THE EFFECT OF RETRIEVAL BASED CONCEPT MAPPING ON INFORMATION RETENTION AND PERFORMANCE IN CHEMISTRY AMONG FORM THREE STUDENTS AT TURKANA GIRLS' SECONDARY SCHOOL, TURKANA COUNTY-KENYA

BY

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DECLARATION

Declaration by the Candidate

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DEDICATION

I dedicate this work to my dad, the late Humphrey Mukania.

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ABSTRACT

Performance in Chemistry at the Kenya Certificate of Secondary Education (KCSE) examinations has continued to be poor over the years. This has mainly been attributed to ineffective instructional methods that do not promote meaningful learning of scientific concepts. Concerted effort has been made to alleviate this problem including in-service training of teachers through Strengthening Mathematics and Science in Secondary Education (SMASSE) program but the situation has persisted. The aim of this study was to find out if teaching and learning of chemistry can be enhanced by use of Retrieval Based Concept Mapping (RBCM). This is a study strategy that integrates Concept Mapping and Retrieval Practice which have both been found to support meaningful learning and retention of concepts. The objectives were to compare Concept Mapping and Retrieval Practice and also find out which Retrieval Practice activity between Free Recall and Concept Mapping is more superior to the other in enhancing performance and retention of chemistry concepts. Hypothesis were stated and tested at 0.05 level of significance. A non -equivalent quasi experimental design with a pretest and posttest was used with a sample of 103 participant drawn from form three students at Turkana Girls Secondary School using convenient sampling method. Craik and Lockhart's level of processing theory, Ausubel's theory of meaningful learning, context reinstatement and elaborative theoretical accounts guided the study which was conducted for a period of nine weeks during the second term of the Kenyan school calendar. Data was mainly generated from three test instruments administered to participants as Chemistry Pretest, Chemistry Achievement Test and Chemistry Retention Test. Participants in three intact classes which formed the comparison groups were taught the topic 'Organic Chemistry' for three weeks and then subjected to revision of concepts using either Elaborative Concept Mapping, Retrieval Practice by Free Recall or Retrieval Practice by Concept Mapping. Data obtained was analyzed using means, standard deviations, Kolmogorov-Smirnoff test and Kruskal Wallis H test with the help of Statistical Package for Social Scientists version 23. Results obtained showed that Retrieval Practice and Concept Mapping are both effective strategies in enhancing performance and retention of chemistry concepts but Retrieval Practice is a better study strategy than Concept Mapping. This study also found that Concept Mapping when used as a Retrieval Practice activity gives better results than Free Recall. The study therefore recommends that teachers and learners embrace the use of Retrieval Based Concept Mapping (RBCM) as one way of improving performance in chemistry. Center for Mathematics and Science Teacher Education in Africa (CEMASTEA) should consider adopting this study strategy as a teaching and learning model to be incorporated in their SMASSE training modules. It is anticipated that this study will elicit more interest in the areas of Concept Mapping and Retrieval Practice which have drawn little interest among researchers in the Kenyan context.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis Of Variance
ASEI	Activity Student Experiment and Improvisation
CAT	Chemistry Achievement Test
CBS	Computer Based Simulation
CEMASTEA	Center for Mathematics and Science Teacher Education in Africa
CPT	Chemistry Pretest
CRT	Chemistry Retention Test
ECMG	Elaborative Concept Mapping Group
ICT	Information and Communication Technology
INSET	In -Service Education and Training
KCSE	Kenya Certificate of Secondary Education
KNEC	Kenya National Examinations Council
K-S	Kolmogorov- Smirnoff
LTM	Long Term Memory
NACOSTI	National Commission for Science Technology and Innovation
PDSI	Plan Do See Improve
RBCM	Retrieval Based Concept Mapping
RPFR	Retrieval Practice by Free Recall
SMASSE	Strengthening Mathematics and Science in Secondary Education
SPSS	Statistical Package for Social Scientists
STM	Short Term Memory
T/L	Teaching and Learning
TGSS	Turkana Girls' Secondary School

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.0 Overview

This chapter is organized into fourteen sections and gives an introductory flare to the study. It begins by giving a background expose that led to conceiving of the research idea. The key problem to be addressed is then stated in the second section. The third and fourth sections are about the purpose and objectives of the study, followed by research questions that the researcher poses in the fifth section. Sections on significance and justification of study, limitations and delimitation, assumptions, theoretical and conceptual frameworks follow in that order. The chapter ends with a section on operational definition of key terms as used in the study.

1.1 Background to the study

One of the major daily newspapers in Kenya, 'The Daily Nation' ran a headline on May 8th, 2019 which went by;

"Mass failure in science subjects spells doom for Kenya's growth" p.1.

In an article by Wanzala (2019), which highlights a report by university vice chancellors, it is feared that Kenya's 'Vision 2030' and millennium sustainable development goals, which are anchored on science and mathematics, are unlikely to be realized. This is owing to the massive failure in Mathematics and the sciences in Kenya Certificate of Secondary Education (KCSE) examinations. According to the report, dubbed *Status of University Education in Kenya*, more than ninety percent of candidates who sat for mathematics and science subjects in the KCSE examinations failed. Less than ten percent of the candidates qualified for science related courses at universities, leading to some of the courses (one hundred and seven in number) being scrapped off for lack of students. The sentiments presented in the said report were echoed by secondary school principals who wanted the Kenya National Examinations Council (KNEC) to explain why there was mass failure in science subjects in the 2017 KCSE examinations (Atieno, 2018). The principals sought explanations from the government on the massive failure by candidates especially in Chemistry and Biology and at the same time requesting the Teachers Service Commission to employ more science teachers citing shortage. This shocking revelation on the state of science performance is a matter of national concern and points out the significance of science education which needs not be overstated. Teaching science to students helps create societies whose members have critical thinking skills and rational approach towards problems, make well informed decisions and pursue creative ventures. Science educators have for a long time endeavored to improve science achievement through use of more effective instructional strategies, promoting the active role of the learner and the facilitative role of the teacher (Odom &Kelly, 2000). The Kenyan education system is examination oriented characterized by a highly competitive K.C.S.E examination at the end of secondary education cycle. This particular exam determines who earns placement in higher institutions of learning. Students who excel in the exam are selected to pursue competitive courses at government sponsored universities which increases their chances of landing well-paying jobs in the local and international market.

Recently, there has been public outcry following revelation of yet another massive failure by students in the 2019 KCSE examinations. According to statistics presented by Wanzala (2019b) of the nation newspaper, more than a third of the candidates who sat for the examinations failed to attain grades that would allow them to pursue professional courses, hence joining the growing population of secondary school leavers who are either forced to seek low paying, poorly funded artisan courses or completely drop out the education system. This situation is alarming given the massive resources that the government of Kenya, just like many governments in developed and developing nations allocate to education (UNESCO, 2005). In Kenya, Science Technology and Innovation (S.T.I) is among the pillars for economic development as outlined in 'Vision 2030', an economic development blueprint. It is in this respect that science education is now seen as one of the avenues to realize 'Vision 2030' (Teachers' Image, 2013). As Kenya intents to have international ranking for her children's learning in Mathematics, Science and Technology (Government of Kenya, 2007), the government has put in place measures and strategies towards this course. They include improving instructional strategy of science subjects through initiatives such as Strengthening Mathematics and Sciences in Secondary Education (SMASSE), whose main objective is to equip teachers with techniques and strategies that enhance effective learner involvement through innovative classroom practices (CEMASTEA, 2016).

Other measures taken by the government of Kenya through the ministry of education include formation of subject panels at district level and training of as many teachers as possible on skills for marking (Odhong', 2011) There is however considerable concern about the declining quality of basic sciences in many secondary institutions in Africa (Markow & Lonning, 1998; Jack, 2013; Waswa, 2009). Chemistry is one of the science subjects taught in Kenyan secondary schools and its concepts are widely applicable. Several technological breakthroughs that are continuing to be witnessed are built upon this subject which is said to be the pivot on which the wheel of science rotates (Gongden, Gongden & Lohdip, 2011). Most people in the industrialized nations have a higher standard of living; better health, greater wealth, more nutritious food due to Chemistry (Hill& Petrucci, 1999). Ikedolapo and Adetunji (2009) observes that chemistry knowledge is required for the successful study in very many important professions.

The problem of poor performance in science is quite serious in chemistry. Researchers (Childs & Sheehan, 2009; Jack, 2013, Taber, 2001; Kilic & Cakmak, 2013, Sheppard, 2006) are in accord that chemistry is perceived to be a difficult subject. Some attribute this to its specialized language, mathematical and abstract conceptual nature and the amount of content to be learned (Gabel, 1999; Moore, 1998) as cited by BouJaoude and Attieh (2007). Taber and Coll (2002) note that the chemistry concepts are abstract in nature and require students to construct mental images of things they cannot see, and thereby find it hard to relate to. A further complication in the learning of chemistry (and other sciences) concerns the medium of instruction. The literature on students_ problems with scientific language literacy, points to confusion between scientific terminology and similar sounding (or the same words in common language usage), suggesting this may result in students not understanding the meaning of scientific terms (Johnstone & Selepeng, 2001). Barchok (2011) points out that lack of conceptual understanding has impeded students' attainment of meaningful learning. There is an added complication of learners having to operate on and inter-relate three levels of thought: the macro, the sub micro atomic and molecular level and the representational use of symbols and Mathematics.

Johstone (1991) is cited in Childs & Sheehan (2009) as having described the multilevel thought needed in chemistry: the macroscopic level refers to what is tangible and visible like dissolving a salt in water, the submicroscopic level refers to what is molecular and invisible, an example being ions and molecules, while the symbolic level refers to chemical symbols and equations representing ions, atoms, molecules and so on.

The difficulty in understanding chemistry concepts is clearly manifested through poor performance in summative examinations. In Nigeria for instance, Jack (2013), acknowledges that this has been quite a serious problem. Ssempala (2005) asserts that poor performance in chemistry, more so by girls, at 'A' level exams in Uganda potentially contributes to lowering their interests in the subject thus reducing women participation in science and technological fields. Studies in Kenya (Mochire, 2010; Otieno, 2012; Waswa, 2009; Barchok, 2011, Kinya, 2018) are in response to poor performance in chemistry at national examinations. The following table **1.1** provides a summary of national performance in chemistry in the KCSE examinations in the recent past in Kenya.

Table 1.1: ***Comparison of national KCSE candidates' overall performance (Mean Score out of 200) in science subjects between the years 2010-2014.***

Subject	**Chemistry**	**Physics**	**Biology**
Year	**Subject Mean Score out of 200 marks**		
2010	49.79	70.22	58.39
2011	47.31	75.82	64.87
2012	55.86	75.72	52.41
2013	49.00	80.20	63.26
2014	64.31	77.68	63.65

(Source: KNEC, 2008-2015)

Table **1.1** indicates that chemistry had the lowest mean score rating in 2010, 2011 and 2013. In 2012 and 2014, chemistry had the second lowest mean score and a similar trend in performance is observed for chemistry in Turkana County. Turkana Girls Secondary School is a leading national school in Turkana County and has over the years registered poor performance in chemistry at KCSE. Table **1.2** shows a comparison of mean scores of performance in three science subjects by KCSE candidates at TGSS.

Table 1. 2: ***A comparison of performance in science subjects at KCSE by TGSS candidates.***

	Science Subjects mean ratings (out of 12)		
YEAR	**BIOLOGY**	**CHEMISTRY**	**PHYSICS**
2009	7.89	5.16	6.61
2010	7.37	5.49	6.4
2011	7.60	6.05	6.83
2012	7.00	6.18	6.9
2013	8.93	7.04	7.12

(Source: TGSS Academic Office)

From table **1.2** it can be observed that at TGSS, Chemistry has continually registered low mean score compared to the other two science subjects. Research findings have also indicated that a number of topics in chemistry contain concepts that are challenging to students (Childs & Sheehan, 2009; Jack, 2013, Waswa, 2009; Gongden, Gongden & Lohdip, 2011; Reid, 2008). A study in Greece by Salta & Tzougraki (2004) established that students' attitudes regarding the difficulty of chemistry lessons are related to concepts, symbols, and problems' solving. The application of chemistry concepts and symbols depends on the students' ability to transfer from one level of thought to another which is a challenging requirement for learners.

