of achievement on learners in groups E_2 and C_2 which were not pretested, correlating results were observed. This correlates with findings from Research by Mupira, and Ramnarain (2018). Similar observations are reported by Mwangu and Sibanda (2017). Equally Skamp and Peers (2012) Kacer (2016) and are of similar school of thought. Chowdhury (2016) in a study that examined effectiveness of 5Es constructivist approach in learning established a significant improvement on learners' achievement in Mathematics. Other studies that have opined similarly include that of Oludipe and Oludipe (2013), Kauts and Sikand (2019), Sakalli (2015) and Wegayehu (2019)

To examine on the likely effect of pre-test sensitization on the result, an assessment was carried out. This was under taken using an independent t-test for the two groups C_2 and E_2 as in Table 4.6.

Table 4.6: Independent Sample t-Test for Post-test Results

Group	N	Mean	SD	SE	df	F	p-value	t-value	p-value
C_2	52	30.54	16.90	2.343	101	0.736	.393	5.198	.000
E_2	50	48.71	18.55	2.598					

The Levene's test for equality of variance achieved on data from C_2 and E_2 illustrated insignificant difference in variances in achievement (F=0.736, p=0.393) for learners in C_2 and E_2. The data obtained thus fits the assumption of homogeneity of variance when C_2 and E_2 are statistically compared. This finding necessitated a further analysis on the mean for the two groups which gave the following results, t (101) = 5.198, P < 0.001. A mean difference that statistical test amounts it as significant thus existed between the scores of C_2 and E_2. These two groups were not pre-tested. Notable was the experimental group mean score which was higher besides being indicative of a score that was statistically significant. For the pre-tested groups, a similar observation on the mean difference was arrived at refuting a possible presence of pre-test sensitisation.

4.3.2 Effect of 5E Guided Model on Students Achievement

The first hypothesis sought to establish whether there exists a statistically significance difference in achievement on learners taught "structure and bonding" using 5Es model in ICT based lessons compared to conventional methods. To achieve this, a one way ANOVA was used to analyse all the four groups on the data obtained from Chemistry student achievement test (Post-test SCAT). Table 4.7 and 4.8 shows the results obtained.

Table 4.7: Effect of 5E Guided Model on Students Achievement

	N	**Mean**	**SD**	**SE**	**95% confidence interval for mean**		**Min**	**Max**
					Lower Bound	Upper Bound		
C_1	44	33.6364	19.97800	3.01180	27.5625	39.7102	.00	64.00
E_1	51	41.9608	12.65853	1.77255	38.4005	45.5211	24.00	64.00
C_2	52	30.5385	16.89699	2.34319	25.8343	35.2426	4.00	80.00
E_2	50	48.7059	18.55079	2.59763	43.4884	53.9234	24.00	100.00
Total	197	38.8485	18.46625	1.31234	36.2604	41.4365	.00	100.00

The ANOVA descriptive data obtained evidently pointed out that learners in groups E_1 and E_2 had a higher score (M=41.96, SD=12.66 and M=48.71, SD=18.55 respectively) in post-test results compared to group C_1 and C_2 (M=33.64, SD=19.98 and M=30.54, SD=16.90 respectively). Table 4.8 represents the statistical findings.

Table 4.8: Effect of 5E Guided Model on Students Achievement (ANOVA)

	Sum of squares	df	Mean square	F	Sig.
Between Groups	10235.840	3	3411.947	11.624	.000
Within Groups	56941.615	194	293.513		
Total	67177.455	197			

The ANOVA results *F* (3, 194) = 11.62, *p* < .001 points at a mean difference that is significant at 0.05 level of significance. A further analysis using a Post Hoc test (Tukey) which allowed the study to locate the specific differences within the groups, yielded to correlating findings.

Table 4.9: Post Hoc Test Results

(I) Group	(J) Group	Mean difference (I-J)	SE	Sig.	95%	
					Lower bound	Upper bound
C1	E1	-13.97727*	2.53511	.000	-20.5469	-7.4077
	C2	1.93619	2.52380	.869	-4.6041	8.4764
	E2	-9.41845*	2.53511	.002	-15.9880	-2.8489
E1	C1	13.97727*	2.53511	.000	7.4077	20.5469
	C2	15.91346*	2.42817	.000	9.6210	22.2059
	E2	4.55882	2.43993	.245	-1.7641	10.8817
C2	C1	-1.93619	2.52380	.869	-8.4764	4.6041
	E1	-15.91346*	2.42817	.000	-22.2059	-9.6210
	E2	-11.35464*	2.42817	.000	-17.6471	-5.0622
E2	C1	9.41845*	2.53511	.002	2.8489	15.9880
	E1	-4.55882	2.43993	.245	-10.8817	1.7641
	C2	11.35464*	2.42817	.000	5.0622	17.6471

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

The results show that the post test results for E_1 (M=41.96, SD=12.66) is significantly different from C_1 (M=33.64, SD=19.98) and C_2 (M=30.54, SD=16.90). Consistent with this finding, data obtained show that the post test results for E_2 (M=48.71, SD=18.55) is significantly different from C_1 (M=33.64, SD=19.98) and C_2 (M=30.54, SD=16.90). Findings show that students in experimental groups who were exposed to 5Es model in ICT integrated lessons achieved significantly better than those in conventional methods.

These findings are consistent with similar study findings in Chemistry education. For instance, Opara and Waswa (2013) in a study on “enhancing students’ achievement in Chemistry through the 5E model” pointed at an improved achievement. Study by Skamp and Peers (2012) that elucidated insights from teachers’ feedback revealed that 5Es model positively influenced on science achievement Kolomuc, Ozmen, Metin, and Acisli (2012) found that the group that was exposed to the 5Es model achieved better. It can therefore be concluded that use of 5Es model in ICT integrated lessons is a better instructional approach that results to better academic achievement of students exposed to it. $\mathbf{H_{O1}}$ was therefore rejected.

4.4 5E Model and Achievement of High and Low Ability Students

The second objective sought determine the effect of use of 5Es model in ICT integrated lessons on learners’ achievement based on ability with a specific focus on “structure and bonding”. Students in the two test groups that were pre-tested (E_1 and C_1) were classified as low (LA) and high (HA) ability based on results obtained from the Pre-test SCAT.

4.4.1 Students’ Ability in Chemistry

Learners were categorised as LA or HA as guided by the scores achieved in the Pre-test SCAT as in Table 4.10.

Table 4.10: Students’ Ability in Chemistry

Group	**Students’ ability**				**Total**	
	LA		HA			
	F	%	F	%	F	%
C1	34	35.8	10	10.5	44	46.3
E1	43	45.3	8	8.4	51	53.7

Total	77	81.1	18	18.9	95	100.0

Table 4.10 contains a summary of data obtained on students' achievement in the pre-test SCAT based on their ability. According to the data, a majority of the students (81.1%) were categorized as LA. Of those categorized as LA, there slightly more students (45.3%) from E_1 in comparison to C_1 (35.8%). For the learners in the HA category, slightly more learners (10.5%) were drawn from C_1 as compared to E_1 (8.4%)' Comparatively, findings illustrates that based on students' ability, there were more LA students in E_1 relative to those in C_1. Conversely, more HA students were found in C_1 compared to learners of the same category in E_1. In order to assess whether the learners composition based on ability was homogenous or otherwise, an independent sample t-test was thus achieved. Results obtained were as presented in Table 4.11.

Table 4.11: Independent Sample Test for Students' Ability in Chemistry

Group	N	Mean	SD	SE	df	F	p-value	t-value	p-value
C_1	44	1.227	.4239	.0639	93	3.017	.086	.867	.388
E_1	51	1.157	.3673	.0514					

It was established that there existed no significance difference between variances of C_1 and E_1. As per findings from Levene's test for equality of variance (*F*=3.017, p = 0.086), the test for homogeneity gave positive findings that meant the two groups had comparable characteristics based on ability. Equally for E_1 (M=1.157, SD=.424) and C_1 (M=1.227, SD=.367) groups, t(93)=.867, p = .388 meant that these groups had a close mean that could be compared indicative of the similarity in learners characteristics apparently needed for the study.

4.4.2 Effect of 5E Guided Model on Low and High Ability Students

The study proceeded to establish the effect of 5Es model in ICT integrated lessons on students' achievement in Chemistry based on ability. H_{O2} stated that there is no significant difference in achievement in “structure and bonding” between learners guided by 5Es model in ICT integrated lessons and those using conventional methods based on ability. A two way ANOVA was performed on the post-test SCAT results to determine the effect of the teaching strategy on learners’ achievement. A summary of the findings is shown in Table 4.12.

Table 4.12: Effect of 5E Guided Model on Low and High Ability Students (Descriptive)

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	4898.512[a]	3	1632.837	6.781	.000	.183
Intercept	103923.223	1	103923.223	431.582	.000	.826
Ability	3097.943	1	3097.943	12.865	.001	.124
Group	2088.731	1	2088.731	8.674	.004	.087
Ability * Group	273.682	1	273.682	1.137	.289	.012
Error	21912.436	91	240.796			
Total	164752.000	95				
Corrected Total	26810.947	94				

a. R Squared = .183 (Adjusted R Squared = .156)

Two way analysis of variance model used indicate that ability accounts for 15.6% of the total variance in students’ achievement implying that ability explains about one-sixth of the total variance in achievement. According to the findings, ability and groups are significant though the interaction effect is insignificant, $F(1,95)=1.14$, p = .289. The differences in the achievement of HA and LA students was significant, $F(1, 95)=12.87$, p = .001. Similarly, significant differences exist between groups (5Es model in ICT lesson and conventional methods.), $F(1,95)=8.67$, p =004, . Table 4.13 compares the group mean.

Table 4.13: Student Ability Group Means

Student Ability	**Group**	**Mean**	**SE**	**Mean**	**SE**

HA	C1	36.45	2.79	49.80	3.68
	E1	48.49	2.99		
LA	C1	31.29	2.66	35.14	1.78
	E1	38.98	2.37		

It was observed that the achievement of HA students (M=49.80, SE=3.68) was significantly different from those of LA students (M=35.14, SE=1.78). Similarly, findings illustrates that the achievement in E_1 (M=48.49, SE=2.99) was significantly different from that of C_1 (M=36.45, SE=2.79). For the low achiever, the pair wise comparison pointed at a greater impact that was significant (M=38.98, SE=2.37) in E_1 than those in C_1 (M=31.29, SE=2.66). As for the ability, the Univariate test findings were also significant, $F(1,91)=12.87$, $p = .001$, and test groups, $F(1,91)=8.67$, $p =.001$. (Table4.12).

These findings are consistent with that of Manzo, When, Liets, Torre, and Gomez (2016) who examined how 5Es instructional model influences low ability and high ability learners in relation to achievement. Low ability learners recorded a better achievement. Han (2015) in STEM related research came to a conclusion that low ability learners showed a significant improvement in Mathematics scores. On the other hand, study by Agarwal and Agarwal (2018) that ventured in science education and 5Es constructivist learning approach established neutrality on high ability learners, average ability learners and low ability learners. Amongst the groups, no significant difference was found.

On the contrary, these findings contradicts to that of Atomatofa and Ajaja (2017) in a study dubbed “learning environments as basis for cognitive achievements of students”. Study findings showed that 5Es instructional model resulted to better achievement for both high and low ability learners. Kauts and Sikand (2019) established that high ability learners instructed through the 5Es instructional model had a higher score at various domains of cognitive ability than the learners using the conventional strategies. These assertions agrees with a similar research by De Castrol et al., (2015). Likewise, Alhaji and Dan (2015) is of a similar opinion and concludes that high ability learners exhibits a significant improvement in the overall mean score.

This study endeavored to determine the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on ability. The Univariate test findings gave a statistically significant difference, $F(1,91)=12.87$, $p = .001$, and test groups, $F(1,91)=8.67$, $p =.001$. It was thus concluded that use of 5E model in ICT integrated lessons has a greater effect on low ability compared to high ability students. Therefore, hypothesis H_{02} which stated that there is no significant difference in achievement in "structure and bonding" between learners' taught through the 5Es model in ICT integrated lessons and those taught through conventional strategy based on ability was rejected.

4.5: 5Es Instructional model and Achievement of Students with Negative and Positive Attitude towards Chemistry

This study also endeavored to find the effect of 5Es model in ICT integrated lessons on learners with negative and positive attitude towards the subject. Ho_3 of the study tried to find whether there exists a significant difference in the achievement in Chemistry of learners with negative and positive attitude towards the subject when taught using 5Es model in ICT integrated lessons.

4.5.1: Students' Attitude towards Chemistry

The attempt to establish the effect of 5E model in ICT integrated lessons on the achievement based on attitude began with categorization of learners attitude as positive (PA) and negative (NA). This was based on the results obtained from the students' questionnaire. The questionnaires were administered to all the four sampled schools at the beginning of the study. This helped asses the harbored attitude towards Chemistry as at the commencement of the study (See appendix I). After a four weeks period of intervention using the 5Es instructional model of constructivist approach, the same questionnaire was administered to all the four schools. This helped asses any discrepancies on the harbored attitude towards Chemistry as at the end of the intervention after learner were exposed to the 5Es instructional model. Besides editing, the data collected was further coded and with the aid of computer software it was analyzed in Table 4.13.