For Chemistry to be well learnt, making conceptual connection between representations and developing understanding of underlying concepts are important (Kilic & Cakmak, 2013). Two reasons, according to these researchers, for students lacking understanding of chemistry are; rote learning (memorizing ideas) instead of learning meaningfully (co-relating new knowledge to previously learned). Secondly, students are unable to recognize the key concepts and concepts relationships needed in order to understand the material. According to Ikedolapo and Adetunji (2009), it is necessary that students studying chemistry should understand the subject so that they can apply their knowledge to their everyday interactions with people and the dynamic environment. This position is supported by Ajaja (2011), BouJaoude &Attieh (2007) and Barchok (2011) among other researchers who have supported the idea of meaningful learning of chemistry concepts.

Concept Mapping is a teaching and learning strategy that has been found to be effective in enhancing meaningful learning of science concepts. In the field of science, Concept Mapping is meant to address the problem of linking the often multidirectional nature of the subject especially in chemistry where students are faced with the three levels of knowledge representation (Jack, 2013). This strategy requires a learner to identify important concepts and show how they are interrelated (Sket & Glazar, 2005). Personal meaning is given to subject content by thinking in multiple directions. Meaningful learning according to Ausubel (1968) is a process in which new information is related to an existing relevant aspect of an individual's knowledge structure and which correspondingly must be the result of an overt action by the learner. Taber (2001) describes how meaningful learning is achieved. The researcher alludes that the human brains work to make some sense of an individual's experiences, and to use available resources (in terms of existing conceptions) in order to interpret information into something meaningful. Such interpretations are based on existing conceptual frameworks for converting the experiences into meaningful mental images. Forming a network of concepts is important because in the world of science, concepts are very interrelated and many of them build on each other as Asan (2007) points out. Such links and relations between concepts stimulate the construction of integrated knowledge structures by the learner (BouJaoude & Attieh, 2007) and represents important aspects of the organization of concepts in the cognitive structure of the learner (Primo & Shavelson, 1996).

Previous research work has also established that Concept Mapping in science education is useful in enhancing retention of learnt material (Jack, 2013; Odom &Kelly, 2000; Ikedolapo & Adetunji (2009); Yekta & Nasrabadi, 2004). Ajaja (2011) is of the opinion that Concept Mapping can help move information into long term memory and understanding of complex ideas. It is also claimed that Concept Mapping bears a similarity to the structure of long term memory (Asan, 2007). Ausubel's proposition on meaningful learning is interpreted in terms of long term memory; the more knowledge is understood and stored meaningfully, the more links are created between ideas and concepts (Reid, 2008). Concept maps are helpful in the process of elaboration which involves addition of meaning to new information by connecting with already existing knowledge (Woolfolk, 1998). Elaboration, according to the writer, is a form of rehearsal which activates information in the working memory long enough to have a chance of long term storage in memory. Elaboration enhances deeper processing of material being learnt which facilitates recall of the material later on. This idea stems from Craik & Lockhart (1972) who proposed the 'level of processing' theory which suggested that how long information is remembered is dependent on how completely it is processed and connected with other information (Feldman, 2011). Gray (2002) agrees with this proposition by adding that the more deeply something is thought about, the more likely it is to be remembered. For him, thinking deeply involves hooking up the idea to an already existing structure of information in memory. Concept Mapping comes in handy to this effect; making it possible for learners to construct their own understanding of concepts and make connections of ideas in their cognitive domains which act as retrieval paths during recall. The conception that concept maps makes students remember information longer and be able to use it more effectively makes it the possible alternative to conventional teaching and learning methods.

Retrieval Practice (also known as practicing retrieval, test enhanced learning or self-testing) is another active learning strategy that has been found to promote meaningful learning (Smith, Whiffen & Karpicke, 2016) and enhance retention of learnt concepts (Karpicke & Bauernschmidt, 2011; Karpicke & Blunt, 2011; Smith, Roediger & Karpicke, 2013). A wealth of past research gives consistent findings which support the idea that practicing retrieval promotes long term retention more than does spending equivalent time repeatedly studying. To practice retrieval simply means to purposefully reconstruct knowledge (Karpicke et al, 2011) by repeatedly retrieving information from memory. This act alters memory (Karpicke, 2017) thus improving future retrieval of that knowledge (Karpicke, Lehman & Aue, 2014) and other related information (Karpicke, 2018). The process of retrieval is not neutral for learning (Karpicke, Lehman & Aue, 2014, Smith, Blunt, Weinstein, Nunes & Karpicke, 2016), instead every time information is retrieved there is some change that occur which improves one's ability to retrieve and reconstruct that knowledge in future. Retrieval Practice is mainly implemented in the classroom by having students take tests or quizzes (Smith & Karpicke, 2014) hence the benefits from the process are referred to as testing effects (Smith, Blunt, Whiffen & Karpicke, 2016). However, it is not the act of taking a test that yields such benefits (Karpicke, Lehman & Aue, 2014) but rather the processes that tend to occur during testing. Almost all classes incorporate testing but rarely are tests thought as learning tools. In most cases they are conceptualized as assessment tools meant to measure learning outcomes (Karpicke & Aue, 2015). Learning is generally considered as the process of acquiring and encoding new knowledge and retrieval as a separate process that measures what has been stored in memory and the best learning is thought to occur when students elaborate on what they are studying through meaningful connections (Larsen, Butler & Roediger, 2013). Tests are used to assess what was learned in a prior experience but are not seen as learning events. It may be obvious that tests can promote learning by providing feedback about what is known or unknown by a learner. Recent research in cognitive science however show that the act of taking a test by itself without any feedback or restudy of material produces considerable effects on learning. Many students lack the metacognitive awareness of the benefits of Retrieval Practice (Weinstein, Nunes & Karpicke 2016). In most studies that have compared Retrieval Practice with alternative study techniques like repeated studying, students have generally predicted that they would remember information better after engaging in repeated studying than by practicing retrieval (Smith, Whiffen & Karpicke, 2016). Such beliefs by educators and students according to Nunes & Karpicke (2015) are inaccurate and cause students not to engage in Retrieval Practice.

Despite the general preference by both learners and teachers of elaborative study techniques over others, most research studies comparing the efficacy of Retrieval Practice with such alternative techniques have provided evidence that Retrieval Practice is more superior in terms of enhancing learning and retention of concepts. For instance, Karpicke & Blunt (2011) observes that Retrieval Practice produces more meaningful learning than elaborative studying with Concept Mapping. Blunt & Karpicke (2014), in their study entitled “retrieval based Concept Mapping” they compared two formats of Retrieval Practice and concluded that Retrieval Practice either by paragraph format or by Concept Mapping produce better performance than restudying. Larsen, Butler & Roediger (2013) compared an elaborative technique known as self –explanation, which involves having students generate explanations about why a particular piece of information is important and how it relates to their existing knowledge, with test enhanced learning and found out that both learning activities can produce superior long term retention and application of knowledge but testing is generally more effective than self- explanation alone. Even though extensive research work has been conducted on Retrieval Practice, there is still no commonly agreed upon theoretical explanation of the mechanisms underlying the process (Lehman, Smith, & Karpicke, 2014). Two commonly fronted theoretical accounts: the episodic context and the elaborative accounts seem to be inconsistent yet they intend to offer an explanation about the same phenomena. Proponents of the elaborative account propose that the process of retrieving information from memory makes the memory trace to be elaborated by increasing the number of retrieval cues making it likely that information will be successfully retrieved in future (Roediger & Butler, 2011). Carpenter (2009) says that in an attempt to retrieve target information from memory, several semantically related information is activated leading to elaboration during initial retrieval which enhances retention on subsequent tests (Lehman et al, 2014). Retrieval may involve deep, elaborative processing and therefore Retrieval Practice may operate just like any other elaborative study task (Karpicke & Smith, 2012).

On the other hand, the episodic context account proposed by Karpicke, Lehman and Aue (2014) attributes the benefits of Retrieval Practice as resulting from the process of recollecting the context of a prior learning episode (Karpicke & Zaromb, 2010). Context reinstatement is the underlying mechanism of this account and it is said to occur during retrieval by creating a unique set of context features that becomes associated with successfully retrieved items (Lehman, Smith & Karpicke, 2014). Context representation is updated to include a composite of features from both past and present contexts and on a later test, context is again reinstated to accomplish retrieval (Karpicke, Lehman & Aue, 2014). In comparing key tenets of the two accounts, it can be noted that they both attribute the benefits of Retrieval Practice to size of the search set and the strength of cues that aid memory. Whereas Retrieval Practice restricts the size of the search set and reduces the number of memory cues as predicted by the episodic context account, elaboration expands the search set and increases the number of cues that aid memory.

Key questions arise at this point with regard to the two theoretical explanations of Retrieval Practice: One concern of Lehman et al., 2014 is that if semantic elaboration is the underlying mechanism responsible for the benefits of Retrieval Practice, why then is it that conditions that directly bring about this type of elaboration such as Concept Mapping do not produce performance similar to Retrieval Practice conditions. Secondly, if elaboration is not only responsible for Retrieval Practice but also for the process of Concept Mapping, is it possible that a combination of these two techniques can yield benefits superior to those of using Retrieval Practice or Concept Mapping alone? The present research was motivated by these pertinent questions where it sought to investigate the efficacy of retrieval based Concept Mapping, elaborative Concept Mapping and Retrieval Practice study techniques in enhancing learning of chemistry concepts.

1.2 Statement of the problem

The present study deals with the difficulties Kenyan secondary school students experience in understanding chemistry concepts. The problem of poor performance in chemistry by students in summative exams has preoccupied researchers and educational stakeholders for quite some time. Several research findings and recommendations have been made in view of alleviating this problem but it has persisted. Even though there are several causal factors associated with the prevailing problem, it has mainly been attributed to inappropriate instructional techniques. This has prompted researchers and educational stakeholders to design and recommend the use of teaching and learning models aimed at improving chemistry instruction. Despite such concerted efforts, learners still continue to show difficulties in understanding chemistry concept as evidenced by dismal performance in the subject at KCSE. This study therefore sought to address the problem by investigating the efficacy of a teaching and learning model dubbed Retrieval Based Concept Mapping (RBCM) in supporting conceptual understanding and long term retention of chemistry concepts. Retrieval Practice and Concept Mapping are active learning strategies that have been proven to enhance meaningful learning, understanding and retention of concepts. Unfortunately, there is none or diminutive evidence of their uptake by both teachers and learners in Kenyan learning institutions. A lot of emphasis has been placed on the processes involved in acquisition and encoding new knowledge (Nunes & Karpicke, 2015) and retrieval considered neutral because the process of accessing knowledge is not thought to change knowledge (Karpicke et al, 2014). This inaccurate assumption on learning has been impressed upon by several education systems where students are thought to learn via the traditional lecture method, reading, highlighting, study groups and so on (Roediger & Butler,2011). Tests are given in classrooms to assess what has been learnt without affecting it in any way (Blunt & Karpicke, 2014; Karpicke & Roediger, 2008) with their benefits being attributed to the studying done to prepare for them (Karpicke,2018). Neither Concept Mapping nor Retrieval Practice is used at Turkana girls Secondary school for teaching and learning Chemistry. The present study will help correct such mistaken metacognitive believes by teachers and learners on testing and help focus their attention not just on encoding of information but more so on its retention.

1.3 Purpose of the study

The purpose of this study was to determine the effectiveness of Retrieval Based Concept Mapping learning model in enhancing information retention and performance in chemistry among form three students at Turkana Girls' Secondary School.

1.4 Objectives of the study

Specific objectives in this study were to:

i. Examine the efficiency of Retrieval Practice relative to Concept Mapping in enhancing information retention and performance in chemistry among form three students at Turkana Girls' Secondary School.

ii. Establish the most suitable Retrieval Practice activity between Concept Mapping and Free Recall in enhancing retention of information and performance in chemistry among form three students at Turkana Girls' Secondary School.

1.5 Research questions

The following questions guided the present study:

i. How does Retrieval Practice compare with Concept Mapping in enhancing retention of information and performance in chemistry among form three students at Turkana Girls' Secondary School?

ii. Which Retrieval Practice activity between free recall and Concept Mapping is more suitable in enhancing retention of information and performance in chemistry among form three students at Turkana Girls' Secondary School?

1.6 Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

$H_0 1$: There is no significant difference in information retention and performance in chemistry between form three learners at TGSS who study chemistry concepts by Concept Mapping and those who study by retrieval practice.

H_02: Concept Mapping and free recall Retrieval Practice formats are not significantly different in enhancing retention of information and performance in chemistry among form three learners at TGSS.

1.7 Significance of the study

One crucial goal of educational research is to identify effective strategies by comparing and contrasting instructional strategies and identify ones that lead to durable, meaningful learning (Karpicke & Blunt, 2011). The present study has implications oriented towards this course. Results and recommendations from this study will likely inform educational stakeholders like CEMASTEA in their quest to design suitable educational programs to improve teaching and learning of science subjects and Mathematics. It is also expected that the present findings will spark off a myriad of interests among educational researchers who will use them as a platform for future experimental efforts which will help lead the way to better instructional strategies using Retrieval Practice, Concept Mapping and other educational techniques. This is based on the understanding that contemporary research on retrieval based learning seeks to deepen the theoretical knowledge about Retrieval Practice and also identifying most effective ways to implement retrieval based learning activities in classroom settings (Nunes & Karpicke, 2015; Grimaldi &Karpicke,2013). Results of this study will inform curriculum developers so as to be able to design and develop appropriate material and programs for effective implementation of chemistry curriculum. Lastly, teachers of chemistry will greatly benefit from the present study as they implement chemistry curriculum in schools.

1.9 Justification of the study

In any educational practice, students are required to learn and then retain a very large volume of complex information (Dobson, 2013) to be reproduced later especially in an exam. This is one of the most difficult challenges faced by many instructors who get frustrated when they spend time and effort discussing a topic in class, but at some time later, the learner cannot remember that information (Terenyi, Anksorus & Persky (2018). Despite the immense challenges presented by the above mentioned goal, relatively little research has investigated the direct effects of long term retention of particular educational interventions (Larsen, Butler & Roediger, 2013). This is perhaps occasioned by a common assumption on human learning that learning occurs when people encode new knowledge and experiences (Karpicke & Blunt, 2011) and the best learning is thought to occur when learners elaborate on what they are studying (Blunt &Karpicke,2014). However, contemporary views on learning propose that learning is more than the encoding or construction of knowledge from experience. Research in cognitive psychology suggests that retrieving information from memory seems to greatly enhance future recall (Larsen, Butler & Roediger, 2009). While benefits of Retrieval Practice in educational practices are almost beyond contention, there is need to understand how well it compares with other methods of active learning (Larsen, Butler & Roediger, 2013) yet few studies (Karpicke & Blunt 2011; Blunt & Karpicke 2014) provide this kind of comparison. Furthermore, (Smith & Karpicke, 2014) are of the opinion that if Retrieval Practice is to be implemented in classrooms, then it is important to know which Retrieval Practice formats are most effective for promoting meaningful learning. There are reasons to expect that Concept Mapping could be used as a technique to implement Retrieval Practice.

An analysis of past research on Retrieval Practice reveals that very few studies have investigated the strategy in the context of an actual class. Most of such studies have been conducted outside classroom settings (Dobson, 2013) and the kind material used has been mostly word lists or brief texts which do not reflect a typical learning condition. Of key concern is that none of previous studies has investigated Retrieval Practice with chemistry material which is unique given the fact that the concepts are complex and interoperate at three levels of thought: macroscopic, microscopic and symbolic. The current researcher is keen to find out if the benefits of Retrieval Practice hold for such material with high element interactivity. Another gap noted with past related studies is that the length of delay before final test was on average short; ranging from no delay, five minutes ,3 days, to one week. Results from these studies could be challenging to implement in educational practice basing on the suggestion by (Nunes & Karpicke, 2015) that;

> *"In order to integrate findings from cognitive science with educational practice, at a minimum researchers must use authentic educational materials, tasks that would be plausible in educational settings and assessments that are relevant to real world learning outcomes" pg. 9.*

The present study seeks to address the aforementioned inadequacies by investigating the effects of Retrieval Practice on learning using chemistry material in an actual classroom setup that depicts a characteristic educational setting.

1.9 Scope of the study

A distinction is made between direct and mediated benefits of Retrieval Practice. This study is limited to the direct and not mediated benefits of Retrieval Practice. There are other possible general ideas that attempt to offer theoretical explanations of the mechanisms of Retrieval Practice including transfer appropriate processing and strength and retrieval effort but the present study narrowed down to two common accounts. Key predictions from the said accounts such as elaboration and context reinstatement were not directly manipulated in this study. Even though the study sought to examine the efficacy of Retrieval Practice with relatively complex material compared to those used in past studies, it did not manipulate complexity of material in this study.

1.10 Research assumptions

In conducting the proposed study, the following assumptions were made;

i. Possible mediating effects of Retrieval Practice and Concept Mapping were evenly distributed across all participating members in respective groups
ii. None of the participants had prior knowledge or skills on Concept Mapping and Retrieval Practice.
iii. Participants in both experimental and control groups had similar chemistry background knowledge.

1.11 Limitations to the study

The biggest limitation to this study was that there could be other causes of failure to retain information other than lack of elaborative encoding and Retrieval Practice. The challenge here was to establish clearly that poor achievement is a result of failure to retain rather than to retrieve information. Measuring memory is challenging given that several factors influence memory retention and forgetting. It was not possible to hold constant such factors and there is a possibility that they could have influenced the outcome of the present study. The presence of uncontrolled variables could have reduced internal validity but according to McBurney & White (2007), it does not necessarily render it invalid. Another limitation has to do with the population sample used; only form three students of the same gender from a single school were sampled for the study. This sample may not be representative of all secondary school students in Kenya, lowering external validity (McBride, 2010). Even though the sample used was somewhat biased, research in psychology is conducted to study relationship between variables rather than to accurately estimate population values (Cozby, 2007). One reason in support of small population samples according to Goodwin (2005) is that outcomes from research involving large population samples can produce erroneous conclusions about behavior.

1.12 Theoretical framework

Two main theoretical accounts on which this study was anchored are the elaborative account and the episodic context account. These accounts offer explanations about the mechanism underlying the benefits of Retrieval Practice. The elaboration theory also offers explanation on the effects of Concept Mapping on memory and learning. Other theoretical underpinnings for this study are Ausubel’s theory of meaningful learning and Craik & Lockhart level of processing theory. When learners engage in meaningful learning, they are able to make connections of new information to the one already existing in their memory. They should be willing to make such connections which form a network of concepts in their memory that serves as retrieval cues. Concept Mapping is likely to support meaningful learning by enabling learners to construct their own understanding of concepts, making links in memory hence making it easier to recall what they have learned.

The level of processing theory postulates that the deeper information is processed during encoding, the longer it will be retained in memory hence easily recalled. Deep level processing entails elaboration of information which can be achieved by visualization, organization, chunking among other techniques of improving memory. Construction of concept maps fosters deep processing of information by enabling learners to visualize how concepts are interconnected and interrelated. Concept maps are organized either hierarchically or spatially and one can choose to include at the nodes elaboration features like video clips, sound recordings and graphics. It is therefore postulated that by engaging in Concept Mapping, meaningful learning is achieved hence learners are able to relate and connect various concepts in their memories.

Theories of Retrieval-Based Learning attempt to answer the fundamental question of why initial successful retrieval enhances the likelihood of subsequent retrieval, relative to control conditions in which learners do not practice retrieval. There are three common theoretical ideas that provide useful explanation why practicing retrieval during learning bolsters long-term retention; Transfer-Appropriate Processing theory, Elaborative retrieval account and the episodic context account. Transfer-appropriate processing refers to the general idea that performance on a learning and memory task will be best when the processing that a student engages in during an initial learning activity matches or overlaps with the processing required during a later, final assessment (Kolers and Roediger, 1984) in Karpicke (2017). Because learners are required to retrieve and use knowledge during a final criteria assessment, they should practice retrieving and using knowledge during initial learning activities. Just in the same manner that people learn to play a musical instrument or to play a sport. If a person wants to learn how to play the guitar, practicing by playing the instrument is essential; listening to someone else play the instrument, or reading about how to play it, cannot be an alternative to practicing the skill itself. However, Karpicke (2017) asserts that while transfer-appropriate processing may offer an instinctive explanation of the importance of retrieval for learning, it does not offer a mechanism that explains how or why engaging in retrieval improves learning hence other theories are required to explicate the mechanisms by which retrieval enhances learning.

The Elaborative Retrieval account and Episodic Context Account, describe possible mechanisms of retrieval-based learning, but the accounts differ in the nature of the underlying mechanisms they propose. Carpenter (2009) proposed an elaborative retrieval account whose general idea is that semantic elaboration occurs during the process of retrieval and enhances subsequent recall. Elaboration is broadly conceptualized as the activation of cue relevant information that becomes incorporated with successfully retrieved items (Carpenter and Yeung, 2017). More specifically, the idea is that when subjects are given a cue and asked to recall a target item, they generate several additional items that are semantically related to the cue. These items are incorporated with the target to form an elaborated memory trace that is memorable in the future. The account also proposes a specific mechanism by which elaboration is thought to occur: During the process of retrieval, subjects activate several semantically related words that are then encoded along with the target to form a more elaborated and recallable representation.

On the other hand, the episodic context account proposed by Karpicke, Lehman & Aue (2014), assumes that the mechanism underlying Retrieval Practice is one that alters episodic context representations in such a way that increases the effectiveness of the episodic context cue for eliciting target information (Lehman et al, 2014). There are four key assumptions of the episodic context account in its attempt to explain retrieval practice effects. First, during learning, it is not just information about items that is encoded but also the temporal/episodic context in which those items occurred (Howard & Kahana, 2002). Second, during retrieval, an attempt is made to reinstate the episodic context associated with an item as part of a memory search process (Lehman & Malmberg, 2013). Third, when an item is successfully retrieved, the context representation associated with that item is updated to include features of the original study context and features of the present test context. Finally, when people attempt to retrieve items again on a later test, the updated context representations aid in recovery of those items, and memory performance is improved.

The elaborative retrieval and episodic context accounts can be seen as competing theoretical accounts that offer different views of the mechanisms that produce retrieval-based learning. However, as Carpenter and Yeung (2017) rightfully note, the accounts are not mutually exclusive. It may be the case that in certain circumstances or for certain types of materials, retrieval affords a great deal of semantic elaboration which in turn promotes retention, whereas in other circumstances retrieval conditions lead learners to think back to prior episodic contexts. In this study it was postulated that when learners engage in Retrieval Practice using Concept Mapping information is not only elaborated but the representation of episodic context is altered hence improving one's ability to guide memory search on future tests.

1.13 Conceptual framework

In the present study, it is conceptualized that when learners engage in learning by Retrieval Based Concept Mapping, information is elaborated by adding more features or attributes resulting in deep level processing. Deep level processing of information enables updating of context representations during Retrieval Practice which facilitate retrieval of items. Elaboration also helps learners to learn meaningfully by interrelating and interconnecting science concepts. Meaningful learning, enhanced information retention and information retrieval results in improved performance in chemistry. In summary, a combination of Concept Mapping and Retrieval Practice is thought to yield the greatest benefit when the two are integrated as a study technique by learners. The role of Concept Mapping is to facilitate retention of concepts while Retrieval Practice aids the learner to retrieve retained concepts. This conceptualization is summarized in figure **1.1**.