Table 4.14: Students' Attitude towards Chemistry – Pretest

Statement	Strongly disagree		Disagree		Not sure		Agree		Strongly agree		Total	
	F	%	F	%	F	%	f	%	f	%	F	%
Learning Chemistry is fun.	11	5.6	37	18.8	57	28.9	70	35.5	22	11.2	197	100.0
Chemistry is necessary to solve daily life problems.	9	4.6	24	12.2	55	27.9	63	32.0	46	23.4	197	100.0
I hate Chemistry.	5	2.5	9	4.6	39	19.8	86	43.7	58	29.4	197	100.0
upon finishing school, I would like to work with individuals good in making discoveries for Chemistry	8	4.1	3	1.5	42	21.3	88	44.7	56	28.4	197	100.0
I'm not good at Chemistry.	6	3.0	17	8.6	51	25.9	79	40.1	44	22.3	197	100.0
I do not need to work in the lab upon finishing school.	3	1.5	11	5.6	43	21.8	70	35.5	70	35.5	197	100.0
Chemistry is one of the most interesting lessons	4	2.0	9	4.6	43	21.8	86	43.7	55	27.9	197	100.0
Chemistry lessons bore me.	7	3.6	11	5.6	41	20.8	87	44.2	51	25.9	197	100.0
Working in a laboratory and earning some money may be interesting	13	6.6	32	16.2	63	32.0	68	34.5	21	10.7	197	100.0
Chemistry is easy for me to learn.	2	1.0	11	5.6	48	24.4	78	39.6	58	29.4	197	100.0
I'm looking forward to an ICT integrated Chemistry lesson.	4	2.0	2	1.0	47	23.9	78	39.6	66	33.5	197	100.0
To make career about Chemistry is boring.	9	4.6	18	9.1	49	24.9	75	38.1	46	23.4	197	100.0
There is no fun in use ICT tools in learning Chemistry	40	20.3	72	36.5	32	16.2	22	11.1	31	15.7	197	100.0
Although I work hard, I don't understand Chemistry lessons.	5	2.5	17	8.6	35	17.8	86	43.7	54	27.4	197	100.0
I want to become an ICT expert after high school.	4	2.0	16	8.1	44	22.3	81	41.1	52	26.4	197	100.0
Chemistry knowledge is important to find a good job.	2	1.0	2	1.0	34	17.3	80	40.6	79	40.1	197	100.0
Use of internet doesn't makes Chemistry easy	7	3.6	22	11.2	45	22.8	69	35.0	54	27.4	197	100.0
I don't like Chemistry projects.	15	7.6	35	17.8	74	37.6	48	24.4	25	12.7	197	100.0
I find the topic on "the periodic table" difficult	9	4.6	16	8.1	26	13.2	93	47.2	53	26.9	197	100.0
I don't like how teachers teach Chemistry	7	3.6	16	8.1	51	25.9	90	45.7	33	16.8	197	100.0
Mean	3.71											
SD	0.666											

Data obtained show that students scored highly for attitude (M=3.71, SD= 0.666) in the students' questionnaire administered during the pre-test. When interpreted this implied that a majority of the students had an attitude that could be termed as positive towards Chemistry. Specifically, a greater number of students indicated knowledge in Chemistry is key to finding a decent job (80.7%), a greater number intimated that Chemistry is essential in resolving day-to-day life difficulties (55.4%), a majority of them were convinced that they would co-work closely with individual good at making innovations for Chemistry once they clear with schooling (73.1%) and a significant proportion believe that Chemistry lessons is among the most interesting (71.6%).

Fewer students confessed that they don't like Chemistry projects (37.1%), less than half of the students believed learning Chemistry is fun (46.7%) and a majority confessed they don't like how teachers teach Chemistry (62.5%). A greater number of students indicated that the topic on "the periodic table" which is a prerequisite of the topic "structure and bonding" as very difficult (74.1%). However, a majority of the students had a positive attitude towards use of technology in learning. Specifically, a greater number were looking forward to an ICT integrated lessons in Chemistry (73.1%) while only a very small number showed no fun in use ICT tools in learning Chemistry (26.8%)

Consequently, categorization of the students' attitude was undertaken by comparing their average score against the actual score in the scale of attitude. On computing students' score on the scale of attitude, it was established that the minimum score was 26 while the maximum score in the scale was 99. For the learners who scored more than 62.5 were regarded as having positive attitude (PA) while those whose score was below 62.5 were categorised as portraying negative attitude (NA) yielding data.

Table 4.15: Students' Attitude (Categorized)

	Group								Total	
	C1		E1		C2		E2			
	f	%	F	%	F	%	F	%	F	%
NA	7	3.6	12	6.1	11	5.6	8	4.1	38	19.3
PA	37	18.8	39	19.8	41	20.8	42	21.3	159	80.7
Total	44	22.3	51	25.9	52	26.4	50	25.4	197	100.0

Data in obtained show that (80.7%) scored highly in the scale of attitude and were thus categorized as PA students compared to those categorized as NA students (19.3%). It was also shown that the different categories of students relative to their attitude were fairly distributed across the four test groups of the study. Table 4.16 compares the mean of the groups using a one way ANOVA.

Table 4.16: PA and NA Group Means (ANOVA)

	Sum of squares	Df	Mean square	F	Sig.
Between Groups	.214	3	.071	.452	.716
Within Groups	30.456	193	.158		
Total	30.670	196			

Data obtained indicated an insignificant mean difference in the variation in the distribution, $F(3, 193)=0.452$, $p=0.716$ at 95% level of significance. Additionally, post-test items mean and the pre-test items mean in the scale of attitudes was sought for to help assess the effect of 5Es model in ICT integrated lessons on students' attitude. Table 4.17 compares students mean in the pre-test and post-test

Table 4.17: Students Mean in the Pre-Test and Post-Test

Test	Mean	SD
Pre-test	3.71	0.666
Post-test	3.84	0.549

Data obtained showed that consistent with previous observation, students score for attitude was high; M=3.84 (SD=0.549) out of 5. Compared to the M=3.71 scored during the pre-test, this imply a positive change of 0.13 in the scale of attitude.

4.5.2 Effect of 5E model in ICT integrated lessons on NA and PA Students (Descriptive)

To realise the third objective, the effect of 5Es model in ICT integrated lessons on learners' achievement in Chemistry in regard to their attitude towards Chemistry was examined. Equally, the study anticipated on establishing whether 5Es model in ICT based lessons has any effect on students' attitude. To assess whether 5Es model in ICT integrated lessons has significant impact on learners' achievement differently based on their attitude (whether NA or PA), a two way ANOVA test of pre and post-test attitude was operationalized and summarized in Table 4.18 .

Table 4.18: Effect of 5E model in ICT integrated lessons on NA and PA Students (Descriptive)

Source	Type III sum of squares	Df	Mean square	F	Sig.	Partial Eta squared
Intercept	190023.971	1	190023.971	643.828	.000	.773
Attitude	519.903	1	519.903	1.762	.186	.009
Group	5937.965	3	1979.322	6.706	.000	.096
Attitude * Group	395.234	3	131.745	.446	.720	.007
Error	55782.787	189	295.147			
Total	364976.000	197				
Corrected Total	67130.315	196				

a. R Squared = .169 (Adjusted R Squared = .138)

Results obtained show that as a model, the effect of 5Es model in ICT enhanced lessons on students' achievement was significant. It accounted for 17% of the total variance in learners' achievement. In particular, findings illustrated an insignificant mean difference of students with positive and negative attitudes, $F(1,197)=1.762$, $p = .186$. However, significant differences were found between groups (5Es model in ICT based lessons and conventional methods), *F*(3,197)=6.706, p <.001, though there existed insignificant interaction effect between attitude and groups, *F*(3,197)=0.446, p = .720. Table 4.19 compares the group mean.

Table 4.19: PA and NA Group Means Comparison

Student Attitude	Group	Mean	SE	Mean	SE
PA	C1	40.18	2.83	42.25	2.86
	E1	45.86	2.96		
NA	C1	35.06	3.54	38.05	1.36
	E1	42.25	2.86		

Within the groups, insignificant difference in achievement existed between students with positive attitude (M=42.25, SE=2.86) from those with negative attitude (M=38.05, SE=1.36). Nonetheless, a difference that was significant was detected in the achievement of students in E_1 (M=41.63, SE=2.84) compared C_1 (M=35.06, SE=3.54). Results from the Univariate test were significant too for test group, *F*(3,189)=6.706, p < .001, but insignificant for attitude, *F*(1,189)=1.762, p =.186,.

The study thus proceeded to establish the effect of 5Es model in ICT based lessons on student's attitude towards Chemistry through a one way ANOVA. Learners' score variation based on the domain of attitude in pre-test and post-test alongside test groups (experimental or control) guided the analysis as summarized in Table 4.20 .

Table 4.20: Effect of 5E Model in ICT based lesson on Students' Attitude (Descriptive)

	N	Mean	SD	SE	95% Confidence interval for mean		Min	Max
					Lower Bound	Upper Bound		
C_1	44	1.2941	8.87903	1.33856	.3005	5.6995	14.00	24.00
E_1	51	3.0000	6.31916	.88486	.4832	3.0714	13.00	18.00
C_2	52	2.3077	11.58860	1.60705	.9186	5.5340	22.00	45.00
E_2	50	3.4200	8.08145	1.14289	1.1233	5.7167	18.00	25.00
Total	197	2.4822	8.91147	.63492	1.2301	3.7344	22.00	45.00

On the elements of attitude, the change in the learners mean score as from the data obtained show that from E_2 were highest (M=3.42). This was closely followed by those from E_1 (M=3.00). C_2 registered a slightly lower mean, (M=2.31) while C_1 recorded a mean of (M=1.29) as in Table 4. 21.

Table 4.21: Effect of 5Es Model in ICT integrated lessons on Students' Attitude (ANOVA)

	Sum of squares	df	Mean square	F	Sig.
Between Groups	129.343	3	43.114	.539	.656
Within Groups	15435.845	193	79.978		
Total	15565.188	196			

ANOVA results $F(3, 196) = .539$, $p = 0.656$ pointed at an experiential mean difference deemed as insignificant. Findings imply that whereas 5Es model in ICT integrated lessons seems to have a greater effect on the attitude of students with positive attitude towards Chemistry compared to those with negative attitude, the difference in the effect is insignificant. Therefore, data obtained failed to reject the subsidiary hypothesis which aimed at establishing whether 5Es model in an ICT based lesson has any effect on students' attitude.

These study findings augers well with that of Ibe (2017). The attitude of scholars trained with 5Es model was more positive than on conventional method. An investigation by Kassir and Forawi, (2017) on learners' attitude with the group exposed to the 5Es instructional model showed collating findings. Moreover, Muhammad, Omwirhiren and Abubakar (2019) on "mole concepts" established that the attitude of the learners who were exposed to the 5Es instructional model of learning improved significantly after the treatment which concurs with the study findings.

Findings of the study led to a conclusion that use of 5Es model in ICT lesson in teaching Chemistry affects both cohorts with either positive or negative attitude in a similarly manner . Findings therefore, failed to reject null Ho_3 which indicated that there exists no significant difference in achievement in “structure and bonding” on learners’ taught through the 5Es model in ICT integrated lessons and those taught through conventional methods based on attitude

4.6 5E Model and Achievement of Male and Female Students

This research anticipated to find the effect of 5E model in ICT integrated lessons on learners’ achievement based on their gender. Hypothesis four, Ho_4 of the study tried to find whether there exists a statistical difference and establish if it is significant between the achievement of male and female students exposed to 5E model in ICT integrated lessons.

4.6.1 Students Distribution by Gender

Data obtained from the study on students’ sex was as presented in Table 4.22.

Table 4.22: Students Distribution by Gender

Group	**Gender**				**Total**	
	Male		Female			
	F	%	F	%	F	%
C_1	19	9.6	25	12.7	44	22.3
E_1	23	11.7	28	14.2	51	25.9
C_2	31	15.7	21	10.7	52	26.4
E_2	24	12.2	26	13.2	50	25.4
Total	97	49.2	100	50.8	197	100.0

Results obtained show that there were 97 male and 100 female students. A one way ANOVA test was undertaken to illustrate students’ distribution in the groups. Table 4.23 presents the findings.

Table 4.23: Students’ Distribution (ANOVA)

	Sum of squares	**df**	**Mean square**	**F**	**Sig.**
Between Groups	.816	3	.272	1.085	.357

Within Groups	48.422	193	.251
Total	49.239	196	

ANOVA statistics, $F(3,193)=1.08$, $p = 0.357$ for the test of homogeneity pointed to an insignificant differences at 0.05 level of significance indicating similarity in distribution of students in the groups based on gender thus permitting further analysis. The study thus proceeded to compare students' achievement based on gender in the pre and post-test. Data obtained from the pre-test were as tabulated in Table 4.24.

Table 4.24: Students' Achievement in Pre-test by Gender

	Gender				**Total**	
	Male		Female			
	F	%	F	%	F	%
Below 20	30	31.6	36	37.9	66	69.5
20 – 45	12	12.6	15	15.8	27	28.4
Above 45	0	0.0	2	2.1	2	2.1
Total	42	44.2	53	55.8	95	100.0

Results obtained show that a majority of the students who were pre-tested (69.5%) scored less than 20% in the pre-test exam. Amongst this population, there were slightly more females (37.9%) compared to males (31.6%). Further, findings illustrated that slightly more females than males (15.8% compared to 12.6%) scored between 20 and 45% and all those who scored more than 45% were all female students. Consequently, independent sample t-test was operationalized. This test served in comparing the achievement of male and female students in the pre-test. Table 4.25 presents the findings

Table 4.25: Male and Female Students in the Pre-Test. (t-test)

Gender	**N**	**Mean**	**SD**	**SE**	**T**	**p-value**
Male	42	16.5714	10.58564	1.63340	1.140	0.257
Female	53	19.4717	13.52008	1.85713		

Findings showed that the mean achievement of females (M=19.47) was slightly higher than that of males (M=16.57), the mean difference though being insignificant, $t(93)=1.140$, p =

.257. Findings imply that females achieved slightly better than males. When these students were exposed 5Emodel in ICT integrated lessons and then post tested, the outcome was as seen Table 4.26.

Table 4.26: Students' Achievement in Post-test by Gender

	Gender				Total	
	Male		Female			
	F	%	F	%	F	%
Below 20	8	8.4	8	8.4	16	16.8
20 – 45	18	18.9	27	28.4	45	47.4
Above 45	16	16.8	18	18.9	35	35.8
Total	42	44.2	53	55.8	95	100.0

An analysis of the post-test outcomes correlated on gender indicate a general trend of improved achievement, less than a third of students who scored less 20% in the pre-test having the same score in the post-test based on gender. Specifically, finding illustrated same proportions of male and female students (8.4%) scoring less than 20%, more females than male students scoring between 20 and 45% (28.4% and 18.9% respectively) and slightly more female than male scoring above 45% in the post-test (18.9% and 16.8% respectively). A comparative analysis of achievement in the post-test using independent sample t-test was as presented in Table 4.27

Table 4.27: Gender Achievement in the Post-Test (t-test)

Gender	**N**	**Mean**	**SD**	**SE**	**T**	**p-value**
Male	42	37.1429	18.41072	2.84084	0.492	0.624
Female	53	38.8679	15.71628	2.15880		

Findings indicated an insignificant mean difference, t(93)=.492, p = .624 in males and females though the mean achievement of female students (M=38.87) was slightly higher than that of male students (M=37.14).