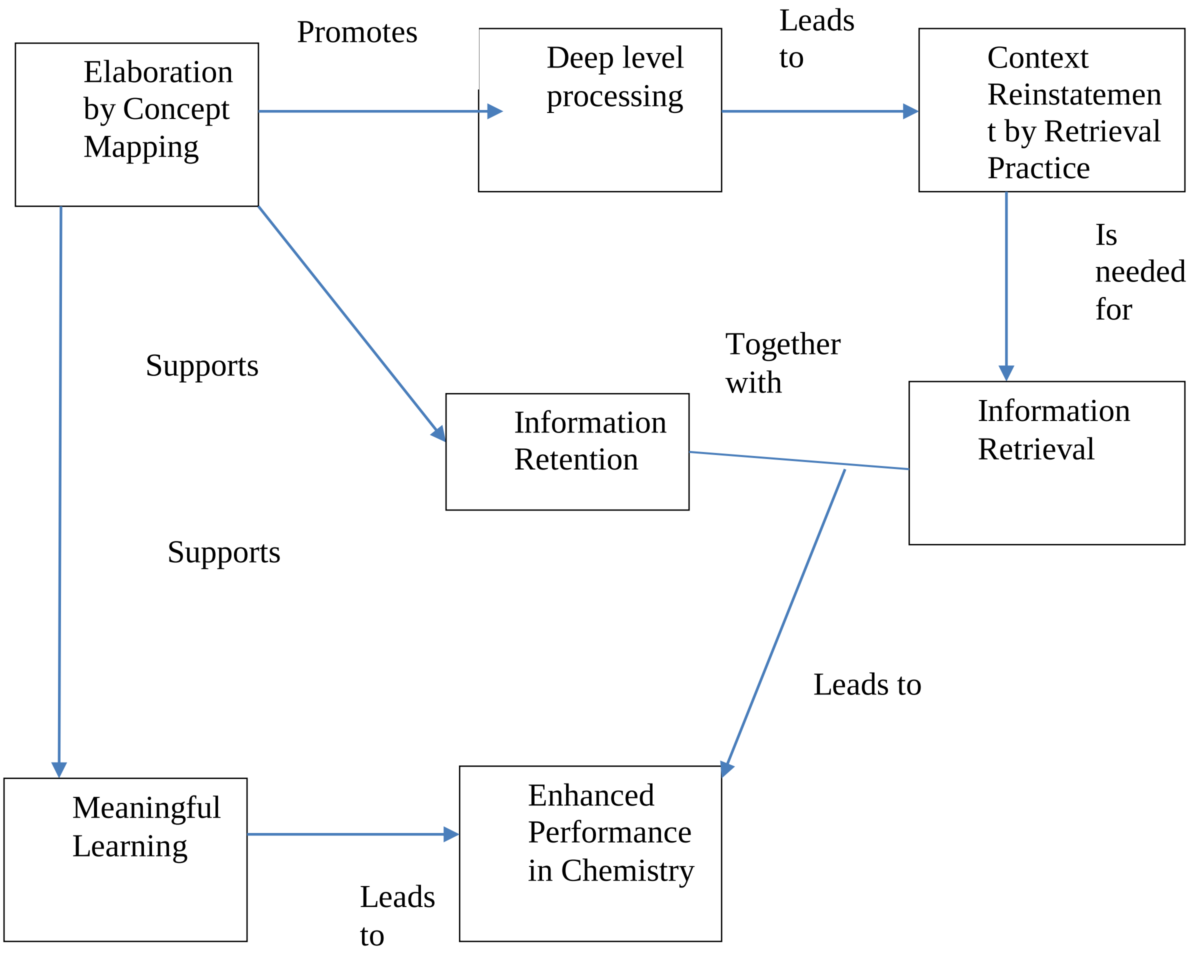


Figure 1. 1: A concept map summarizing conceptualization of the proposed study.

1.14 Operational Definition of Key Terms

Achievement in chemistry academic ability in chemistry that is measured by how much a learner scores in a test. This was measured by the Chemistry Achievement Test (CAT). In this study achievement and performance are used interchangeably.

Concept map – a two dimensional diagram with links and nodes use to summarize and show how concepts in a given subject area are related and connected.

Elaboration- a process of making information more meaningful by engaging in activities that supports deep level processing during encoding.

Quasi experimental design- a type of experimental design where participants are assigned to their respective experimental groups by a non-random criteria.

Retention- the ability to retain information in long term memory and retrieve it later on when needed to be used in examination situation(s). The Chemistry Retention Test was used to measure retention.

Retrieval- when a learner is able to recall information stored in long term memory.

Retrieval Practice- the process of purposeful reconstructing knowledge by repeatedly retrieving information from memory.

Retention interval – a period from the time information is studied to the time a retention test is given. In this study the retention interval was three weeks.

Retrieval Based Concept Mapping- a study technique that integrates concept mapping and retrieval practice.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews existing literature on Chemistry Education Research, Concept Mapping and Retrieval Practice. The chapter begins with an exploration of general literature related teaching and learning of chemistry. It was vital to review such information so as to bring out issues related to how chemistry should be taught and understand the factors affecting teaching and learning of chemistry in Kenya. Other themes on which relevant information has been explored in this chapter are;

- Active learning strategies: Concept Mapping vs. Retrieval Practice
- Concept Mapping and Meaningful Learning
- Concept Mapping and Information Retention

The chapter ends with a summary from the information gathered in the review.

2.1 Teaching and Learning of Chemistry

In the Kenyan secondary school curriculum, students are required to study at least two science subjects in which they are examined in the KCSE at the end of their four -year secondary education cycle. Chemistry is one of the science subjects offered at this level and most schools have in their internal policies made it a compulsory subject (Mokoro, Wambiya & Aloka, 2014). Two other science subjects offered to learners are Biology and Physics. The study of chemistry involves understanding the structure, properties and composition and the changes of matter that form the environment around (Njagi & Njagi,2015).

The relevance of chemistry in society needs not be overstated; its concepts are applicable in many of the day to day activities no wonder Opara and Waswa (2013) are of the proposition that 'chemistry is life'. It is a prerequisite subject to the study of courses such as medicine, pharmacy, engineering and other technological courses which play a pivotal role in fostering the achievement of Kenya's economic development blueprint; 'Vision 2030'. Moreover, the study of chemistry equips learners with critical skills of observation, analysis, experimentations, manipulations of variables and equipment which are very important in scientific investigations.

Despite this unique position taken by chemistry, the performance of students in the subject has not been good as depicted in summative examinations not only in Kenya but most countries in Africa and other parts of the world. Several studies have been conducted, some aimed at establishing the possible reasons behind this prevailing situation while others attempting to offer practical solutions to the problem. Several factors have been identified as possible causes of the low performance in chemistry at KCSE. They include teachers' negative perception of learners' ability (Ogembo, Otanga &Yaki, 2015), ineffective teaching methodologies (Cheruiyot, 2018; Keter, Barchok & Ng'eno, 2014; Kyalo, 2016; Mwangi, 2016), negative attitude and perception of learners (Khaombi, 2016; Kyalo, 2016), and lack of science process skills (Wachanga &Mwangi, 2004). Other factors include: lack of laboratory facilities in most schools (Cheruiyot, 2018), lack of effective practical work (Ituma &Twoli, 2015; Khamali, Mondoh &Kwena, 2017), lack of student motivation to be taught the subject (Keter, Barchok & Ng'eno, 2014), ineffective use of scientific language

(Chepyegon, 2011), and inherent difficult nature of the subject (Khamali et al, 2017) among others.

Among several probable factors contributing to poor performance in chemistry, use of ineffective instructional strategies stands out as the most prevalent reason. Both teachers and learners have been accused of engaging in teaching and learning strategies that do not promote meaningful learning of chemistry concepts. Cheruiyot (2018) observes that the current challenges facing the education system are as a result of wrong instructional methods used by teachers of science and mathematics especially chemistry in their presentations. Teachers have focused on teacher centered approaches of teaching to accomplish their classroom activities. This proposition is supported by Keter, Barchok & Ng'eno (2014) who acknowledges that most teachers use teacher centered teaching methods resulting in poor understanding of concepts and consequently poor performance by learners in chemistry. According to Kyalo (2016), most teachers use the lecture method and Mwangi (2016) attributes poor performance to poor teaching methods among other factors. It is out of this concern that the government of Kenya, through CEMASTEA, has rolled out inset teacher training programs like SMASSE, whose aim is to equip teachers of science and mathematics with requisite skills for effective content delivery to learners. SMASSE themes are based on research findings and recommendations on instructional strategies that are effective for teaching and learning science subjects.

Researchers in the field of chemistry education have offered suggestions on what they find to be the most appropriate method of teaching and learning chemistry. In the view of (Wachanga & Mwangi, 2004), in order to teach and learn chemistry successfully, there is need for correct use of a teaching method whose activities target most of the learning senses. It has been proposed that teaching of chemistry should be student centered where learners are actively involved in the learning process. A lot of emphasis has been placed on the use of the practical approach in teaching and learning of chemistry. It is in this vein that KNEC evaluation reports have regularly directed teachers to expose learners to more practical work that involves investigations (KNEC 2008-2015). Chemistry is inherently a practical subject where scientific concepts, principles and skills are developed through experimental investigation (Njagi & Njagi, 2015). Through science practical work, learners are given the opportunity to gain meaningful learning, acquire appropriate skills and attitudes to apply the concepts in novel situations. Practical oriented teaching is the best because theoretical work is related to real life situations which learners can associate and connect with for effective learning. Existing literature suggest that students enjoy laboratory work because it is more active, something they find more motivating (Hart, Mulhall, Berry, Loughran & Gunstone, 2000). In the laboratory, students have a chance to engage in hands-on activities, and learners find laboratory-based activities to be motivating and exciting (Markow & Lonning, 1998).

Despite the key role played by practical work in enhancing learning of chemistry, some challenges have been experienced by teachers with regard to effective implementation of practical lessons. One of the biggest challenges pointed out is lack of sufficient resources for laboratory work in secondary schools. Cheruiyot (2018), in his assessment of perceptions to SMASSE project on teaching and learning of chemistry in Bomet County observes that most schools lack well equipped science laboratories and this could be a contributing factor to poor performance in examinations despite the SMASSE- I.N.S.E.T training offered to teachers. The recent past has seen an upsurge in the candidature of students being examined in chemistry at KCSE (Njagi & Njagi, 2015; Mwangi, 2016; Kiige & Onywoki, 2016). This rise according to Njagi & Njagi (2015) is attributed to the introduction of subsidized secondary education in the year 2008. Such large number of students, they add, strains the physical, material, financial and human resources available for chemistry instruction hence compromise quality (Kiige & Onywoki, 2016). The other challenge commonly manifested hence preventing effective practical work implementation is the lack of technical knowhow by teachers on planning, structuring, and execution of chemistry practical lessons. Conventional step by step laboratory practical procedures that learners are subjected to seem not to yield the expected results. This in the view of Ituma & Twoli (2015) is because this kind of laboratory process is not investigative and does not provide enough opportunities for students to use their minds to solve problems in the laboratory. Mwangi (2016), approves this position by stating that whilst a practical approach is generally effective, it is seen as relatively ineffective in developing students' conceptual understanding of the associated scientific ideas and concepts. Although there is a positive relationship between chemistry practical work and performance in chemistry, the nature, quality and frequency of laboratory practical work needs to be put into consideration (Khamali et al). A suggestion by Ituma & Twoli, 2015 is that:

> "*Learners should be guided to identify problems and potential solutions, design their own procedures, predictions, products and solutions and link their experiences to activities, concepts and principles"* pg. 3.

Given the challenges facing implementation of the practical approach, which is the most recommended approach of teaching chemistry, the question posed at this point is; "which way for teachers of chemistry?" What alternatives are available at teachers' disposal for successful implementation of chemistry curriculum? A number of teaching models have been put forth by chemistry education researchers. These models are carefully planned instructional strategies which endeavor to improve the status of chemistry instruction (Nbina & Mmaduka, 2014).

Opara and Waswa (2013) were guided by Piaget's concepts of assimilation, accommodation and organization to develop what they referred to as the 'learning cycle'. This model of learning incorporates social constructivism principle which views learning as an active social process where leaners share ideas and interact in groups to build their understanding together. In their conclusion, they assert that the learning cycle is beneficial to both boys and girls and recommend that it should be adopted and used by teachers. A related study was conducted by (Ituma & Twoli, 2015) whose impetus was determining the practices that could develop scientific thinking skills in learners. A design- based- research design was employed to develop a Secondary School Chemistry Investigative Practical Work. This model was meant to serve as a route map to organizing and developing of instructional materials for use in chemistry learning of practical work. The outcome is that learners are intellectually and physically involved in the Chemistry learning activities which can lead to better understanding of science concepts and development of both manipulative and process skills. A teaching and learning model dubbed Cooperative Mastery Learning Approach was found to enhance students' motivation to learn chemistry irrespective of gender. Developed by Keter, Barchok & Ng'eno (2014), this strategy brings together Cooperative Learning and Mastery Learning approaches to teaching. Being a hybrid of the two approaches it is able to motivate students by not only appealing to their cognitive domain but also their affective domain. The researchers recommend the model to be used in order to improve performance and bridge the gender gap between boys and girls in learning of science.