4.6.2 Effect of 5E Model on Male and Female Students

Subsequently, the study proceeded to test the effect of 5E model in ICT integrated lessons on students' achievement based on gender. A two way ANOVA test was done to show the impact of 5E model in ICT integrated lessons on students' achievement in Chemistry based on gender as were made accessible in Table 4.28.

Table 4.28: Effect of 5E Model on Male and Female Students

Source	**Type III Sum of squares**	**df**	**Mean square**	**F**	**Sig.**	**Partial Eta squared**
Corrected Model	1739.972[a]	3	579.991	2.105	.105	.065
Intercept	132172.665	1	132172.665	479.746	.000	.841
Group	1670.076	1	1670.076	6.062	.016	.062
Gender	89.306	1	89.306	.324	.571	.004
Group * Gender	19.762	1	19.762	.072	.789	.001
Error	25070.975	91	275.505			
Total	164752.000	95				
Corrected Total	26810.947	94				

a. R Squared = .065 (Adjusted R Squared = .034)
b. Group Mean E_1= 41.91; SE=2.34
c. Group Mean C_1= 33.44; SE=2.53

As a model, the effect 5Es model in ICT integrated lessons on groups was significant in the experimental group E_1 (M=41.91, SE=2.34) and C_1 (M=33.44, SE=2.53). From the Univariate test findings there existed a significant difference for test groups, $F(1.91)=6.06$, p=0.016. Table 4.29 presents group mean

Table 4.29: **Male and female group means comparison**

Gender	**Group**	**Mean**	**SE**	**Mean**	**SE**
Male	C1	32.00	3.81	36.70	2.57
	E1	41.39	3.46		

Female	C1	34.88	3.32	38.65	2.28
	E1	42.43	3.14		

Based on gender, results show that female students posted a higher mean achievement in "structure and bonding" (M=38.65; SE=2.284) compared to male students (M=36.70; SE=2.57). The differences were however insignificant, $F(1, 91)=.324$, $p =.571$. Within the groups, female students in E_1 posted a higher mean (M=42.43) compared to male students (M=41.39) in the same group. Similarly, the mean achievement of female students (M=34.88) in C_1 was slightly higher than male students in the same group (M=32.00). Findings imply that though the use of 5Es model in ICT integrated lessons in teaching Chemistry impacts students of different gender in a similar manner as founded on the insignificant outcome across gender, the achievement level difference across the control and experimental group revealed its supremacy as a process of instruction in Chemistry. Therefore, data gotten failed to reject H_{O4} that had indicated that there is no gender difference in achievement in "structure and bonding" for learners guided by 5Es model in ICT integrated lessons and those using conventional methods

On the whole, the study findings concurs with that of Umahaba (2018) on the impact of 5Es instructional model on gender and its effects on achievement in chemical "equations concept" in Nigeria. Similary Ibe (2017) in a study dubbed "use of 5Es instructional model in teaching Biology" did not yield to a statistical difference that was significant between the two genders. Moreover, Tagbo (2017) concluded that gender is not a strong determining factor as far as learner's achievement is concerned. Ibe, Nwosu, Obi and Nwoye, (2016) and Chowdhury (2016) equally concurs with this study findings

4.7 Challenges of Implementing 5E Model (Qualitative Data)

Qualitative data acquired from teachers of chemistry applying 5Es model in ICT integrated lessons through interview and the observation schedule was analysed using thematic analysis. Kiger and Varpio (2020) defines thematic analysis as "a method for analyzing qualitative data that entails searching across a data set to identify, analyze, and report repeated patterns that involves interpretation in the processes of selecting codes and constructing themes" . The interviews and the observations were transcribed verbatim or "near verbatim". Summary of statements of the main points from each respondent was done though duplicated ideas were deleted to arrive at reduced categories that were grouped together and labelled as themes. The generated thematic areas were analysed hand in hand with any emergent auxiliary themes. Moreover, subjective experiences from the interviewed teachers pertaining integrating the 5Es instructional model in an ICT integrated lesson were entwined into narrative. Consequently, the much needed link emerged that bridged the fifth study objective to raw data . Confidentiality of each respondent was strictly observed. For anonymity, respondents from experimental school E_1 and experimental school E_2 were transcribed as respondent E_1 and respondent E_2 respectively.

Findings indicated time factor as a major challenge in the implementation of the 5Es instructional model. Both respondents E_1 and respondent E_2 admitted that transiting from one phase of the 5Es instructional model to another was a major challenge besides inadequate activities due to time constraints. Data obtained from the observations made during implementation of the 5Es model in ICT integrated lessons for both respondents had similar findings. As per the observation schedule, time was moderately managed. To counteract this challenge, the teachers were necessitated to ensure that students observed punctuality while attending the ICT lessons besides being more proactive in guiding the learners as they transited across the 5Es.

Inadequate number of computers was also identified as an impediment towards execution of the 5Es instructional model in ICT integrated lessons. Notably, respondent E_2 complained of few numbers of computers that demanded learners in the sampled school to be paired when integrating 5Es model in ICT integrated lessons. Respondent E_1 on the other hand complained of some computers that are were old and were quite slow in responding to various commands during the process of teaching and learning. Inadequate number of computers made some learners remain dormant as their counterparts dominated in the browsing of the internet as they navigated through the 5Es. To overcome this challenge the teachers made deliberate efforts by engaging all learners. The major role of the teacher was to ensure that learners actively participated during the ICT lesson besides providing equal opportunities as they circumnavigated through the 5Es.

Commenting on the challenge faced related to internet connectivity respondent E_2 noted:

> "My most frustrating moments is when the internet goes down while navigating through the 5Es model. The experience is horrible as one can neither upload nor download content. You have to remain hopeful though the waiting is indefinite. Time is lost in the process and learners become unmanageable."

There was sufficient evidence that low internet connectivity especially when the net was down sometimes caused delays in downloading and uploading content when the ICT lesson was in progress. This gave rise to related issues such as poor time management besides poor class control. Similar sentiments were evident from respondent E_1. To counter this short coming precautionary measures were put in place prior the ICT lesson began. Teachers back up the ICT lesson by downloading teaching content before the beginning of the ICT lesson.

Maintaining class control was cited as a challenge when executing the 5Es instructional process in an ICT integrated lesson. Some learners could divagate away from the set learning activities and visit unrelated internet sites .This compounded with large number of students in a class posed unprecedented challenge in management of learners. However, for effective instructional process respondent E_1 and respondent E_2 had to remain vigilant and expedite the smooth flow of the lesson by deliberately moving around the class to see what learners were doing in their respective groups.

It was evident that a concrete and a well-defined school ICT policy was not well established in the sampled schools especially on funding and more precisely on acquiring the internet bundles. This occasioned the research to have a subsidiary budgeting as an intervention to purchasing internet bundles, an effort undertaken to seal the gap. Furthermore from interviews done on respondent E_1 and respondent E_2 who executed the 5Es instructional model in ICT integrated lessons, it was established that there was inadequate financial funding towards ICT department in schools.

4.7.1 Discussions of Findings on Challenges of Implementing 5Es Model in ICT Integrated lessons

Data obtained elucidates the presence of a number of challenges that we cited by interviewees as well as those registered from the observations made during the process of executing 5Es model in ICT integrated lessons in Murang’a County. The challenges resonate around five themes which include time constraints, inadequate number of computers low internet connectivity, poor class control and lack of a concrete and a well-defined school ICT policy

The prevailing scenario is similar to that of a study by Wilson (2012) in a study on “Trends and issues in instructional design and technology” that insinuated time as a key impediment in the smooth execution of the constructivist approach. Likewise in survey that was designed to investigate the challenges teachers face when implementing 5Es instructional model indicated that there were difficulties in time management (Enugu & Hokayem 2017). On inadequate numbers of computers, finding correlate with that of Richards, Birbal and Ramdass (2020) who observed that some learners remained dormant in the assigned discussion groups due to reduced hands on engagement. Moreover, unreliable internet access resulted to limited browsing of the websites. Other impediment to the smooth flow of the 5Es instructional process in an ICT integrated lesson included poor Class control .This assertion is supported by Lin, Wang, and Lin (2012). Additionally, the study findings on lack of concrete and a well-defined school ICT policy resonate well with findings from Lim (2007).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The main findings from this study are summarized in this chapter. Recommendations for different education stakeholders are also presented. Subsequently suggestions for further research are set forth.

5.2 Summary of the Study

This study intended to investigate the effect of 5Es instructional model in ICT integrated lessons on learner's achievement in teaching the topic "structure and bonding." This brought about comparing the outcome of the 5Es model in ICT integrated lessons and the conventional methods in ICT integrated lessons in teaching "structure and bonding" in Chemistry. In precision the following research objectives guided the study; (a) establish effect of 5Es model in ICT integrated lessons on learner's achievement in "structure and bonding"; (b) determine the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on ability; (c) establish the effect of use of 5Es model in ICT integrated lessons on learners' achievement based on attitude; (d) determine the gender difference on learners' achievement in "structure and bonding" for learners exposed to the 5Es model in ICT integrated lessons; (e) establish the challenges encountered in using the 5Es model in ICT integrated lessons

A quasi- experimental design of the Solomon four type was applied to show the impact of the instructional process used in ICT integrated lessons on students' conceptualization and consequently achievement in “structure and bonding”. A sample that involved 197 respondents took part in this study. The Data obtained was quantitatively and qualitatively analyzed. All descriptive statistics and inferential statistics comprising t-test and ANOVA was used to show the relationship between the identified parameters which were used in the derivation to the new body of knowledge.

Expedient information is provided by the study on 5Es instructional model in ICT integrated lessons on learners’ achievement in “structure and bonding” in teaching Chemistry. This will help in demystifying the opacity in the topic under study and subsequently bring about improvement on learners’ academic achievement.

5.3 Summary of Main Findings and Implications

5.3.1 Learners’ Level of Chemistry Achievement before Treatment

On the pre-test SCAT scores, descriptive statistics presented a situation that revealed that both groups, the one exposed to the 5Es model in ICT based lesson (E_1) and the other group exposed to conventional methods (C_1)) acquired similar mean score before the intervention. The mean score of learners that were instructed through the 5Es model in ICT based lessons was comparable to that of the learners instructed through conventional methods. C_1 achieved slightly better compared to E_1.

An analysis using the t-test on pre-test score revealed no statistically significant difference between C_1 and E_1 before the treatment was administered. An independent sample t-test used to compare males and females achievement in the pre-test showed that the mean achievement of females was slightly higher than that of males, the mean difference though being insignificant, at the commencement of the study. On attitude the study found no significant difference between those students instructed through 5Es model in ICT integrated lessons and those exposed to conventional methods at the beginning of the study. The different categories of students relative to their attitude were fairly distributed across the four test groups of the study, a one way ANOVA analysis indicating an insignificant mean difference in the variation in the distribution. On ability an analysis of test results showed no significant mean difference. From the study findings it is evident that the two groups had similarities on achievement, gender, ability and attitude before exposing to 5Es instructional model in an ICT integrated lesson, hence homogeneous.

5.3.2 Effect of 5Es Instructional Model on Students' Achievement in Chemistry

Findings pointed at a significant difference between control and experimental groups. From the ANOVA results the observed mean difference is significant. Further the post-test SCAT mean scores for E_1 and E_2 were better when compared to C_1 and C_2. It was therefore evident that the learners who were instructed using the 5Es model in ICT integrated lessons, had a better achievement than the learners instructed through conventional methods. Hence, H_{O1} which stated that there is no significant difference on learners' achievement in "structure and bonding" for learners taught through the 5Es model in ICT integrated lessons vis-à-vis learners instructed through conventional methods was rejected.

5.3.3 5Es Instructional Model and Learners Achievement in Chemistry Based on Gender

Results findings show that female students posted a higher mean achievement in "structure and bonding" compared to male students. The differences were however insignificant. Within the groups, female students in E_1 posted a higher mean compared to males. Findings imply that use of 5Emodel in ICT integrated lessons in teaching Chemistry impacts students of different gender in a similar manner thus the insignificant effect across gender. Therefore, data obtained failed to reject $H0_4$ that stated that there existed no gender difference in achievement in "structure and bonding" for students taught through the 5Es instructional model in an ICT integrated lesson.

5.3.4 5Es Instructional Model and Learners Achievement in Chemistry Based on Ability.

Regarding learners ability and achievement in Chemistry when HA learners and LA learners were instructed through the 5Es instructional model in ICT integrated lessons findings showed that a significant difference in SCAT (post-test). The effect was however greater for low achiever. Results could be inferred to mean that use of 5Emodel in ICT integrated lessons has a greater effect on low ability compared to high ability students. The implications of this finding can be concluded to mean; influence of 5Es instructional process impacts more on LA than HA learners. Thus, H_{O2} that stated that there is no significant difference on learners' achievement in "structure and bonding" for learners' taught through the 5Es instructional model in ICT integrated lessons based on ability was rejected

5.3.5 5Es Instructional Model and Learners Achievement in Chemistry Based on Attitude.

Based on Univariate test results, there was insignificant difference for the learners with PA and NA after intervention. This could imply that 5Es model when used in ICT integrated lessons in teaching "structure and bonding" affects students with PA and NA similarly thus the insignificant effect on attitude. Ho_3 stated that there exists no significant difference in achievement in "structure and bonding" between learners' taught through the 5Es model in ICT integrated lessons and those taught through conventional methods based on attitude. As regards learner's attitude and achievement in Chemistry when learners were instructed through the 5Es model in ICT integrated lessons, ANOVA results shows that the observed mean difference was insignificant. Findings imply that whereas use of 5Es model in ICT integrated lessons seems to have a greater effect on the attitude of students with positive attitude towards Chemistry compared to those with negative attitude, the difference in the effect is insignificant. Therefore, data obtained failed to reject the subsidiary hypothesis.