The growing requirement for teachers to infuse Information and Communication Technology (ICT) in teaching and learning of science subjects has prompted researchers to develop teaching and learning models that are geared towards satisfying this emerging demand. It is in this vein that the effects of a Computer Based Simulation (CBS) teaching approach on the learning of chemistry were investigated by Mihingo, Wachanga and Anditi (2017). The study was motivated by poor performance in chemistry by students at national examinations due to teaching method among other factors. Like most models mentioned so far, the CBS approach was found to be more appropriate than regular teaching method regardless of gender. It is worth noting that the suggested models highlighted so far place a lot of emphasis on the active participation of the learner and meaningful learning of chemistry concepts.

It is expected that with the availability and use of these teaching models in the offing, performance in chemistry would have improved tremendously but this has not been the case. Even with SMASSE interventions the problem at hand is still prevalent. One of the aims of SMASSE was to help improve teachers' content knowledge and teaching methodology by equipping them with competence skills for them to adopt strategies of meaningful and deep learning (Opara & Waswa, 2013). Evaluation studies conducted on the impact of SMASSE have given the I.N.S.E.T training a green light with regard to addressing teachers' pedagogical skills, content mastery, attitudes, and use of T/L materials (Cheruiyot, 2018). Through the Activity-Student-Centered-Experiment –Improvisation (ASEI) pedagogical paradigm and Plan- Do-See-Improve (PDSI) approach, science teachers' confidence has improved and their ability to deliver lessons is more effective (Nduku, 2017). However, very few teachers have embraced ASEI/ PDSI methodology in teaching chemistry (Nduku, 2017) and this has hampered its implementation. Challenges faced include heavy workload on teachers who have cited lack of enough time to prepare ASEI lesson plans and lack of teaching and learning resources in most schools (Cheruiyot, 2018). Such a slow enactment of ASEI/ PDSI strategies by teachers could be the reason why learners are still doing badly in chemistry examinations at national level despite the SMASSE intervention. A study by Kiige & Onywoki (2016) on the effects of SMASSE on KCSE performance in Mathematics and Chemistry subject in Kikuyu sub county, the researchers concluded that SMASSE does not show positive impact on the performance of Mathematics and Chemistry notwithstanding the fact that teachers confidence and lesson delivery has improved tremendously. The situation seems to be the same in Makueni (Kyalo,2016), Kilifi (Khamali et al, 2017) Nairobi (Mwangi,2016), Machakos, Kitui (Nduku, 2017), Bomet (Cheruiyot, 2018) just to mention a few where researchers are in agreement that SMASSE project has not helped much in solving the problem of poor performance in chemistry at KCSE.

The present study's idea sprung out of a conviction that none of the intervention measures mooted so far has proved quintessential in helping improve performance in chemistry. This researcher sought to investigate the efficacy of two widely recommended teaching and learning approaches that are less explored in the Kenyan context. Sufficient evidence exists in literature on Concept Mapping and Retrieval Practice techniques in support of them promoting meaningful learning and retention of learnt concepts. The two approaches are not mutually exclusive but complementary and researchers have also considered the possibility of combining them for optimum results. The idea of meaningful learning and information retention is mentioned by a number of researchers investigating performance in science subjects by Kenya students. This has however not been their main focus of their studies and in designing alternative teaching models. Perhaps this could be the reason why most intervention measures have not been much effective; the psychological constructs of memory retention and retrieval of information have yet to be considered intensely. The current study aimed to correct this situation by developing a teaching/ learning approach from a psychological point of view. Retrieval Based Concept Mapping (RBCM) is the learning strategy suggested by the current study to be used in the T/L of chemistry. The next section is on review of existing literature on Retrieval Practice and Concept Mapping.

2.2 Active Learning Strategies: Elaboration versus Retrieval Practice

A large number of studies have shown that Elaborative Studying and Retrieval Practice are both effective in promoting meaningful learning and retention of information. However, educators heavily rely on elaborative studying which hold a central place in contemporary education with Retrieval Practice being used less frequently (Karpicke & Blunt, 2011). Students also lack awareness of the benefits of Retrieval Practice (Grimaldi & Karpicke, 2013) and their focus, just like most teachers, falls on processes involved in encoding new knowledge (Nunes & Karpicke, 2015). Repeated testing has been misconstrued as a practice meant to measure learning outcomes but does not by itself directly contribute to learning. On the contrary, a considerable amount of research has shown that the act of retrieving information from memory enhances learning and retention better than increasing the quality and quantity of study (Larsen, Butler & Roediger, 2013). When students receive instruction over some information through a lecture or reading assignment, practicing to recall that information afterward increases the chances that it will be recalled again in the future. Information that students practice recalling is retained significantly better than information that they do not practice recalling. Furthermore, practicing to recall information enhances later retention even when compared to alternative, non-retrieval-based strategies that involve additional exposure to the material, such as copying the information, or organizing it in a new way.

Retrieval Practice is a powerful way of enhancing memory (Hupbach, 2015) and research studies have compared the efficacy of the two learning techniques in promoting learning and retention of learnt material. Researchers in cognitive psychology have also investigated a potential approach to making Retrieval Practice more effective by enriching the process with the requirement to elaborate on the learning contents and linking them to what is already known (Endres, Carpenter, Martin, & Renkl, 2016). Results from these studies present a mixed bag of findings with some showing that Retrieval Practice is more superior to elaborative studying. Others have found out that implementing Retrieval Practice using elaboration activities like Concept Mapping yields greater benefits than using either of the two strategies on their own. Others results from related studies show that Concept Mapping and paragraph formats are equally effective as Retrieval Practice activities.

The architecture of a retrieval practice experiment entails an initial learning phase where learners study a set of materials. In the second phase, students in a retrieval practice condition are engaged in one or more set of activities requiring them to practice retrieving materials. Students in the control condition do not practice retrieval and may be involved in spending extra time restudying the material or complete other study activities like elaborative studying. In the third and final phase, students in all conditions take a final criteria test. According to Karpicke (2017), the general setup for retrieval practice experiment seems not complex but a few methodological issues must be considered when designing retrieval based learning research. Such issues include:

i. Direct verses mediated effects of retrieval practice.

Retrieval can influence learning in a variety of ways. Mediated effects of retrieval are realized through the processing that occurs during another activity by making study activities more effective. Thus, the effect of retrieval on learning is mediated, by enhancements in subsequent restudy. For instance, when students take a test, the outcome of the test provides feedback to teachers on the learners' strengths and weaknesses hence they are able to tailor their instruction accordingly. Students can also be motivated through tests because knowing about an upcoming test often leads students to increase their study efforts. Roediger and Karpicke (2006) proposed that these are mediated effects of testing or retrieval on learning.

In addition to the mediated effects of retrieval on learning, retrieval also produces direct effects on learning. The direct effects of retrieval can be seen when students study a set of materials and then practice retrieval without restudying or receiving feedback after retrieval. Any gains in learning from practicing retrieval, without restudy or feedback, represent direct effects of retrieval processes on learning.

ii. Balancing retrieval success and retrieval effort

Results from research on retrieval based learning clearly indicate that retrieval practice influences memory and learning. However, questions arise as to whether such effects are due to repeated retrieval, per se, or whether any re-exposure to the material under study would produce similar results. That is, periodically restudying the material could possibly produce effects similar to repeatedly retrieving them. To alleviate that concern, many investigators like Roediger and Karpicke (2006) have compared retrieval practice to conditions in which people restudy material. Several studies have shown that retrieval practice enhances retention even when compared to repeated studying, casting doubt on the idea that the results simply stem from re-exposure to the materials. However, comparing repeated retrieval to repeated study introduces a new set of methodological concerns. Specifically, subjects in retrieval practice conditions typically do not successfully retrieve the entire set of to-be-learned material, while students in repeated study conditions re-experience all of the materials. There is almost always an imbalance in re-exposure to the materials across conditions, a difference that depends on the level of retrieval success that students achieve in retrieval practice conditions. Because of differences in re-exposure to the materials across conditions, comparisons of retrieval practice and repeated study conditions are biased in favor of repeated studying. This makes it all the more impressive when retrieval practice outperforms repeated study, but it sometimes creates situations where no retrieval practice effect, or an advantage of repeated study, is observed.

Ideally, one would want to maximize retrieval success to equate exposure across conditions. Some investigators have attempted to equate exposure by providing feedback on retrieval trials. Although feedback does re-expose subjects to correct answers, and feedback is clearly beneficial when one's aim is to improve learning in educational settings, the provision of feedback introduces mediated effects and prohibits one from assessing the direct mnemonic effects of retrieval on learning. As an alternative, investigators might increase retrieval success by providing more initial retrieval support or by giving initial tests very shortly after material has been studied. However, conditions that increase initial retrieval success also make retrieval easier, and a good deal of evidence suggests that initial retrieval effort is an essential ingredient of retrieval-based learning.

In order to illustrate how concept mapping and retrieval practice strategies are complementary in supporting learning, four related studies which have compared the influence of Elaborative Study and Retrieval Practice approaches on learning and information retention are described. On the outset, several elaborative techniques have been developed in a bid to help learners generate their own systems of understanding knowledge. One example of an active learning strategy is what is referred to as 'self-explanation'. It involves learners generating explanations about why a particular piece of information is important and how it relates to their existing knowledge. A study by Larsen, Butler & Roediger (2013) directly compared the efficacy of this elaborative study technique with Retrieval Practice in terms of promoting long term retention and application of clinical material. The study also investigated the efficacy of combining self-explanation and self-testing given that the two techniques are not mutually exclusive. Forty-seven first year medical students participated in a teaching session that covered four clinical topics and was followed by four weekly learning sessions. Students were randomly assigned to perform one of the four learning activities for each topic: testing with self- explanation, testing without explanations, studying a review sheet with self-generated explanations and studying a review sheet without explanations. The same activity was repeated for each topic in all four sessions. Six months later, they took a free recall clinical application test on all four topics.

Results from the study led to a conclusion that repeated testing and generating self-explanations are learning activities that can produce superior long term retention and transfer but testing is generally more effective than self-explanation alone. The explanation for this finding was that Retrieval Practice is a more difficult task than generating explanations for information; hence the difficulty inherent in encoding and retrieving knowledge leads to more durable learning. This explanation seems to be in line with a proposition by (Lehman et al, 2014) who assert that retrieval tasks that provide the fewest cues produce the largest benefit. When more difficult tasks are used, they add, target information is less readily available and a more extensive search of memory is required allowing for most elaboration. A methodological gap is portrayed in the design of this particular study which is pointed out by the researchers. Sample explanations were provided on the answer sheet in an effort to avoid having to penalize students who might have forgotten so much information that they could not generate an explanation. This made it difficult to distinguish the effect of writing explanations from that of reading an explanation on an answer sheet. It was also observed that there was an interaction indicating some variation in the effectiveness of the learning techniques among topics. This may imply that some types of information may be learnt through self- explanation just as well as through testing.

The finding that repeated testing produces more robust long term retention and transfer of knowledge relative to ‘self-explanation’ has been replicated in other studies in which Retrieval Practice has been compared with other active learning techniques. For example, Karpicke & Blunt (2011) compared the effectiveness of Retrieval Practice and elaborative studying with Concept Mapping for producing meaningful learning of science materials. In one of the two experiments in the study, eighty undergraduate students first studied a brief science text under one of the four learning conditions within a single initial learning session. In the study-once condition, students studied text in a single study period. In the repeated study condition, students studied text in four consecutive study periods. In the elaborative Concept Mapping condition, students studied the text in an initial study period and then created a concept map of the concepts in the text. The Retrieval Practice condition entailed students studying and then practicing retrieval by recalling as much of the information as they could on a free recall test. After recalling once, the students restudied the text again and recalled again. The students returned to the laboratory one week later for a final short answer test. Results from this experiment showed that Retrieval Practice produced the best learning, better than elaborative studying with concept maps. The second experiment was a replication of the first one but extended to determine effectiveness of Retrieval Practice and Concept Mapping with different types material, individual differences among learners and different final test formats. In the study's experimental design, each student created a concept map with one science text and practiced retrieval with of a second text. This way they were able to determine how students with varying learning abilities benefited from the effects of Retrieval Practice and Concept Mapping. It was also postulated that the effectiveness of different learning activities can depend on the structure of the materials that students are learning. The researchers therefore sought to generalize their results to texts that represent different knowledge structures commonly found in science education: text with enumeration structures and those with sequence structures. Text structure was manipulated between subjects, half of them studied the two enumeration texts and half studied the two sequence texts. Final text format was also manipulated between subjects with half taking a final test that involved answering short answer questions, the other half created concept maps on the final test. Results from the study showed that even when the final test involved constructing a concept map, practicing retrieval during original learning produced better performance than engaging in elaborative study by creating concept maps. However, students produced a greater proportion of ideas on the initial concept map than they did on the initial tests in the Retrieval Practice condition hence the initial level performance favored the Concept Mapping condition. Results on the final short answer test were similar for verbatim and inference questions. The major finding by this study that Retrieval Practice is more effective than elaborative study with Concept Mapping appears to poke holes in the elaborative account of Retrieval Practice. The benefits of Concept Mapping are attributed to elaboration of information during encoding and if elaboration is the underlying mechanism for Retrieval Practice and Concept Mapping then the two techniques should produce near equivalent benefits for learning.

It is in the same vein that Karpicke and Smith (2012) questions the perception that elaborative encoding processes are responsible for the effects of Retrieval Practice. If that was the case, then the researchers wonder why it is not possible to induce elaboration directly during repeated study events and produce effects that are the same as or similar to those produced by repeated retrieval. In the study reviewed above, the advantage of Retrieval Practice was also observed across texts with different structures identical to those commonly found in science education. The type of material used in the study is relatively plausible and befitting a real educational setup. This is based on the fact that majority of prior studies on Retrieval Practice have used relatively simple material (Eglington & Kang, 2016) like word pairs and the effect size has been large.

In a study entitled ‘learning with retrieval based Concept Mapping’, Blunt and Karpicke (2014) conducted two experiments in which they examined effectiveness of Concept Mapping when used as a Retrieval Practice activity. In the first experiment, students read educational text and practiced retrieval either by writing down as many ideas as they could recall in paragraph format or by creating concept maps. In the second experiment, the format of the activity (paragraph versus concept map) and the presence or absence of text (repeated study or Retrieval Practice) was crossed in a factorial manner. Thirty -two undergraduate students participated in the study which was a conceptual replication of Karpicke and Blunt (2011) with one main change; rather than having students create concept maps while viewing text, they instead created them in the absence of texts. During Concept Mapping Retrieval Practice, students retrieved material by creating a concept map, whereas during paragraph Retrieval Practice, students wrote as much of the material as they could recall in paragraph format. Students were tested in small groups in two sessions. During the learning phase, students read one text for five minutes, re-read it for five minutes and recalled it again for ten minutes in one of the two Retrieval Practice conditions. Before completing the Concept Mapping Retrieval Practice condition, the students were instructed about the nature of Concept Mapping activity. During recall periods, they were given a sheet of paper and told to recall the text by creating a concept map. In the paragraph Retrieval Practice condition, students saw a response box on a computer screen and were told to recall as much of the information from text as they could by typing their responses on the computer during the ten- minute recall period.

The second experiment was designed with two main purposes in mind. First, to replicate experiment one and generalize the results to a new set of text materials. Second, two new conditions were included to directly compare Concept Mapping and paragraph formats when they are used as Retrieval Practice activities (without the texts) with when they are used as repeated study activities (with text present). Results showed that actively retrieving material during learning either by creating concept maps or by writing the material in paragraph format enhanced long term retention more than completing the same activities in the presence of the materials. Therefore, Concept Mapping and paragraph formats were equally effective as Retrieval Practice activities. Despite these findings, there are speculations that Concept Mapping might not serve as an effective retrieval based learning activity compared to free recall. The argument here is that Concept Mapping could introduce additional cognitive load during the process of retrieval or the mapping task might function as a secondary task that divides students' attention thus weakening the benefits of Retrieval Practice (Blunt & Karpicke, 2014). There are reasons to believe that for retrieval to be successful, the activity should be challenging enough to allow students to think back to a previous time when they learned information and retrieve what they remember from the context (Karpicke & Aue, 2014). At the same time, students need to successfully retrieve information hence Smith, Whiffen and Karpicke (2016) speculate that ensuring successful retrieval and context reinstatement can be fairly challenging. The point of discussion here has to do with which activity of Retrieval Practice between free recall and Concept Mapping presents a challenge to students, greater enough to induce context reinstatement yet not so much to hamper retrieval success.

The fourth and last related study reviewed here is one by Endres, Carpenter, Martin, & Renkl (2016) whose title is Enhancing Learning by Retrieval: Enriching Free Recall with Elaborative Prompting. The study sought to explore a potential approach to making retrieval more effective by enriching retrieval instructions with the requirement to elaborate on the learning contents and link them to what is already known. In the study, free recall condition was compared with a prompted recall condition in which learners were required to recall the information and apply it to their lives. Fifty-six undergraduate students were randomly assigned to one of these two conditions. They learned from a video-recorded lecture. One week later, learning outcomes were assessed by a posttest measuring fact recall and comprehension of the contents from the video lecture. Learners in the prompted recall group, compared to the free recall group, used more elaborative strategies in response to the recall task and achieved better comprehension scores. The effect on comprehension was mediated by the use of elaborative strategies. This pattern of results supports the constructive retrieval hypothesis, stating that retrieval is most effective when it involves constructive elaboration of the contents being learned. These findings encourage the use of pedagogical tasks in classroom teaching that combine elaboration and retrieval.

2.3 Concept Mapping

Concept maps have become a widely used educational tool which enjoys widespread popularity in educational settings (Grimaldi, Poston & Karpicke, 2015). A concept map is a graphical way of representing knowledge. It is made up of nodes that are interlinked by labeled and directed lines (Chiou, 2008). Nodes can be circles or boxes and they represent concepts. Lines represent a relation between a pair of concepts and the labels on the line tell how two concepts are related (Primo & Shavelson, 1996). Two nodes and a labeled line form a proposition, which is the basic unit of meaning in a concept map. Concept Mapping refers to the activity of creating a concept map (Alias & Tukiran, 2009), whose procedure as outlined by Karpicke (2018) starts by identifying key ideas, placing the ideas in nodes and drawing lines that link related ideas with a written description of the nature of the relation along the link. According to Sisovic & Bojovic (1999), concepts are the most important of all forms of knowledge; mental tools that enable a person to understand the environment.

Concept Mapping strategy, according to Markow and Lonning (1998), allows the theoretical ideas of Piaget, Ausubel and Von Glasserfeld to be implemented by teachers. Concept maps sprung out of Joseph Novak's research work. He was investigating the acquisition of science concepts by children at Cornell University and his development was an outgrowth of David Ausubel's theory of meaningful learning. They are hierarchical with broader, more general items at the top and more specific topics arranged in a cascade below them (Ajaja, 2011). When creating a concept map, the focus topic is positioned at the top with other concepts arranged underneath it on several levels. Lines are drawn from higher concepts to each of the lower level concepts that they are related to; and also between concepts on the same level.

Through Concept Mapping students understand complex ideas and ambiguous relationships are not only shown but also clarified, thus helping a learner to understand by showing their connections to other ideas (Ajaja, 2011). Asan (2007) alludes that the structure of knowledge can be visualized by Concept Mapping. Such a structure can be visualized where connections are revealed and students are helped to see how individual ideas form a larger whole. Concept maps also help students develop logical thinking and study skills, a useful requirement particularly in science education since science concepts, as Asan (2007) points out, are very inter-related and build on each other. When students see a clear organized picture of a broad unit covering various concepts, then they would build a deeper understanding and appreciation of these concepts. It can be said that concept maps are meant to bring out what is contained in a student's cognitive structure so as to see what the learner already knows (Primo & Shavelson, 1996). In the present study, the efficacy of concept mapping when used as a retrieval practice activity was investigated with regard to enhancing learning and retention of chemistry concepts. The basis of combining the two techniques is to reap maximum benefits from the learning opportunities that they offer hence the need to find out how best to design pedagogical tasks that integrates concept mapping and retrieval practice.

2.4 Concept Mapping and Meaningful Learning

Researchers have proposed meaningful learning as a suitable approach to teaching and learning of science concepts. To learn meaningfully is to interrelate and interconnect science concept; the learner is able to have a deep understanding of concepts and make meaning out of them hence be able to apply to novel situations. To learn meaningfully requires active participation of the learner and this is opposed to rote learning where learning is by memorization of facts without making much meaning out of them. Meaningful learning is one of the greatest concerns of cognitive psychology as Novak and Canas (2006) observe. It occurs if a learner has relevant prior knowledge and the learner should be willing to apply the effort needed to attain meaningful learning (Boujaoude & Attieh, 2003). Assimilation theory stems from Ausubel's idea of meaningful learning which occurs if the learner has relevant prior knowledge (Novak, 1998). For Novak, meaningful learning builds a person's cognitive structure by assimilating new concepts into one's existing conceptual structure (Ajaja, 2011). Taber (2001) describes how meaningful learning is achieved; the human brain makes sense of new information by using existing conceptions to interpret information into something meaningful. Previous learning is therefore important in understanding and interpretation of information. Markow and Lonning (1998) notes that most of the misconceptions that learners hold are due to either ignoring or not recognizing student's prior knowledge. Meaningful learning requires active involvement of the learner and this can be encouraged by the process of

Concept Mapping. Concept Mapping provides a basis for relating new knowledge to previously assimilated knowledge.

Ausubel's theory of meaningful learning is most important in explaining how to transform information from short term memory to long term memory. According to this theory, it occurs when complex ideas and information are combined with students' own experiences and prior knowledge to form personal unique understandings (Kilic & Cakmak, 2013). When students comprehend the relationship of what is being learnt to other knowledge the information is imbibed completely hence remembered better. Meaningful learning occurs by the process of subsumption when potentially meaningful propositions are subsumed under more inclusive ideas in existing cognitive structure (Odom & Kelly, 2000). The learner must consciously relate new ideas to relevant aspects of their current knowledge structure in a conscious manner. The process of meaningful learning can be improved by Concept Mapping, graphically representing concepts in a hierarchically arranged structure and begins to progressively differentiate among concepts. In summary, Concept Mapping is believed to facilitate meaningful learning by serving as a framework to help organize knowledge and to structure it. The problem of poor performance in chemistry can be alleviated by encouraging students to learn concepts meaningfully as opposed to rote learning. The present research's main focus was how students' performance in chemistry can be improved by use of concept maps and Retrieval Practice as study skills. The underlying conception here is that if students are exposed to study strategies that are more effective in enhancing the retention of concepts learnt, then they are likely to achieve better in examinations hence improved performance.

2.5 Concept Mapping and Information Retention

In a typical learning experience, a learner is expected to retain the concepts learnt and be able to reproduce later especially in an examination. Previous research work has associated Concept Mapping with enhanced information retention and subsequent improvement in performance. It is in this respect that this study endeavors to determine if students' retention of chemistry concepts can be fostered by Concept Mapping. A student's concept map is interpreted as representing important aspects of the organization of concepts in his/her memory or cognitive structure (Tsai & Huang, 2002). Learning is an experiential process whose evidence that it has taken place is the change in behavior. The change can be demonstrated through students' response to questions (Taber, 2003). Effective learning can therefore be measured by the ability to retain learnt material and apply it to novel situations. According to Feldman (2011), memory is a process by which information is encoded, stored and retrieved. Various models are used to explain how memory functions. One such widely accepted model is the three systems approach which proposes that there exist three separate memory stores; sensory, short term and long term. According to this model, there are three basic tasks performed by human memory; encoding, storage and retrieval. Baron and Kalsher (2005) add that encoding is converting of information into a form that can be entered into memory; storage involves retaining information over varying periods of time. When specific information is needed at later times, it is located and accessed through the process of retrieval.

The second model is the 'level of processing' which is particularly related to how information is encoded. Its central idea is the proposition that how long information is remembered largely depends on how completely it is analyzed and connected with other information (Woolfolk, 1998). A blend of these two models is the position taken by the researcher in order to explain the process of memory and how it can be improved in a learning situation. Sensory information enters the S.T.M when attention is directed to it. Information in S.T.M enters L.T.M through the process of rehearsal (Baron& Kalsher, 2005). It is however important to note that the kind of rehearsal carried out determines whether or not the transfer is made. Information is more likely to be transferred to L.T.M if it is elaborated during encoding. This occurs when information is considered and organized by expanding on it to make it fit into a logical framework, linking it to other information in memory or transforming it in some other way. Atkinson, Smith. & Bem (1993) suggest that forgetting from L.T.M is not due to loss of the information but rather the loss of a link to the information.