5.3.6 Challenges of Integration 5Es instructional model in ICT Integrated Lessons in Teaching Chemistry

The study investigated on challenges encountered while integrating the 5Es instructional model in an ICT integrated lesson. Findings indicated time factor as a key impediment in the implementation of the 5Es instructional model. To counteract this challenge, the teachers were necessitated to ensure that students observed punctuality while attending the ICT lessons besides being more proactive in guiding the learners as they transited across the 5Es.

Inadequate number of computers was also identified as an impediment towards execution of the 5Es model. Notably, learners in the sampled schools had to study in groups of two learners per computer. This made some learners remain dormant as their counterparts dominated in the browsing of the internet as they navigated through the 5Es. To overcome this challenge the teachers made deliberate efforts by engaging all learners.

Occasional low internet connectivity especially when the net was down sometimes caused delays in downloading and uploading content when the ICT lesson was in progress. To counter this short coming precautionary measures were put in place prior the ICT lesson began. Teachers back up the ICT lesson by downloading teaching content before the beginning of the ICT lesson.

Maintaining class control was cited as a challenge when executing the 5Es instructional process in an ICT integrated lesson. The teacher was to remain vigilant and expedite the smooth flow of the lesson besides moving around the class to see what learners were doing in their respective groups.

A concrete and a well-defined school ICT policy was not well established in the sampled schools especially on funding and more precisely on acquiring the internet bundles. This occasioned the research to have a subsidiary budgeting. Furthermore from interviews done on the teachers executing the 5Es instructional process, it was established that there was inadequate financing towards ICT department in the schools.

5.3.7 Hypotheses Testing Summary.

Table 5.1: Hypotheses Testing Summary

Hypotheses	**Decision**
H_{O1}: There is no significant difference in achievement in “structure and bonding” between learners using 5Es model in ICT integrated lessons and those using conventional methods	Rejected
H_{O2}: There is no significant difference in achievement in “structure and bonding” between learners guided by 5Es model in ICT integrated lesson and those using conventional methods based on ability	Rejected
H_{O3}: There is no significant difference in achievement in “structure and bonding” between learners guided by 5Es model in ICT integrated lessons and those using conventional methods based on attitude	Accepted
H_{O4}: There is no gender difference in achievement in “structure and bonding” for learners guided by 5Es	Accepted

model in ICT integrated lessons and those using conventional methods	

5.4 Conclusion

The conclusions drawn from this study are presented in relation to the objectives as follows:

i. For the objective investigating on learners' achievement, the study concludes that use of 5Es instructional model in ICT integrated lessons leads to a better conceptualization of concepts. The 5Es instructional model employed in ICT integrated lessons is thus an essential approach needed for meaningful learning in Chemistry.

ii. On gender disparity, the study concludes that use of 5Es model in ICT integrated lessons in teaching Chemistry impacts students of different gender in a similar manner.

iii. For the objecting investigating on low ability and high ability learners, it was established that LA learners achieved better than HA learners when the two categories were taught using 5Es instructional model.

iv. Use of 5Es instructional model in ICT integrated lessons has insignificant effect on learners with either positive attitude or negative attitude towards Chemistry.

v. Time factor, inadequate number of computers, poor internet connectivity, poor class control and lack of concrete and a well-defined school ICT policy were among the challenges encountered while implementing the 5Es instructional model in ICT integrated lessons.

5.5 Recommendations

As guided by the findings and conclusions of this study, the following recommendations are thus put forward.

5.5.1 Recommendations for Implementation.

(a) A consolidation of the findings of this study guided the research in proposing technology based instructional model related to 5Es for enhancing learning in Chemistry suitable for developing countries like Kenya.This model is elucidated in levels that intertwine the variables guiding the research.

Level 1

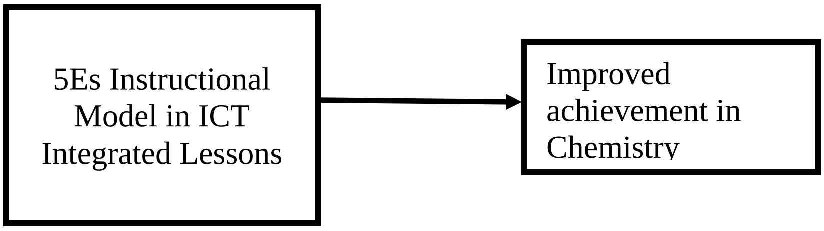


Figure 5.1: First Level for the Instructional Model in the Integration of the 5Es in ICT integrated lessons in the Teaching of Chemistry.

Figure 5.1 links 5Es instructional model in ICT integrated lessons to an improved achievement in Chemistry as depicted in the study findings. ICT integrated lessons that are instructed through the 5Es model could thus mitigate the low achievement in Chemistry and precisely on “structure and bonding” which have been a challenge to many secondary school students in Kenya. Therefore it is imperative that 5Es model blended with ICT be integrated in the teaching of Chemistry in secondary schools for an enhanced achievement.

Level 2

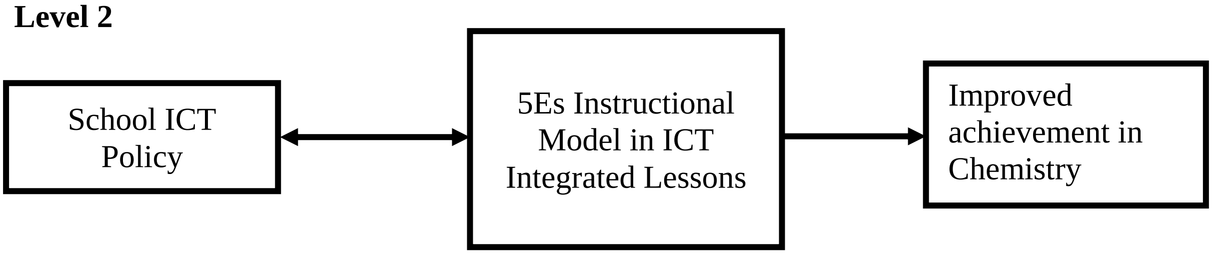
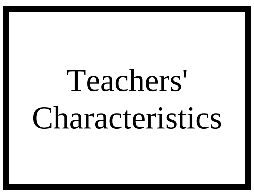


Figure 5.2: Second Level for the Instructional Process Model in the Integration of the 5Es in ICT integrated lessons in the Teaching of Chemistry.

Figure 5.2 depicts school ICT policy as a core component for the 5Es model in an ICT integrated lesson. Interview from the teachers implementing the 5Es instructional process in ICT integrated lessons established that a concrete and a well-defined school ICT policy was not well established in the sampled schools especially on funding and more precisely on acquiring the internet bundles. It is therefore ideal that every school have a robust ICT policy that is either funded by the government or by the school through the various stake holders. This will guarantee an efficient internet connectivity that will help in accessing the vast web tools.

Apparently, the literature reviewed points at concerted efforts by the Kenya government in formulating practicable policies that would promote integration of ICT in classroom. For instance Koech report principally focused on integration of ICT in classroom instruction. Likewise Computers for Schools Kenya (CFSK) supplied computers and establish internet connectivity in learning institutions (Randerson, 2011). Moreover, CEMASTEA equally supports ICT integration in Kenyan schools (Mariga, et al., 2017). Empirical data pointed at the National ICT Innovation and Integration Centre (NI_3C) as a body that zeroed in at developing effective hub that could propagate use of ICT in education (Kadzo, 2011). Therefore, school ICT policy is a key factor that may leads to improved achievement in Chemistry when using 5Es model in ICT integrated lessons.

Level 3



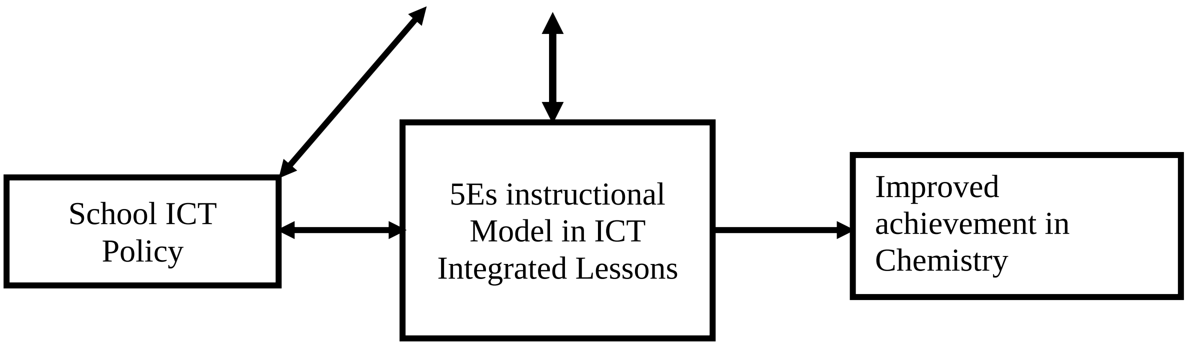


Figure 5.3: Third Level for the Instructional Process Model in the Integration of the 5Es in ICT integrated lessons in the Teaching of Chemistry.

Figure 5.3 shows the connections and association between schools ICT policy, teachers' characteristics and the use of the 5Es instructional model in ICT integrated lessons in relation to learner achievement. This study had embarked on a through training on teacher implementing 5Es model in ICT integrated lessons (Appendix VIII). The developed instructional model postulated that teacher training has a significant effect on learners' achievement. The research further interviewed teachers to gage their attitude towards implementing the 5Es model in ICT integrated lessons. The teachers who used 5Es model in ICT integrated lessons ascertained that 5Es model made teaching more systematic, more efficient, more creative and made student assessment easier.

Use of 5Es model in ICT integrated lessons gave a global orientation to students besides an enhanced level of conceptualization. It may be conclude that the rigorous training received on 5Es model in ICT integrated lessons positively shaped the attitude of teachers implementing it. Therefore, the developed model opines that teachers should obtain the needed training on 5Es model in ICT integrated lessons. This will be a crucial undertaking in backing the school ICT policy for more meaningful learning. The ministry of education in collaboration with school management ought therefore to offer support needed in giving induction courses to Chemistry teachers for a full integration of 5Es instructional model in an ICT integrated lesson. Again, teacher training institutions which includes Kenyan universities and colleges should as well train teacher trainees on use of 5Es instructional model in an ICT integrated lesson.

Level 4

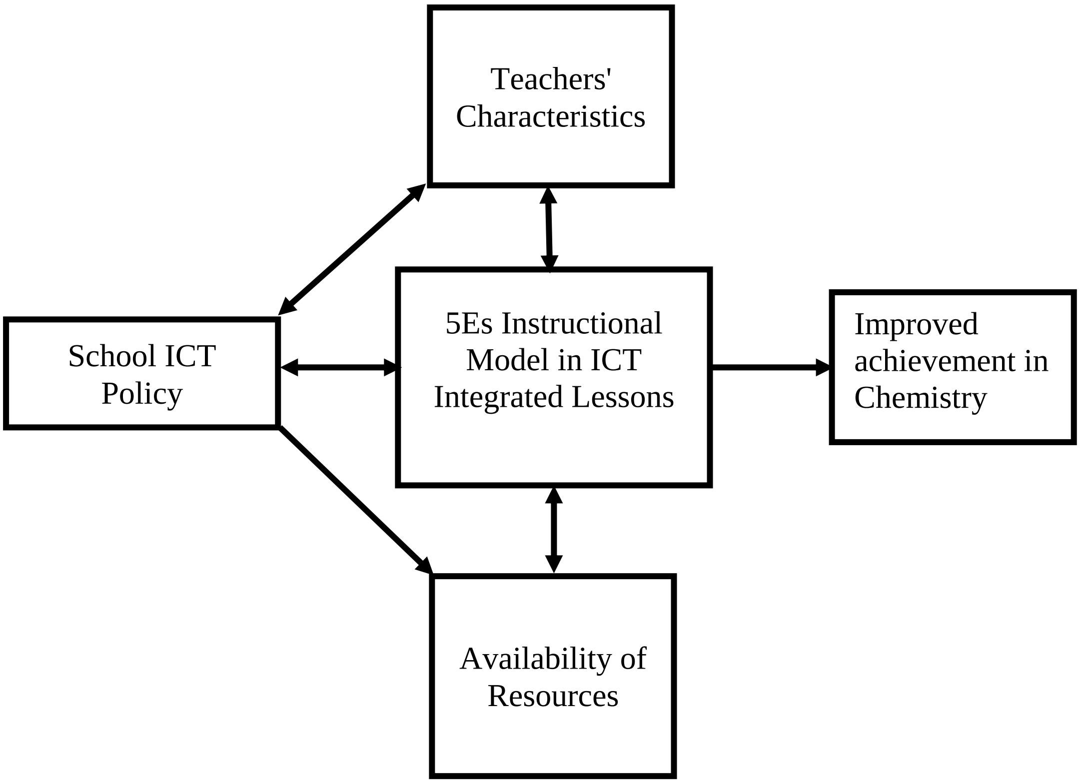


Figure 5.4: Fourth Level for the Instructional Process Model in the Integration of the 5Es in ICT integrated lessons in the Teaching of Chemistry.

Figure 5.4 marshals in the idea of ICT resources in pedagogy. The study narrowed down to schools that had well equipped computer labs which enabled learners access web 2.0 tools with ease as they navigated through the 5Es model. For instance, among other ICT tools, tablet computers are emerging as reliable learning tools due to their portability and flexibility in use. Therefore if availed to learners in high schools through government contribution and other non-governmental organizations they would probably guarantee effective integration of the 5Es instructional model in an ICT integrated lesson

Final level

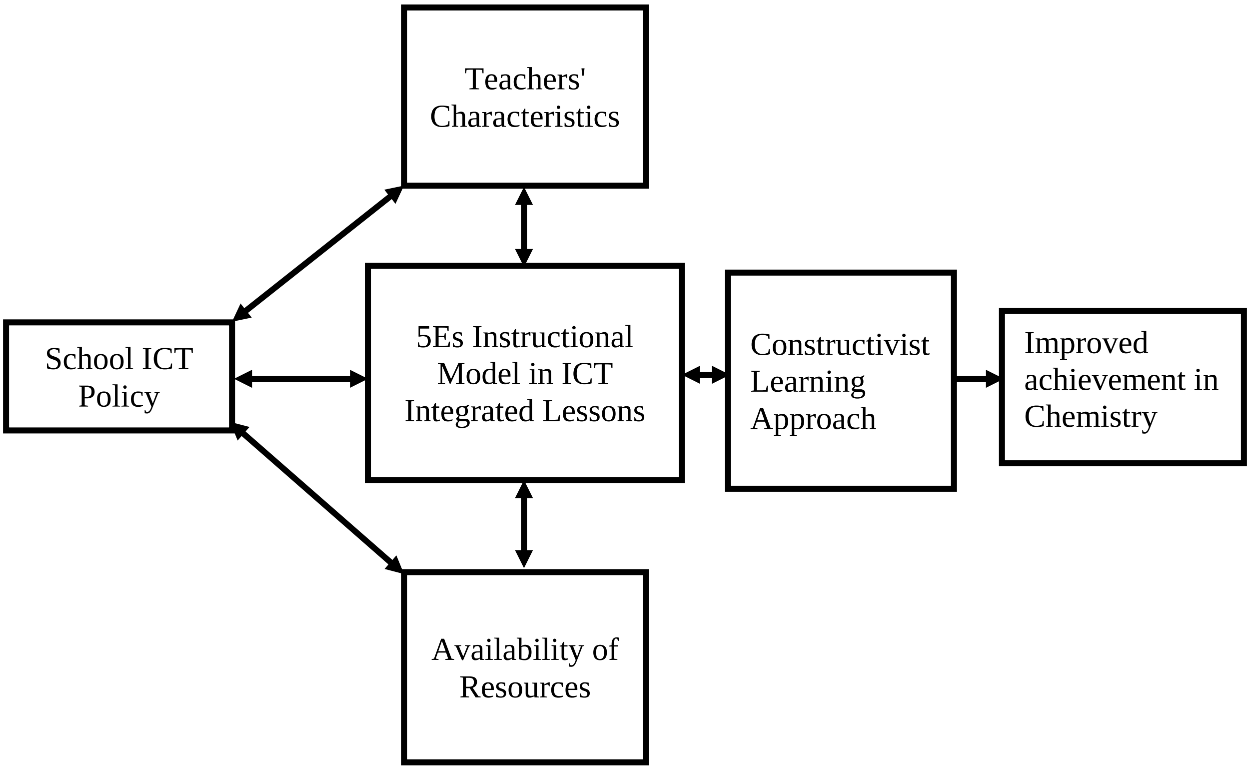


Figure 5.5: The final Level for the Instructional Process Model in the Integration of the 5Es in ICT integrated lessons in the Teaching of Chemistry.

Figure 5.5 acknowledges the Constructivist theory as a key contributor to an improved achievement in Chemistry. Constructivist learning is defined by four core values namely: active learning; social collaboration; knowledge creation; and situated learning (McKinley, 2015). The 5Es model in ICT integrated lessons embraces the four core values as postulated in the constructivist theory. This is realised through the 5Es model which includes steps of engagement, exploration, explaining, elaborating, and evaluating. Consequently, active class participation is realised. The aspect of collaboration amongst learners is evident as they explore, explain and elaborate on the concepts being taught. In a nutshell the learner is actively involved in the knowledge creation. It is therefore important that constructivist learning approach be employed when using the 5Es instructional model in ICT integrated lessons

In conclusion, the five key components of the developed model which includes school ICT policy, teachers' characteristics, availability of ICT resources and the constructivist teaching approach when well interlinked with 5Es model in ICT integrated lessons would perhaps give an enhanced means of content delivery in the modern classroom. Consequently, an improved achievement in Chemistry would be realized. This model is recommended to be adapted by all educational stake holders to improve achievement of "structure and bonding" and Chemistry as a subject.

(b) Based on the findings emanating from the first study objective, teachers teaching Chemistry should be encouraged to use 5Es instructional model in ICT integrated lessons so as to improve achievement in Chemistry at secondary school level. This undertaking would amount to a mitigating factor in counteracting low achievement in Chemistry which have been a challenge to many secondary school students in Kenya.

(c) Evidence based on the second objective guided the study in recommending use 5Es instructional model in ICT integrated lessons on LA learners. This cohort of learners significantly improved on achievement compared to HA learners.

(d) Findings from the third study objective imply that use of 5Es model in ICT integrated lessons in teaching Chemistry impacts students of different gender in a similar manner. This revealed its supremacy as a process of instruction. Therefore, the study recommended that teachers should to be encouraged to integrate 5Es model in ICT lessons.

(e) Teachers teaching chemistry should be encouraged use of 5Es model in ICT lessons since learner's attitude and achievement has insignificant difference.

(f) To overcome the encountered challenges and towards a smooth expedite of the 5Es model in ICT integrated lessons, the board of management (BOM) in conjunction with the school administrators should provide mitigating ventures. This can be achieved through providing secured rooms where ICT resources such as computer tablets are in safe custody. They can as well ensure there is no power failure when ICT integrated lesson is in progress by providing a back-up generator. Furthermore, an elaborate school ICT policy should be put in place to provide solutions to any emergent ICT related issues in schools.

5.5.2 Recommendations for policy.

(a) 5Es instructional model in ICT integrated lessons should be given more prominence particularly by KICD who are curriculum developers in Kenya. 5Es instructional model in ICT integrated lessons should thus be entrenched in the secondary school Chemistry curriculum as a coherent instructional process that can be used in the teaching of Chemistry.

(b) ICT resources such as computer tablets should be availed to learners in high schools through government support and other non-governmental organizations. This will enable Chemistry teachers in effectively applying the 5Es instructional model in an ICT integrated lesson.

(c) Teacher training institutions through MoE including Kenyan universities and colleges should train teacher trainees on use of 5Es model in ICT integrated lessons particularly on how to expeditiously use the 5Es model while using modern technological tools in pedagogy. The skills and expertise needed should be assessed through an examination and practically evaluated when the teacher trainees undertake the teaching practice.

5.5.3 Suggestions for Further Research

(a) The location of this study was in Murang'a County while the subject on focus was Chemistry. Studies in other subjects or location to establish the effect of the 5Es instructional model in ICT integrated lessons on student's achievement are thus suggested

(b) A study of the impact of teachers' socio-cultural factors on learners achievement when using the 5Es instructional model in ICT integrated lessons is also recommended

(c) A study investigating effects of the 5Es instructional model when using web 3.0 platform on students' achievement in Chemistry is recommended.

(d) A study on the impact of the use of 5Es instructional model in ICT integrated lessons on other STEM subjects will be useful for comparison

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APPENDICES

Appendix I: Students' Questionnaire (SQ)

Introduction

Below are statements meant to collect information related to learning of Chemistry. Give your view against each of them. Kindly feel appreciated for your participation.

Your Serial Number……………

Part A: Sex Details

1. Sex Details (Put a Tick) **Female [ ] Male [ ]**

Part B.

KEY: **SD-Strongly Disagree**

D-Disagree

NS –Not Sure

A-Agree

SA-Strongly Agree

Kindly answer back by indicating the most fitting.

2. For every case select one choice.

Statement	SD	D	NS	A	SA
Learning “Chemistry” is fun.					
To solve daily life problems Chemistry is necessary					
I hate Chemistry”					
After finishing school, I will work and make discoveries for Chemistry.					
I’m not good at “Chemistry”.					
After finishing school, I would not want to work in a laboratory					
One of the most interesting lessons is Chemistry.					
Am bored by Chemistry lessons					
Earning money while working in in a laboratory may be interesting					
Chemistry is easy for me to learn.					
I’m looking forward to an ICT integrated “Chemistry lessons”					
It is boring to make career about Chemistry.					
There is no fun in using ICT tools in learning					
I don’t understand Chemistry even though I work hard,					
After high school, I want to become an ICT expert.					
Knowledge in Chemistry is key in finding a good job.					

Use of internet doesn’t makes Chemistry easy					
I don’t like Chemistry projects.					
I find the topic on “the periodic table” difficult					
I don’t like how teachers teach Chemistry					

Give any other comment which in your own opinion you believe is important to this study

Appendix II: Chemistry Teachers Interview Schedule [CTIS]

The core function of this interview is to establish the encountered experiences in the use of 5Es model in ICT integrated lessons on the topic “structure and bonding”. High level of confidentiality will be used in treating the information given .Further, the information given will be used for the purposes of this study only. Your collaboration is highly treasured.

1. Teacher`s view and experiences about the 5Es model in teaching ICT integrated lessons.

Key

Not at all (1), A little (2), Fairly adequately (3), Adequately (4), A great deal (5)

Statement	1	2	3	4	5
Ease of use					
Systematic teaching process					
Creativity					
Teacher and learner involvement					
Time management					
Administrative support					
Global orientation to students					

2. Briefly highlight on the experiences (positive or negative) in implementing 5Es model in technology based learning?

3. In your opinion, what do you think should be done to ensure effective integration of the 5Es instructional model in technology based learning?

You are thanked for finding time to react to these experiences.

Appendix III: Observation Schedule

Group ________________ Date ___________________ Time _______________

Research Issue	Observation	Comments
Time management	Adequately managed ( ) Moderately managed ( ) poorly managed( )	
Availability of resources	Highly adequate ( ) fairly adequate ( ) Inadequate( )	
Teacher's competence in implementing the 5Es instructional model	Highly competent ( ) Fairly competent ( ) Not competent ( )	
Level of learner involvement	Highly involved ( ) Moderately involved ( ) Lowly involved ( )	
Teacher's class control competency	Highly competent ( ) Fairly competent ( ) Not competent ( )	

Behaviour and motivation of students towards learning tasks	Enthusiastic ( ) Good attitude and response towards learning tasks ( ) Do not enjoy learning tasks and their behaviour is inappropriate ( )	

Appendix IV: Students' Chemistry Achievement Test [Pre –test SCAT]

Sex Details: (Put a Tick) **Female [ ] Male [ ]**

1. a) (i) What is a fume chamber? (1mk)

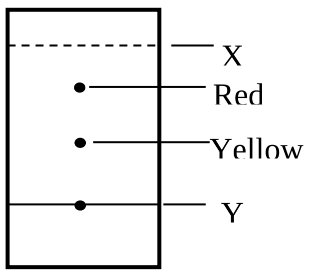
(ii) State 2 uses of fume chamber in a school laboratory (2mks)

b) Apparatus made of plastic have merits and demerits in carrying out laboratory experiments. Identify **two merits** and one **demerit** on using these apparatus.

i) Merits (2 marks)

ii) Demerits (1mk

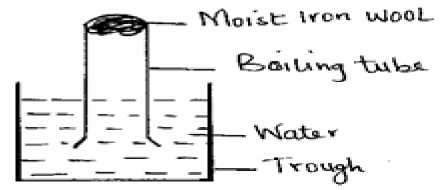
2. The following diagram is a chromatogram that displays the constituents of a flower extract.



(a) What does the line labelled X represent? (1mk)

(b) Give two reason to explain the different positions of red and yellow pigments. (2mks)

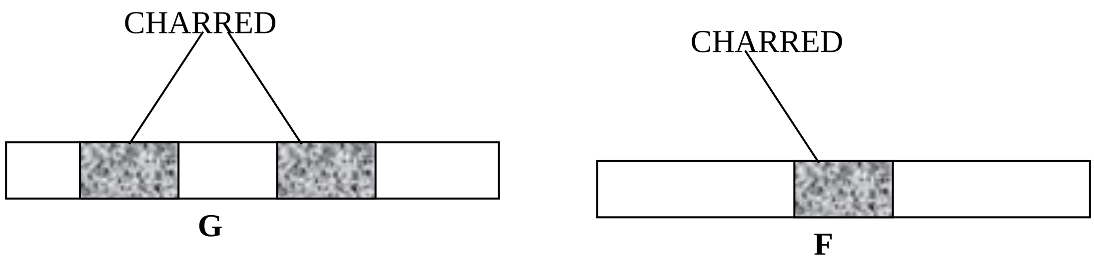
3. Some iron wool was made wet and then put in a test tube that was placed upside down over water as shown in the diagram below.



(a) After four days what do you think was observed on the iron wool? (1 mark)

(b) Expound on the made observations in (a) above. (1 mark)

4. Study the wooden splints labled **G** and and **F** below that were burnt at different parts of a flame from a Bunsen Burner.