Building more links to existing information creates more routes to be followed to get the original information, enhancing retrieval. To sum up, memory can be improved by elaborating items during encoding, this is because the more connections are established between items, the larger the number of retrieval possibilities. The more students elaborate new ideas, the more they have a deeper understanding and the better their memory for the knowledge. Concept maps can be useful in organizing material and building extra links to existing knowledge in memory. This is given the fact that material that is well organized is easier to learn and to remember than bits of information especially if complex or extensive. Moreover, elaborative Concept Mapping offers students the opportunity to completely analyze and think deeply about new information, increasing chances of successful retrieval.

2.6 Concept Mapping and Academic Achievement

Several previous studies have examined the effect of concept mapping on academic achievement in science education. To begin with, Arokoyu & Obunwo (2014) conducted an experimental study whose main objective was to investigate the use of concept mapping as an instructional strategy for retention of organic chemistry concepts. The study relates with the present one given that the topic under investigation in both cases is organic chemistry. The Population for the study was all senior secondary school 3 students in Obio-Akpor, Rivers state, Nigeria. The sample was made up of ninety (90) Senior Secondary 3 (SS 3) Chemistry students split into 2 groups namely experimental and control. The research instruments were validated Organic Chemistry Aptitude Test (OCAT), Organic Chemistry Retention Test (OCRT) consisting of 10 items each and a lesson note on concept mapping. In the methodology for this particular study, the experimental group was taught using concept mapping (that is the treatment) and the control group taught using the normal lecture method (that is no treatment). A post-test which is an equivalent form of the pre-test was administered. Then, after three weeks OCRT which is a reshuffled form of the post-test OCAT) was administered to both groups. The execution of the entire study lasted for 5 weeks.

The results of the study showed that the experimental group performed better than the control group. This shows that concept mapping enhances performance and retention of knowledge. The study recommended that workshops and seminars should be organized by education authorities to sensitize science teachers in order for them to acquire the skills and competences required for effective use of concept mapping strategy. The above reviewed study throws weight to a growing body of research findings that support the use of concept mapping for teaching and learning of science subjects. The study does not however offer an explanation on the mechanisms responsible for enhanced performance and retention of learnt concepts. Contemporary research on educational practices seeks to offer explanations about the underlying mechanisms of educational intervention practices responsible for influencing learning. This is to enable educational practitioners to best structure teaching and learning activities that will yield maximum results from such practices.

Jack (2013) conducted another study which compared concept mapping and guided inquiry instructional strategies. The study aimed at finding out how these instructional approaches can enhance more meaningful understanding of difficult concepts in chemistry and increase academic achievement. The design for the study was quasi experimental pretest, posttest with six intact classes. The study sample consisted of 251 secondary school students from a state in Nigeria. Two chemistry teachers were pre- trained and given copies of instructional packages consisting of six week instructional units, a lesson plan and instructional materials. All the participants were pretested before treatment which extended for six weeks. During this period, students in the experimental group were taught using the concept mapping and guided inquiry methods. The control group on the other hand was taught using the expository method. At the end of six weeks, post achievement test scores were collected, followed by a follow up test four weeks later. Results from the study indicate that students in the experimental groups had higher achievement than those in the control group. Furthermore, those in the concept mapping group performed better than those in the guided inquiry and expository methods.

Previously, results from a study by Alias & Tukiran (2010), were in agreement with those of Jack (2013). The study sought to investigate the effects of using teacher generated concept maps on the learning of linear motion in Physics. A pre and posttest quasi experimental design with a control group was employed, with the samples for the study consisting of two intact classes from a school in Malaysia. A physics achievement test was used to measure knowledge on physics concepts. The experimental group of 28 students was taught physics with the aids of concept maps that were generated by the teacher while the control group (n= 29) was taught using the conventional method without concept mapping. The same test was used for pre and posttest. The researchers found that students learn better when concept mappings are used in the teaching and learning of selected concepts. It was also noted that students retain more of what they have learnt in the long term memory. However, no attempt was made to explain how concept mapping improves retention of learnt material.

Another study entitled ‘The effect of concept mapping on attitude and achievement in a physics course’ produced results that are in agreement with those considered so far. The researcher, (Karakuyu, 2010), used 58 ninth grade students from two classes in a Turkish high school as participants. What differentiates this study from the others that have been highlighted is the fact that concept maps were drawn by the learners and not the teacher(s). The experimental and control groups were pretested with a teacher constructed physics achievement test. The study duration was six weeks, with the classes meeting two times per week. One teacher trained the experimental group to construct concept maps as home work for one week. The same teacher taught the control group in which students covered the same physics content with rote learning as training lectures. During the treatment period, the experimental group participants were required to submit concept maps drawn, the assignment were scored and feedback given. The control group completed traditional homework assignments during the six week study period. Both groups took a post test and concept maps attitude scale at the same time.

Although the research findings from this study shows the positive effects of concept mapping as a tool for teaching and learning, the researcher acknowledges that they are not conclusive. Recommendation is made for further research with a larger sample and also find out the possible benefits from using computers in the process of concept mapping. Similar recommendations were made by Boujaoude & Attieh (2007) whose study examined whether or not the construction of concept maps by students improves their achievement and ability to solve higher order questions in Chemistry.

An attempt to adopt such recommendations like incorporating computers in concept mapping was made by Asan (2007). The research was meant to determine the effects of incorporating concept mapping on the achievement of fifth grade students in science class. The study was conducted over a five day period during classes that met for ninety minutes each day. A total of 23 students were randomly divided into the experimental and control groups. In the control group, students were taught using the lecture method with overhead transparencies and a unit worksheet. On the fourth day, a 60 min pretest was administered, followed by an oral review of the week's material. On day five of the treatment period, students completed a sixty minute posttest.

In the experimental group, students were taught on concept mapping and the procedure for creating concept maps using *inspiration* computer program. They were then placed in groups of three and given a short activity to test their understanding of the process. The teacher introduced the objectives for learning; a short list of 22 concepts was produced during class discussions. After that students worked individually to draw maps of these concepts using *inspiration*. In day five, students completed a 60 minute posttest. Findings of this study revealed that concept mapping has a noticeable impact on students' achievement and attitudes. The sample size for this study was small (23), and this could have been a limiting factor in making generalization of the findings. The study duration was also short; five days may not be sufficient to train students on concept mapping. This is owing to the fact that the skill requires time for mastery (Boujaoude & Attieh, 2007).

The present research's main focus is how students' performance in chemistry can be improved by use of concept maps as a study skill. The underlying conception here is that if students are exposed to study strategies that are more effective in enhancing the retention of concepts learnt, then they are likely to achieve better in examinations hence improved performance.

2.7 Summary

Literature reviewed in this chapter points out to a number of issues related to the present study. First, ineffective T/L approaches is the most predominant reason behind poor performance in Chemistry at KCSE. Several intervention measures have been made including use of various suggested T/L models. Concept Mapping and Retrieval Practice have been found to be effective in enhancing meaningful learning and retention of concepts but have been given little or no consideration as possible strategies that can help out in this situation as useful educational tools in Kenyan schools. Particularly, no study has considered retrieval practice as a possible strategy that can help promote learning of chemistry. It is in this vein therefore that the researcher found it necessary to investigate the effects of a T/L model RBCM on retention and retrieval of chemistry information, which is a precursor to achievement in a subject area.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.0 Introduction

This chapter highlights the procedures and methods that were employed to implement and collect data for the present study. It outlines the design for the study, study location, study population, sampling procedure and instruments for data generation. The pilot study, procedures for data collection and methods of data analysis are also discussed here.

3.1 Location of the Study

The study was conducted at Turkana Girls' Secondary School (TGSS). This is a national school in Loima Sub-county of Turkana County, located 52 kilometers from Lodwar town. The nearest market center to the school is Lorugumu which hosts the Loima Sub-County headquarters. The Latitude of Lorugumu is 2.89 while the Longitude is 35.26. Turkana County is the largest in Kenya and again ranked the poorest. It is bordered by three countries: Ethiopia to the East, Uganda to the West and South Sudan to the North. The county is located in the North Western part of Kenya in an arid area receiving less than ten inches of rain a year and is considered to be an arid zone. The majority of people who reside in this county are the Turkana people who are pastoralists raising cattle, goats and a few camels roaming wherever they can find food and water for their animals. Many of their children still do not have the opportunity to go to school with women earning some income from their beautiful woven baskets and mats.

No food production activities are carried out in this region except for those located next to a river which holds water throughout the year. All food and supplies are brought in from other regions.

TGSS is a three streamed school established in 1978 and currently, the student population stands at six hundred. It is a girls' boarding school with a national status hence it has a catchment area for students which is extensive with students being drawn from all over the country. Majority of students are however natives of Turkana county. The main reason of choosing the school for conducting the study was because of poor performance in Chemistry at KCSE. At TGSS, neither Concept Mapping nor Retrieval Practice is used in the teaching and learning of chemistry and that is why there was need to investigate whether these strategies can help improve on performance in the subject. Moreover, the researcher had a good working relationship with the school community, which was considered a conducive set up that would ensure smooth execution of the study.

3.2 Research Design

A research design is a roadmap or plan used to generate data to be used in a quest to answer research questions. Quasi experimental design was employed for this study. According to (Ary, Jacobs, Razavieh & Sorensen, 2006) this is a type of experimental design where participants are not randomly assigned to their respective study groups. The researcher found this design appropriate since it allowed data to be generated and a comparison of three intact classes to be made without a change in class teaching routine. The type of quasi experimental used was the non- equivalent comparison group pretest-posttest design. It was deemed most fitting in a typical school situation because routines will not be disrupted nor classes reorganized to fit the research study processes. This design is diagrammed as:

$$\mathbf{O_1\text{-------}X\text{-------}O_2\text{----------}O_3}$$

$$\mathbf{O_1\text{--------}Y\text{-------}O_2\text{----------}O_3}$$

$$\mathbf{O_1\text{--------}Z\text{--------}O_2\text{----------}O_3}$$

Figure 3. 1: **A diagrammatic representation of the research design used in the present study**

In the above diagram, X, Y and Z are the treatments, O_1 are pre- tests while O_2 and O_3 are post-tests. The design consisted of three instructional groups: Concept Mapping (Group 1), Retrieval Practice by Free Recall (Group 2) and Retrieval Practice by Concept Mapping (Group 3) which formed the independent variables. In order to ascertain equivalence (in chemistry performance) of the three treatment groups before the experiment, results of both individual participant and group performance in four prior chemistry examinations were analyzed using Kruskal- Wallis test to ascertain whether difference in pre-treatment examination mean scores was significant or not.

3.3 Variables

The independent variables in this study were Concept Mapping and Retrieval Practice whereas the dependent variables were Information Retrieval and Achievement in Chemistry.

.4 Study Population

Target population is all the members or objects involved in a study (Kothari, 2004). The population consisted of form three students (N=107) at Turkana Girls' Secondary School from which a sample for the study was drawn.

3.5 Sample Size and Sampling Procedure

Convenient sampling technique was used to select the school where the study was conducted. In this technique, participants are selected because they are easiest to recruit due to their availability and proximity to the researcher (Mugenda, 2008). The sample size was of one hundred and three (103) with the experimental groups being three intact classes of form three secondary school students at TGSS. One of the classes had 38 students another had, 42 students and the third one had 40. According to Fraenkel & Wallen (2010), a minimum of 30 individuals per group is recommended for experimental research. Similar studies have used sample sizes ranging from 32 (Blunt & Karpicke, (2014)), 47(Larsen, Butler & Roediger, (2013) to 80 (Karpicke & Blunt (2011)). The average age of participants was 17 years old.

3.6 Research Instruments

Three instruments were used to generate data for the study: Chemistry Pretest (C.P.T), Chemistry Achievement Test (C.A.T) and Chemistry Retention Test (C.R.T). The instruments were developed by the researcher and administered to participants as tests. Test items in all the instruments comprised of concepts drawn from the three-week instructional material on the topic Organic Chemistry I.