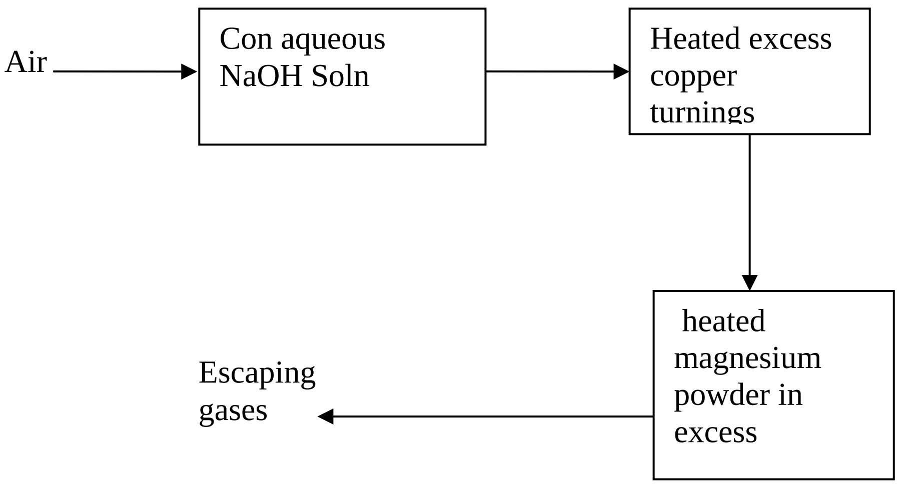
(a) Identify the flame used (1mks)

(b) Give any two characteristics of the flame used above (2mks)

(c) Which flames is best used for lighting? Give a reason. (2mks)

(d) Explain the difference between **F** and **G** (1mks)

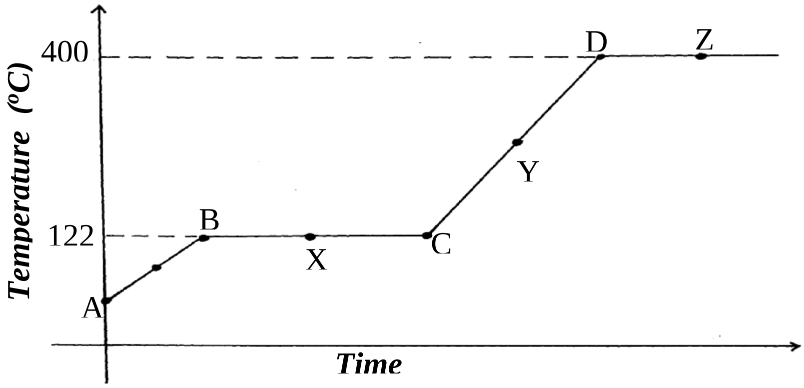
5. Study the flow chart below.



(a) Identify any "escaping gases". (1mark)

(b) Provide a cause as to why the gases escaped as identified in (a) above (1marks)
(c) Write a well-balanced chemical equation showing the chemical reaction that took place in the chamber with Magnesium powder (1mark)

6 The heating curve of a pure substance can be presented as follows.



(a) Addition of sodium chloride to this pure substance would have an effect on the boiling point .Highlight on the effect. (1mks)

(b) Identify the physical changes at ,

i) X (1/2mks)

ii) Z (1/2mks)

7. Q, R and P are elements in the same group.

Element	**Atomic size (nm)**
Q	0.23
R	0.15
P	0.19

Identify the element among the three with the highest ionization energy? Explain (2marks)

8.a) State whether the following are compounds, elements or mixtures. (1 marks)
i) Air
ii) Rust
b). Name one compounds found in air. (1mark)

9. Element N has two isotopes $N_1$and N_2. Their relative atomic masses and their corresponding abundance in percentage is represented in the table below

	Relative atomic mass	**% abundance**
N_1	62.00	69.00
N_2	64.00	30.00

What is the relative atomic mass of **N** **(2mks)**

10 (a) potassium metal reacts explosively with water .As a result it ignites on the water surface.

(i) Explain the cause of the ignition? (1 mark)

(ii) Using a chemical equation illustrate how this ignition happens(1 mark)

(b) Explain why Aluminium oxide cannot be reduced by hydrogen gas while Copper (II) Oxide is reduced .(1 mark)

11. Study the table below.

Solutions	**PH VALUES**
M	1.2
N	7.0
P	13.0

(a) Identify a pair of the solutions that when reacted would give a neutral solution (1 mark)

(b) **Two** of the solutions can react with aluminium hydroxide. Identify them and give an explanation as to why they react with this compound. (2marks)

(c) Fresh extracts from flowers serves as Acid-base indicators though with some limitations. Highlight **one** of these limitations. (1mark)

12. Use the given information and answer the questions that follow.

Element	Electron Arrangement	BP (^oC)
A	2.7	-178
B	2.8.7	-36
C	2.8.8.7	69

(a) Give the general name of elements **A,** B and **C**. (1mark)

(b) **Two** of the elements are coloured gases. Identify one (1 mark)

(c) With help of a chemical equation, show how element **B** reacts with iron metal (1mark)

(d) Identify the element with the highest boiling point. Explain (2marks)

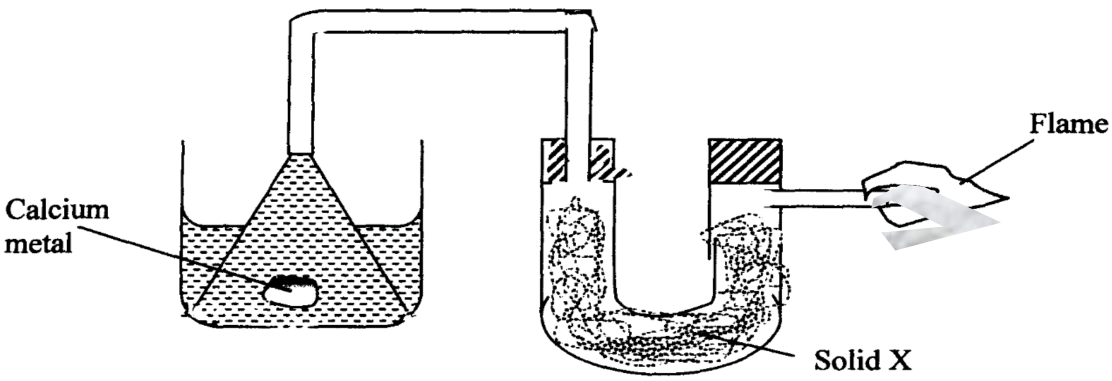
(e) A blue litmus paper was placed in a solution formed after dissolving B in water. What was the observation made in that experiment? Explain (2marks)

13. Below is a periodic table of elements. Use it to answer the questions that follows.

	K					U		
X	Y							

(a) (i) element **D** has an ionic arrangement 2.8 it forms an ion represented as $\mathbf{D}^{-1}$.
On the grid above, show the position of **D.** **(1 mark)**
(ii) Name the chemical family which D belong (1 mark)
(iii) Give one use of element **U** **(1 mark)**
(b) If **K** is reacted with **U,** identify the nature of the resultant compound (1 mark)
(c) Compare the atomic radius of elements **X** and **Y** (1 mark)

14. Study the setup below.



(a) Name solid **X** (1 mark)

(b) Explain how X is adapted to its use (1 marks)

(c) At one end a flame is observed. Write a chemical equation taking place as the flame burns. **(1 mark)**

Appendix V: Marking Scheme [Pre –test SCAT]

1. a) (i) What is a fume chamber? (1mk)
- ***A ventilated enclosure in a Chemistry laboratory.***

(ii) State 2 uses of fume schamber in a school laboratory (2mks**)**
- ***Keeping harmful chemicals***
- ***Preparing volatile chemicals***

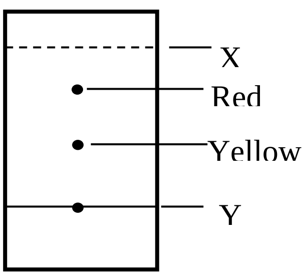
b) Apparatus made of plastic have merits and demerits in carrying out laboratory experiments. Identify **two merits** and one **demerit** on using these apparatus.

i) Merits
- ***Minimizes heat loss***
- ***Don't break easily*** (2 marks)

ii) Demerits

- ***can't be used to heat substances*** ***(1mk)***

2. The following diagram is a chromatogram that displays the constituents of a flower extract.



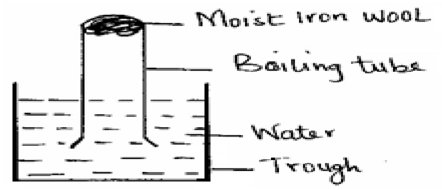
(a) What does the line labelled X represent?

- ***Solvent front*** (1mk)

(b) Give two reason to explain the different positions of red and yellow pigments. (2mks)

- ***The red pigment is more soluble in Y than the yellow pigment***
- ***Density***
- ***Stickiness (any two)***

3.. Some iron wool was made wet and then put in a test tube that was placed upside down over water as shown in the diagram below.



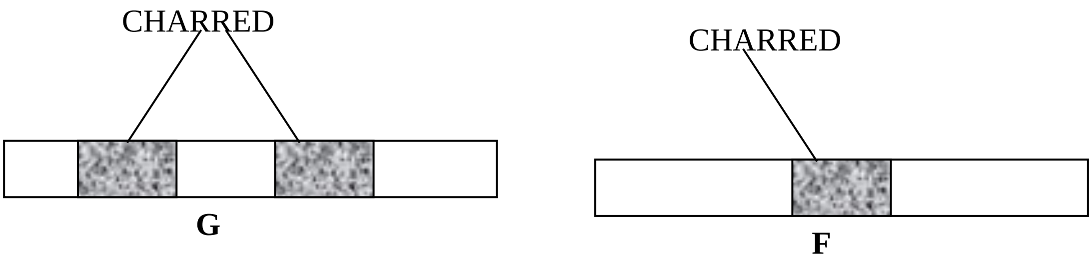
(a) After four days what do you think was observed on the iron wool? (1 mark)

- ***There was a noticeable colour change from grey to brown***

(b) Expound on the made observations in (a) above. (1 mark)

Iron wool had rusted and formed hydrated iron (iii) oxide which is brown in colour

4. Study the wooden splints labelled G and **F** below that were burnt at different parts of a flame from a Bunsen Burner.



(a) Identify the flame used (1mks)

Non-luminous flame

(b) Give any two characteristics of the flame used above (2mks)

- ***Has three zones***
- ***Its blue in colour***

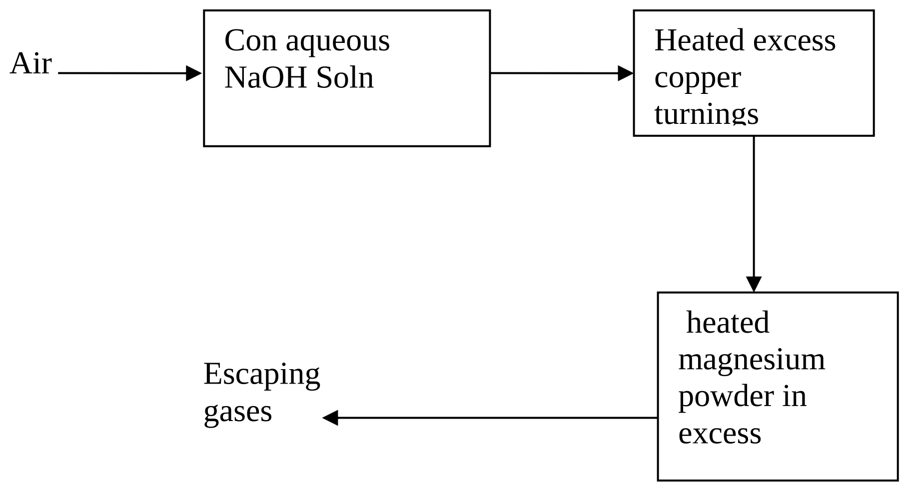
(c) Which flames is best used for lighting? Give a reason. (2mks)

- ***Luminous flame. It burns in a yellow flame thus producing light***

(d) Explain the difference between **F** and **G** (1mks)

- ***Wooden splint G was placed in a zone that contained unburnt gas while F was placed where the gas was completely burnt***

5. Study the flow chart below.



(a) Identify any “escaping gases”. (1mark)

- ***argon***

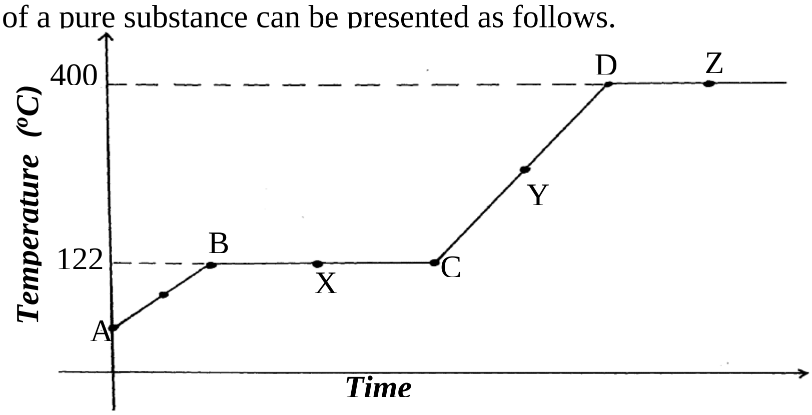
(b) Provide a cause as to why the gases escaped as identified in (a) above (1marks)

- ***It is inert***

(c) Write a well-balanced chemical equation showing the chemical reaction that took place in the chamber with Magnesium powder (1mark)

- ***$3\ M_g + N_{2\,g} \longrightarrow M_{g\,3}N_{2\,g}$***

6 The heating curve of a pure substance can be presented as follows.



(a) Addition of sodium chloride to this pure substance would have an effect on the boiling point .Highlight on the effect. (1mks)

- ***The melting point would be lower than 122 °C. Impurities lowers the boiling point of a pure substance***

(b) Identify the physical changes at ,

i) **X -represents the melting** (1/2mks)

ii) **Z- represents the boiling** (1/2mks)

7. Q, R and P are elements in the same group.

Element	Atomic size (nm)
Q	0.23
R	0.15
P	0.19

Identify the element among the three with the highest ionization energy? Explain (2marks)

- ***the atomic size of element R is 0,15 hence the smallest. This when interpreted mean that as a result of a small atomic radius, electrons in the outer most energy level are strongly attracted towards the nucleus . The ionization energy will thus be the greatest***

8.a) State whether the following are compounds, elements or mixtures. (1 marks)

i) Air

- ***Mixture***

ii) Rust

- ***Compound***

b). Name one compounds found in air.

- CO_2
- H_2O (**any one**) (1mark)

9. Element N has two isotopes $N_1$and N_2. Their relative atomic masses and their corresponding abundance in percentage is represented in the table below

	Relative atomic mass	% abundance
N_1	62.00	69.00
N_2	64.00	30.00

What is the relative atomic mass of **N** **(2mks)**

$$+ \frac{(64.00 \times 30.00)}{100} + \frac{(62.00 \times 69.00)}{100}$$ (*award 1 mark*)

$$= \frac{1920 + 4278}{100}$$

$$= 61.98$$

$$\approx 62$$ (*award the last mark*)

10 (a) potassium metal reacts explosively with water .As a result it ignites on the water surface.

(i) Explain the cause of the ignition? (1 mark)

- ***a lot of heat is generated (exothermic reaction) which results to ignition of Hydrogen in presence of oxygen***

(ii) Using a chemical equation illustrate how this ignition happens (1 mark)

- $K_{(s)} + H_2O_{(g)} \longrightarrow KOH_{(aq)} + H_{2(g)}$
- $H_{2(g)} + O_{2(g)} \longrightarrow H_2O_{(g)}$

(b) Explain why Aluminium oxide cannot be reduced by hydrogen gas while Copper (II) Oxide is reduced. (1 mark)

- ***Aluminium is high and above hydrogen in the reactivity series of elements***

11. Study the table below.

Solutions	PH VALUES
M	1.2
N	7.0
P	13.0

(a) Identify a pair of the solutions that when reacted would give a neutral solution

- M and P (1mk)

(b) **Two** of the solutions can react with aluminium hydroxide. Identify them and give an explanation as to why they react with this compound. (2marks)

- M and P, because ***Aluminium hydroxide is amphoteric***

(c) Fresh extracts from flowers serves as Acid-base indicators though with some limitations. Highlight **one** of these limitations. (1mark)

- ***Give inconsistent results***
- ***Expire shortly (award any one correct)***

12. Use the given information and answer the questions that follow.

Element	Electron Arrangement	BP (^oC)
A	2.7	-178
B	2.8.7	-36
C	2.8.8.7	69

(a) Give the general name of elements **A,** B and **C**. (1mark)

- ***Halogens***

(b) **Two** of the elements are coloured gases at room temperature. Identify one (1 mark)

A or B

(c) With help of a well-balanced chemical equation, show how element **B** reacts with iron metal (1mark)

$3B_{(g)} + 2Fe_{(s)} \longrightarrow FeB_{3(s)}$

(d) Identify the element with the highest boiling point. Explain (2marks)

The element with the highest boiling point is B. The atom of B is the largest due to the four energy levels. The bigger the size of the atom the higher the intermolecular forces of attraction (van der Waals forces) between the molecules

(e) A blue litmus paper was placed in a solution formed after dissolving B in water. What was the observation made in that experiment? Explain

- ***The litmus paper that was blue in colour turned red .Thereafter, the red paper then turned white. Blue paper turned red as a result of the acidic solution formed. Further the paper turned white due to formation of hypochlorous acid which is unstable and looses oxygen atom thus acting as a bleaching agent***

(2marks)

13. Below is a periodic table of elements. Use it to answer the questions that follows.

	K					U		
X	Y							

(a) (i) element **D** has an ionic arrangement 2.8 it forms an ion represented as $\mathbf{D}^{-1}$.
On the grid above, show the position of **D.** **(1 mark)**

(ii) Name the chemical family which D belong (1 mark)

- ***Halogens***

(iii) Give one use of element **U** **(1 mark)**

A mixture of U and acetylene is used to produce a flame used in welding.(Or any other)

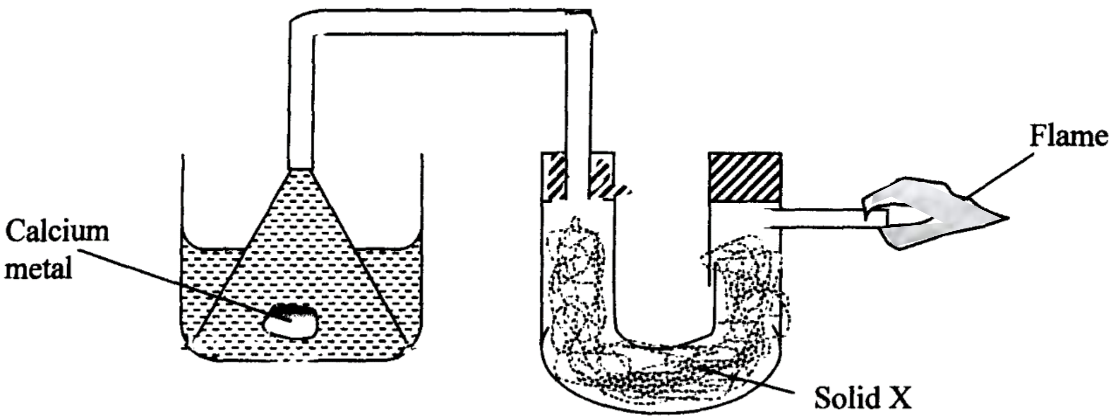
(b) If **K** is reacted with **U,** identify the nature of the resultant compound (1 mark)

- **An ionic compound that is basic in nature**

(c) Compare the atomic radius of elements **X** and **Y** (1 mark)

- ***X has a larger atomic radius when compared to that of Y.***

14. Study the setup below.



(a) Name solid **X** (1 mark)

- ***Anhydrous Calcium chloride***

(b) Explain how X is adapted to its use (1 marks)

Absorbs water thus a good drying agent

(c) At one end a flame is observed. Write a chemical equation taking place as the flame burns. **(1 mark)**

- $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$

Appendix VI: Students' Chemistry Achievement Test [Post –test SCAT]

Sex Details: (Put a Tick) **Female [ ] Male [ ]**

1. a) Make a distinction between the following types of bonds
   i) Co-ordinate bond and
   ii) Covalent a bond. (1marks)

   b) The bonding in the ion ammonium can be presented diagrammatically. Use the information provided below to demonstration the bonding.
   (N = 7, H = 1) (1 ½ marks)

2. a) Aluminium is regarded as a good conductor of both heat and electricity. Provide another reason that makes it suitable in the manufacturing of electric cables. (1marks)

   b) Both magnesium and aluminium metals conductor of electricity. Aluminium is however a better conductor. Explain this difference (1marks)

3. The Relative molecular masses of hexane and ethanol are 86 and 46 respectively. However ethanol boils at a higher temperature in comparison to Hexane. Explain. (1 ½ marks)

4. Explain in terms of structure and bonding, why Silicon (IV) Oxide has a melting point of 2440^{o}C while solid Carbon (IV) Oxide sublimes at -70^{o}C although both elements are in the same period. (1marks)

5. The atomic number of Element **X and Y is** 6 and 8 respectively.
   (a) What is the electronic configuration of:
   i)**X**
   ii) **Y.** (2mark

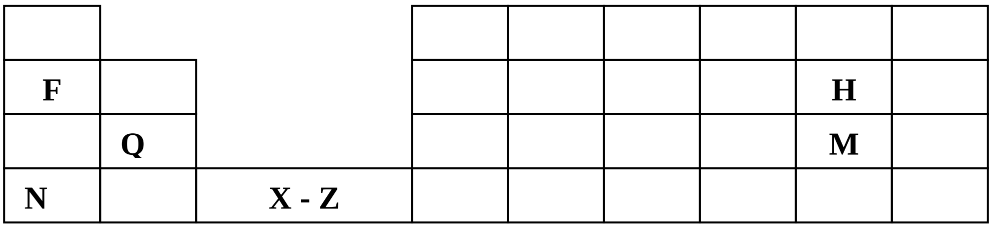
(b) Compound **XY** and **XY_2** have a structural difference. Explain this in terms of bonding (1 marks)

6. The information below is a tabulation of different substances.

Substance		**G**	**H**	**I**	**J**	**K**	**L**
MP (^oC)		801	113 119	39	5	-101	1356
Boiling point (^oC)		1410	445	457	54	-36	2860
Electrical Conductivity	Liquid state	Good	Poor	Good	Poor	Poor	Poor
	Solid state	Poor	Poor	Good	Poor	Poor	Poor

a)(i)Which letter represents a substance with a metallic structure. (½mk)
(ii) Explain (1mk)
(b)(i) One of the substances is molecular in structure as well as a liquid at rtp. Identify it (1mk)
(ii) Support your answer. (1mk)
(c) Substance **H** melts at 113 **^oC** and also at 119 **^oC.** Explain. (1mk)
(d) Explain the difference in the electrical conductivity of G and I in liquid state. (1mk)

7. Study the grid below.



(a) What does **X – Z represent.** (½ marks)
(b) Name the bond made when **H** and **F** combine (1marks)
(c) Show the position of element **J** on the grid given above if its atomic number is 15 (1marks)
(d) (i) Compare the radius of the atoms of element **Q** and **M** (1marks)
(ii) Compare the radius of the atoms of element **F** and **N.** (1 marks)
(iii)d(ii) explain above (1 marks)

(e) (i)From the grid above which non-metal will be the most reactive . (1 marks)
(ii) Explain (1 marks)

(f) With an explanation compare the rate of reactivity of **F** and **N** . (1 ½ marks)

8 . Study the table below.

Element	**Electronic Arrangement**	**I E($KJmol^{-1}$)**
A	2:1	520

B	2:8:1	483
C	2:8:8:1	406

(a) Define the term ionization energy. (1marks)

(b)The ionization energy of element C is 406 **($KJmol^{-1}$)** and thus the lowest.
Explain (1½marks)

9. The table below gives information about elements A_1, A_2, A_3 and A_4

Element	Atomic No	A. R (nm)	I. R (nm)
W	3	0.125	0.85
X	5	0.083	0.023
Y	13	0.134	0.049
Z	17	0.088	0.173

(a)Identify the group in which element **X** belong. (1 marks)

(b) Explain the following observations.
The atomic radius of X is smaller than that of W. (1marks)

(c). Identify another element from the table above that is in the same group as element **Y** (1marks)

10. (a) Diamond is the hardest naturally occurring Substance. Explain (1 marks)
(b) Oxygen gas and nitrogen gas do react at very high temperature. Explain (1 marks)
(c) Grahite is used as a lubricant. explain (1 marks)

11. Elements **W, X, Y**, and **Z** have atomic numbers **19, 9, 12** and **10** respectively.
(a) Identify from the list **an** elements that is a non-metal. (1 mark)

(b) What is the chemical formula of the product between **B** and **C** (1 mark)
(c) Name the bond if element **X** and **Y** are reacted (1 mark)
(d) (i)Which is the most reactive metallic element. (1 mark)
(ii) Explain (1 mark)
(e) Explain why element E is unreactive. (1 mark)
(f) Give one use of element E (1 mark)

12. Some of the elements found in period three forms oxides as shown in the table .

P_4O_6	Na_2O	Cl_2O	SO_2
Solid state at rtp	Solid state at rtp	Gaseous state at rtp	Gaseous state at rtp

(a) One of the oxides is basic in nature. Identify it. (1mark)

(b)(i) SO_2 is gaseous at rtp while Na_2O is a solid.
Explain (2 mark)

13. Some elements in period three react with chlorine as shown

Compound	$AlCl_3$	$MgCl_2$
Boiling point	180°C	1420°C

$MgCl_2$ boils at 1420°C whereas $AlCl_3$ boils at 180°C. Explain (1 mark)

14) Study the table below.

Element	Atomic Radius	Atomic no	Oxide	State at RT	melting point of oxide °C
A	0.181	11	A_2O	Solid	1200
B	0.159	12	BO	Solid	2749
C	0.129	13	………	Solid	2134
D	0.121	14	DO_2	……….	1599
E	0.113	15	………	Solid	573
F	0.105	16	FO_2	………	-73
G	0.088	17	GO_2	Gas	-59
H	0.091	18	Does not exist	Does not exist	Does not exist

(a) The table above is not complete. Fill the blank spaces (1 mark)

(b) There is some notable change in the atomic radius from element A to H. Explain (1 mark)

(c) The oxide of h is noted as a non-existence. Explain why it does not exist (1mk)

(d) The table below is incomplete. Fill the blank spaces with the right information. (1 mark)

Oxide	TYPE of the STRUCTURE	BOND FORMED
BO		
FO_2		

(e) **G** is a poor conductor of electricity whereas C is a good conductor of electricity. Explain this observation (1 mark)

(f) The oxide of **C** is a kind of oxide that reacts with both acids and alkalis. What type of oxide is represented by C (1mar)

Appendix VII: Marking Scheme [Post –test SCAT]

1. a) Make a distinction between the following types of bonds

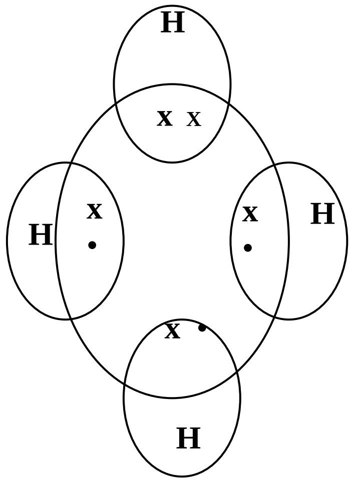
i) Co-ordinate bond

One of the atoms donate the shared pair of electrons.

ii) Covalent a bond.

Each atom contributes one atom to form a bond (1marks)

b) The bonding in the ion ammonium can be presented diagrammatically. Use the information provided below to demonstration the bonding. (N = 7, H = 1) (1 ½ marks)



2. a) Aluminium is regarded as a good conductor of both heat and electricity. Provide another reasons that makes it suitable in the manufacturing of electric cables. (1marks)

- ***It is resistant to corrosion.***
- ***It is light***

b) Both magnesium and aluminium metals conductor of electricity. Aluminium is however a better conductor. Explain this difference (1marks)

Aluminium has 3 delocalized electrons while Magnesium has 2

3. The Relative molecular masses of hexane and ethanol are 86 and 46 respectively. However ethanol boils at a higher temperature in comparison to Hexane. Explain. (1 ½ marks)

- ***Ethanol has both hydrogen and Vander Waals bonds which hold the molecules together. Thus to break these bonds more energy is needed***

4. Explain in terms of structure and bonding, why Silicon (IV) Oxide has a very high melting point of 2440°C while solid Carbon (IV) Oxide sublimes at -70°C although both elements are in the same period. (1marks)

- ***The structure in Silicon (IV) oxide is giant atomic .The covalent bonds holding the constitutional elements are very strong this results to a high BP. Carbon (IV) oxide on the other hand has a low melting point. The Van der Waals forces are relatively weak bonds that hold the molecules together.***

5. The atomic number of Element **X and Y is** 6 and 8 respectively.

(a) What is the electronic configuration of:

i) **X 2.4**

ii) Y. 2.6 (2mark

(b) Compound **XY** and **XY_2** have a structural difference. Explain this in terms of bonding (1 marks)

XY has a dative bond besides covalent bonds while XY_2 has covalent bonds only

6. The information below is a tabulation of different substances.

Substance		**G**	**H**	**I**	**J**	**K**	**L**
MP (°C)		801	113 119	39	5	-101	1356
Boiling point (°C)		1410	445	457	54	-36	2860
Electrical Conductivity	Liquid state	Good	Poor	Good	Poor	Poor	Poor
	Solid state	Poor	Poor	Good	Poor	Poor	Poor

a)(i)Which letter represents a substance with a metallic structure. (½mk)

I

(ii) Explain (1mk)

Compounds that comprises a metallic structure conducts electricity in both states .That is in solid as well as liquid state.

(b)(i) One of the substances is molecular in structure as well as a liquid at rtp.

Identify it ***Substance J.*** (1mk)

(ii) Support your answer. (1mk)

substance represented by letter J melts at 5 degrees and boils at 54 degrees. This implies that the temperature at which it boils is below rtp and at which it boils is above rtp

(c) Substance **H** melts at 113 **ºC** and also at 119 **ºC.** Explain. (1mk)

It exist in allotropic form.

(d) Explain the difference in the electrical conductivity of G and I in liquid state. (1mk)

G conducts electricity while at liquid state. Free and mobile ions thus conducts the current. Letter I is Compounds that comprises a metallic structure conducts electricity in both states. This means there are delocalised electrons.

7. Study the grid below.

F							**H**	
	Q				**J**		**M**	
N		**X - Z**						

(a) What does **X – Z represent.** (½ marks)

- ***Transitional metals***

(b) name the bond made when **H** and **F** combine

Ionic (1marks)

(c) Show the position of element **J** on the grid given above if its atomic number is 15.

See on the grid above

(1marks)

(d) (i) Compare the radius of the atoms of element **Q** and **M** (1marks)

Q is bigger in comparison to M

(ii) Compare the radius of the atoms of element **F** and **N.** (½ marks)

(iii)Explain d (ii) above

N is larger in comparison to N. Down group 1, energy level increases

(e) From the grid above which non-metal will be the most reactive . Explain

H-***It is the most electro negative*** (1 ½ marks)

(f) With an explanation compare the rate of reactivity of **F** and **N** . (1 ½ marks)

F less reactive than N. N has a more energy levels. The atomic radius is big. The attraction of the outer electrons by the protons in the nucleus is less.

8 . Study the table below.

Element	**Electronic Arrangement**	**I E(KJmol^{-1})**
A	2:1	520
B	2:8:1	483
C	2:8:8:1	406

(a) Define the term ionization energy. (1marks)

This is the minimum energy required to remove from the outer most energy level an electron of an atom in the gaseous state

(b)The ionization energy of element C is 406 **(KJmol^{-1})** and thus the lowest. Explain (1½marks)

It has four energy levels. The atomic radius is big. The attraction of the outer electrons by the protons in the nucleus is less.

9. The table below gives information about elements A_1, A_2, A_3 and A_4

Element	Atomic No	A. R (nm)	I. R (nm)
W	3	0.125	0.85
X	5	0.083	0.023
Y	13	0.134	0.049
Z	17	0.088	0.173

(a)Identify the period in which element **X** belong. (½ marks)

Two (2)

(b) Explain the following observations.

(i). the atomic radius of X is smaller than that of W. (1mark)

Across the period the overall effective nuclear charge builds. The pulling of the electron is gradually greater. The resultant radius decreases

(c). Identify another element from the table above that is in the same group as element **Y** (1marks)

X

10. (a) Diamond is the hardest naturally occurring Substance. Explain (1 marks)

The structure of diamond is built by strong bonds known as covalent bonds.

(b) Oxygen gas and nitrogen gas do react at very high temperature. Explain (1 marks)

Nitrogen –nitrogen atoms are joined by three covalent bonds(triple covalent bonds). To break these three covalent bonds , much higher energy is needed

(c) Grahite is used as a lubricant. explain (1 marks)

Each carbon is bonded to 3 others forming hexagonal layers .the bonding of the hexagonal layers is realised through "Vander waals forces". These intermolecular forces are weaker.

11. Elements **W, X, Y**, and **Z** have atomic numbers **19, 9, 12** and **10** respectively.

(a) Identify from the list **two** elements that are non-metals. (1 mark)

(b) What is the chemical formula of the product between **X** and **Z** (1 mark)

XZ

(c) Name the bond if element **X** and **Y** are reacted (1 mark)

Ionic

(d) Which is the most reactive metallic element. Explain (1½ mark)

- ***W-Has a big atomic radius thus readily loses electrons***

(e) Explain why element E is unreactive. (1 mark)

- ***Outer energy level has maximum number of electrons thus not easy to gain or loose electrons***

(f) Give one use of element E (½ mark)

- ***Street lights***

Vacuum tubes or any other

12. Some of the elements found in period three forms oxides as shown in the table .

P_4O_6	Na_2O	Cl_2O	SO_2
Solid state at rtp	Solid state at rtp	Gaseous state at rtp	Gaseous state at rtp

(a) One of the oxides is basic in nature. Identify it. (½mark)

Na_2O

(b) SO_2 is gaseous at rtp while Na_2O is a solid. Explain (1½ mark)

The difference in the state emanates from the structure formed by respective compounds. The structure in SO_2 and Na_2O is simple molecular and giant ionic respectively. Bonding in SO_2 is weaker while in Na_2O is extremely high.

13. Some elements in period three react with chlorine as shown

Compound	$AlCl_3$	$MgCl_2$
Boiling point	180°C	1420°C

$MgCl_2$ boils at 1420°C whereas $AlCl_3$ boils at 180°C. Explain (1 mark)

The huge difference in the BP originates from the structure formed by respective compounds. $AlCl_3$ forms a dimer with the molecules bonded by "van der waals forces". $MgCl_2$ on the other hand exhibits a giant ionic structure with "strong" ionic bonds.

14) Study the table below.

Element	**Atomic Radius**	**Atomic no**	**Oxide**	**State at RT**	**melting point of oxide °C**
A	0.181	11	A_2O	Solid	1200
B	0.159	12	BO	Solid	2749
C	0.129	13	…**C_2O_3**……	Solid	2134
D	0.121	14	DO_2	……….	1599
E	0.113	15	**…E_2O_5……**	Solid	573
F	0.105	16	FO_2	………	-73
G	0.088	17	GO_2	Gas	-59
H	0.091	18	Does not exist	Does not exist	Does not exist

(a) The table above is not complete. Fill the blank spaces (2 mark)

(b) There is some notable change in the atomic radius from element A to H. Explain (2 mark)

The notable change is that there is an increase from H to A. going across the period the radius gradually becomes smaller. Reason-there is gradual build-up of electrons across the period. The pulling of the electrons increases consecutively

(c) The oxide of h is noted as a non-existence. Explain why it does not exist (1mk)

This is based on the stability of the atom that reacts not with oxygen.

(d) The table below is incomplete. Fill the blank spaces with the right information.

(2 mark

Oxide	TYPE of the STRUCTURE	BOND FORMED
BO	***IONIC***	***IONIC***
FO_2	***SIMPLE MOLECULAR***	***COVALENT***

(e) **G** is a poor conductor of electricity whereas C is a good conductor of electricity. Explain this observation (1 mark)

- ***C has a structure known as metallic (has delocalised electrons).G is a non- metal and molecular "molecules are electrically neutral"***

(f) The oxide of **C** is a kind of oxide that reacts with both acids and alkalis. What type of oxide is represented by C (½mar)

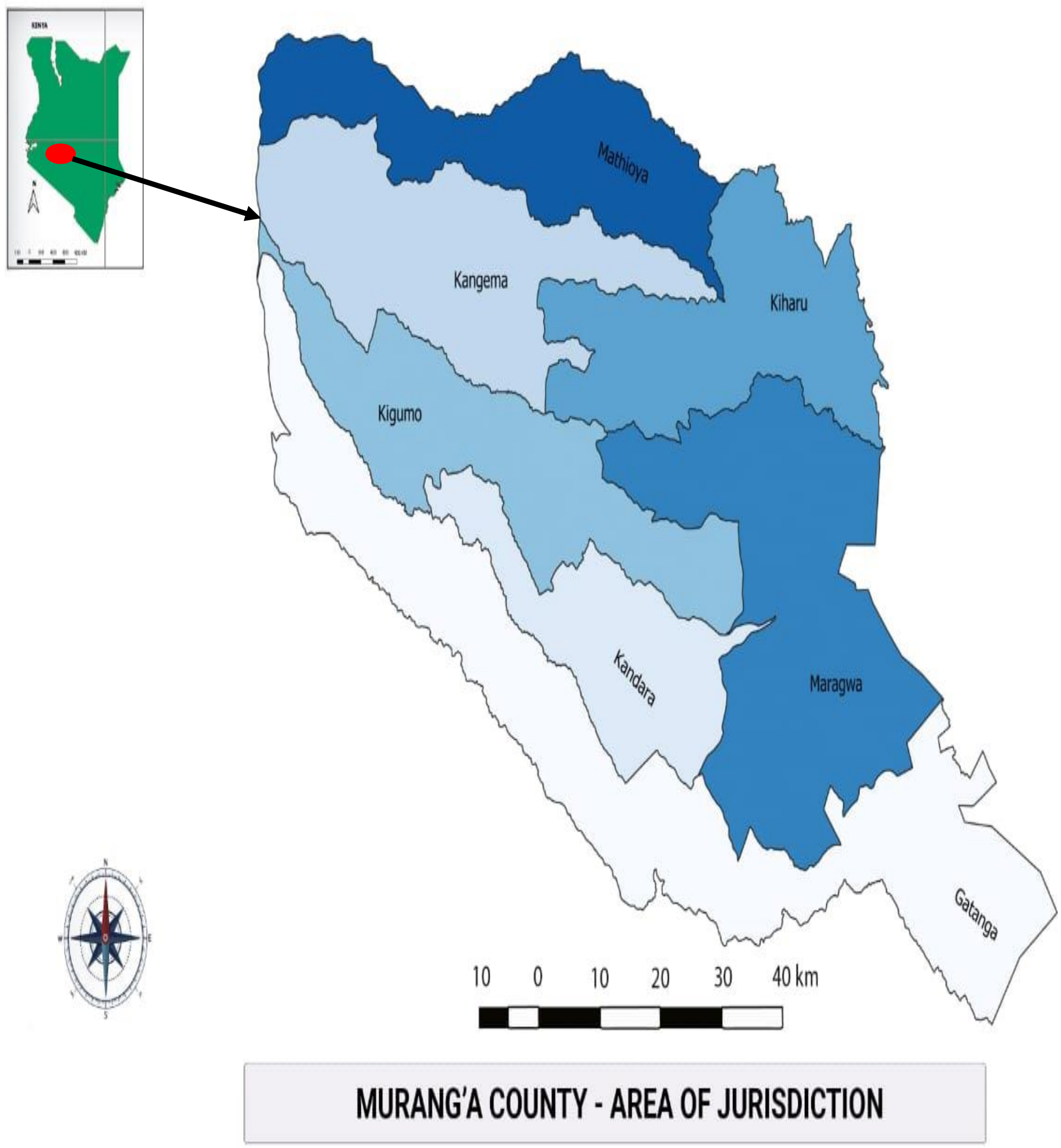
AMPHOTERIC

Appendix VIII: Training Programme for the Teachers Undertaking the 5Es Instructional Model

Week	Day	Duration	Topic	Content to be covered	Comments
1	1	1 hour	The 5Es model	• The origin of the model and its significance in education • The five steps of 5Es instructional model	
	2	1hour	Blending the 5Es model with ICT enhanced lessons	How the 5Es model is integrated in teaching in ICT integrated lessons	
	3	2 hour	Integrating the 5Es model in ICT enhanced lessons	How the 5Es instructional model is integrated in "teaching structure and bonding" in ICT integrated lessons	
2	1	1 hour	5Es guided ICT lesson plans	Actual lesson planning of a lesson to be taught using the 5Es model in ICT integrated lesson on "structure and bonding"	
	2	1 hour	Peer teaching	Actual presentation of a prepared lesson plan on	

				"structure and bonding" using the 5Es model in anICT integrated lesson.	

Appendix IX: A Map of Murang'a County



Source: https://muranga.go.ke/wp-content/uploads/2022/09/map.

Appendix X: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 510987

Date of Issue: 15/December/2020

RESEARCH LICENSE

This is to Certify that Mr.. Sammy Nduati Charagu of Kenyatta University, has been licensed to conduct research in Muranga on the topic: THE 5Es GUIDED INSTRUCTIONAL PROCESS AND ITS EFFECT ON STUDENTS PERFORMANCE IN CHEMISTRY AMONG SECONDARY SCHOOLS IN MURANG'A COUNTY, KENYA for the period ending : 15/December/2021.

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Applicant Identification Number

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Appendix XI: Research Authorization

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GRADUATE SCHOOL

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NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: E83/32325/15

Date: 30th November, 2020

The Director General,
National Commission for Science, Technology & Innovation,
P.O. Box 30623-00100,
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR CHARAGU S. NDUATI-REG. NO. E83/32325/15

I write to introduce Nduati who is a Postgraduate Student of this University. The student is registered for a Ph.D. degree programme in the **Department of Educational Communication & Technology in the School of Education.**

Nduati intends to conduct research for Ph.D. thesis entitled, **"The 5Es Guided Instructional Process and its Effect on Students Performance in Chemistry among Secondary Schools in Murang'a County, Kenya".**

Any assistance given will be highly appreciated.

Yours faithfully,

KENYATTA UNIVERSITY OFFICE OF DEAN 04 DEC 2020 GRADUATE SCHOOL P.O. Box 43844-00100 NAIROBI

PROF. ELISHIBA KIMANI
DEAN, GRADUATE SCHOOL

RM/cao