3.7 Piloting the Study

According to Cozby (2007), a pilot study is a trial run with a small number of participants to determine whether participants understand the instructions, whether the total experimental setting seems plausible, whether any confusing questions being asked etc. A pilot study was conducted in the same school that the present study was conducted (TGSS). Students of a form three class preceding the one used in the present study provided a sample that was used in piloting data collection instruments and procedures. The cohort of students that participated in the pilot study had similar characteristics as that which took part in the research study. Kombo and Dolno (2006) suggest that a pilot study helps in testing the feasibility of the study; the researcher is able to assess the clarity and user friendliness of test instruments and the time required to administer them (Mugenda, 2008). This not only helped the researcher to ascertain the practicability of the intended study but also determine the reliability of the instruments. In addition, time required to conduct specific treatment procedures was ascertained.

3.7.1 Validity of research instruments

Validity refers to the extent to which items in a research instrument measure what they purport to measure. Kothari (1985) suggests that content validity can be determined by using a panel of experts to make a judgment on how well the measuring instrument meets the standards. For this study content validity was tested by discussing the instruments with the supervisors and experienced teachers of chemistry in the school. Suitability of the instruments was analyzed with respect to the research questions. The experts' comments helped to improve the validity of the test instruments by making adjustments on the items where necessary.

3.7.2 Reliability of research instruments

Reliability is the consistency of results obtained by the same subject when an instrument is administered on different occasions (Phelan & Wren, 2006). Reliability of test instruments for this study was determined during the pilot study using the test re-test method. The instruments were administered to the same group of students at a time interval of two weeks. The Pearson Product Moment Coefficient (r) between the two sets of scores estimated the reliability of the instruments to be 0.78, 0.76 and 0.84 for the C.P.T, C.A.T and C.R.T respectively. According to Mugenda & Mugenda (2003) a coefficient of 0.70 or more depicts high reliability of the instruments. Parallel forms reliability was used to examine the similarity between C.P.T and C.A.T given that the two instruments had the same ideas tested but in a different form. According to Salkind (2004) this type of reliability is used when you want to have another set of items that is similar in task demands, but with different content. A Pearson product moment correlation coefficient (r) of 0.72 was obtained.

3.8 Scoring the instruments

The test instruments together with the revision sessions' sheets containing idea units generated were jointly marked and scored by teachers of Chemistry at TGSS. The CPT, CAT and CRT were scored on a scale of 0 to 30. The revision session scores were awarded on a scale of 0 to 15 idea units. The number of test items in the CPT, CAT and CRT were 23, 21 and 22 respectively. Each of the three revision sessions was guided by 15 concept areas from which the students were to generate idea units.

3.9 Data collection Techniques

The study was conducted over a nine- week period during the second term of the Kenyan secondary school calendar year. Three intact classes were randomly assigned to treatment groups. The experiment period was divided into three parts; the first spreading over one week during which participants in their respective groups were introduced to experimental treatment learning conditions basing on the content of a previously covered topic (The Mole). This was meant to train participants on key aspects of Concept Mapping, Retrieval Practice by Free Recall and Retrieval Practice by Concept Mapping. Experimental Group One participants were introduced to Concept Mapping and guided on how to construct a concept map following a step by step procedure adopted from Kilic and Cakmak (2013). Participants in experimental Group Two and Three were trained on how to practice retrieval either by free recall (Group Two) or by drawing Concept Mapping in the absence of material being studied (Group Three).

The second part of the experiment was a three- week instruction period where all groups were taught Organic Chemistry concepts following an instruction schedule prepared in advance (Appendix V). Three teachers of chemistry from TGSS (who served as instructors) were initially trained and used to present the content materials to the participants. At the end of the training, the instructors were given copies of the instructional packages comprising of an instructional guide, a comprehensive lesson plan to be taught and instructional materials. The classes which met five times a week for forty minutes of instruction (four lessons) and one eighty minutes long double lesson. At the end of the instruction period, participants in all groups sat for a C.P.T to assess how much Organic Chemistry concepts they had learnt from the instruction sessions.

In the last part of the experiment, the groups met for three revision sessions in one week each session lasting one hour. During the sessions, each student was provided with a list of key concepts (Appendix IV) guided by a focus question for a particular content area to be reviewed. They were also availed with summarized Organic Chemistry notes for each focus area that was to be reviewed. Participants in the elaborative Concept Mapping condition reviewed Organic Chemistry text in an initial twenty- minutes study period. They were then directed to spend the next twenty minutes creating concept maps on a sheet of paper while referring to the text and reviewing their maps to include all the details from the text in their maps. The group's teacher supervised compliance with these instructions.

In the free recall Retrieval Practice condition, students studied Organic Chemistry text in an initial study period and then practiced retrieval by recalling as much of the information as they could on a free recall test. After recalling once, the students restudied the text and recalled again. After studying text for ten minutes, they were told to recall and write down as much of the information from the text as they could in any order they chose. The recall test lasted for twenty minutes and thereafter they re-read the text in another ten-minutes study period and recalled it again in another twenty- minutes recall period. Text materials were withdrawn from participants after each study period so that they had no source to refer from during recall. The third group's treatment involved practicing retrieval by Concept Mapping. Here, participants were required to draw concept maps just like those for experimental group one, but without referring to text being reviewed. The duration of initial text study period and for constructing concept maps was identical to that in the elaborative Concept Mapping condition. Overall, the total amount of learning time was equal in all the comparison groups.

One week after the treatment period, participants in all groups took a C.A.T (Appendix II) consisting of items from the entire instruction material. This post- test was meant to measure the extent of the treatment effect on participants. Three weeks after treatment, a C.R.T (Appendix III) was administered to participants in the three groups to measure the level of retention of learnt material. A retention interval of three weeks was chosen arbitrarily without a specific criterion being followed. The researcher was however informed by previous related research work. At the end of each revision session, each participant's review sheet of paper was collected and assessed by a team of chemistry teachers. Constructed concept maps were rated basing on a scoring rubric adopted from Kilic and Cakmak (2013).

3.10 Data Analysis Techniques

Raw data obtained from the study was presented in tables for coding and analysis using Statistical Package for Social Scientists (S.P.S.S) version 23. Descriptive statistics (graphs, measures of central tendencies and measures of variability) together with inferential statistics (Kruskal-Wallis) were used to analyze data generated.

3.11 Logistical and Ethical Considerations

According to Mugenda and Mugenda (2003), logistics in research refers to all those processes, activities or actions that a researcher must address or carry out to ensure successful completion of a research project. Upon obtaining a research permit (Appendix VII) from National Commission for Science Technology and Innovation

(N.A.C.O.S.T.I), the researcher sought permission from the Turkana county ministry of education office and then from the TGSS administration to carry out the study from the school. Ethical considerations for this study included debriefing participants at the end about the aim of the study.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, INTERPRETATION AND DISCUSSION

4.0 Introduction

This chapter presents the results of the study. An analysis of data is done and interpretation of findings made and discussed. The focus of the study was to determine if RBCM as a study technique can be effective in enhancing performance and retention of chemistry concepts. A comparison was made with regard to effectiveness of three study strategies associated with Concept Mapping and Retrieval Practice. Data was collected by use of test instruments developed by the researcher and analyzed using both inferential and descriptive statistics. Before analyzing any set of data, a careful determination was made to ascertain whether they met the criteria for a particular statistical analysis. Test for normality was done using the Kolmogorov- Smirnoff test (K-S test) while homogeneity of variance was ascertained using the Levene’s test. Where the requirement for normality of data was not met for instance, an attempt was first made to correct the data using log, square root or reciprocal transformations as suggested by Field (2005). Where such corrections did not work, non- parametric alternative analyses were put to use. This chapter is divided into five sections; Section one deals with an analysis of pre- treatment examination scores, section two gives an analysis of pretest scores. Section three focuses on data obtained by participants during treatment (study/revision sessions) while the fourth and fifth sections presents post treatment data (Chemistry achievement and retention test scores) respectively.

4.1 Pre- treatment Examinations Scores

In order to ascertain equivalence of the three treatment groups at the outset, participants' performance in past four chemistry examinations were analyzed and the results for each group's average score are shown in table **4.1**

Table 4.1: ***Descriptive statistics and Kruskal- Wallis H test for pre-treatment examinations scores per group.***

Variable	Exp. Group	N	Mean	Std. Deviation	H-Value	df	P-Value
Pre-treatment	1	33	52.39	13.33	.328	2	.849
Examinations	2	34	52.09	12.69			
Scores	3	36	51.11	13.02			

The above results (H (2) =.328, p =.849) show that the three treatment groups did not differ significantly in their pre- treatment chemistry examination scores. This implies that the three groups were almost similar in terms of the way they acquired chemistry concepts and hence similar performance ability in chemistry.

4.2 Pretest scores.

After being taught Organic Chemistry concepts, participants in all groups were given a chemistry pretest (CPT) which comprised of test items from the entire topic taught. The pretest was meant to assess the level to which they had acquired and understood the concepts taught. Table **4.2** shows a summary of how the three groups performed on the pretest.

Table 4. 2: ***Descriptive statistics and Kruskal-Wallis H test of Pretest scores***

Variable	**Exp. Group**	**N**	**Mean**	**Std. Deviation**	**H-Value**	**df**	**P- value**
Pretest scores	1	33	13.3	2.378	4.409	2	.110
	2	34	13.2	2.754			
	3	36	14.3	3.086			

The above results show that the Retrieval Practice with Concept Mapping group (group 3) had the highest performance on the pretest (Mean =14.3, Std. Dev= 3.1). Performance of the other two groups in the pretest was almost identical (Mean= 13.3, Std. Dev =2.4) and (Mean= 13.2, Std. Dev= 2.7) for the Elaborative Concept Mapping and Retrieval Practice by Free Recall groups respectively. Kruskal- Wallis H test results indicate that the difference in performance among the three groups on the pretest was not significant (H (2) =4.409, p =.110) and therefore it was concluded that the groups were near identical in terms of performance on the pretest. This finding corroborates the earlier outcome to the effect that the three groups were almost equivalent in acquisition of chemistry concepts. Concerns about existence of group differences with respect to academic ability of participants before exposure to treatment were somehow allayed.

4.3 Revision Sessions Scores

Treatment procedures geared towards testing hypothesis entailed subjecting participants to different study techniques basing on Organic Chemistry concepts taught earlier. Material was fitted into three study units and apportioned to three revision sessions. The aim was to find out which revision strategy would yield the greatest benefits for learners to attain and retain chemistry concepts. During revision sessions, each participant was required to generate idea units from the materials revised in a session in line with the study strategy for their groups. The proportion of idea units produced by a participant was assessed using a specified criteria and recorded. Table **4.3** provides a summary of the average idea units produced per group during the revision sessions.

Table 4.3: ***Descriptive statistics and Kruskal- Wallis H test of average idea units generated during revision sessions.***

Variable	**Exp. group**	**N**	**Mean**	**Std. Deviation**	**H-Value**	**df**	**P-value**
Revision Session Scores	1	33	7.88	1.36	17.925	2	.000
	2	34	7.97	1.03			
	3	36	6.81	1.17			

The results show that on average, the Retrieval Practice by Free Recall group generated the highest proportion of ideas during revision sessions (Average = 8.0, Std.

Dev. = 1.02) followed by the Elaborative Concept Mapping group (Mean = 7.9, Std. Dev= 1.4). The Retrieval Practice by Concept Mapping group had the least proportion of idea units produced (Average = 6.9, Std. Dev= 1.2). A further analysis was done to determine the level of significance of the observed differences in revision session scores. Kruskal –Wallis H test was done and the outcome indicates that the proportion of ideas generated during revision varied significantly among the three groups (H (2) =17.925, p=.000). From these findings, it was concluded that during revision sessions involving Organic Chemistry concepts, participants in the Retrieval Practice by Free Recall group were able to generate the highest proportion of ideas while the Retrieval Practice by Concept Mapping group participants generated the least number of idea units.

4.4 Chemistry Achievement Test Results.

After treatment, participants were subjected to a Chemistry Achievement Test (CAT) which was meant to measure the extent of the treatment effect on participants. Results in table **4.4** show that the Retrieval Practice by Concept Mapping group benefited the most from the treatment procedure (Mean=17.67, Std.Dev. = 3.3), followed by the Retrieval Practice by Free Recall group (Mean = 17.35, Std. Dev. =2.9). The Elaborative Concept Mapping Group performed the least on the achievement test (Mean = 16.55, Std. dev. = 2.6).

Table 4.4: ***Descriptive statistics and Kruskal-Wallis H test of Chemistry Achievement Test scores per group.***

Variable	Exp. group	N	Mean	Std. Deviation	H-Value	df	P-value
CAT	1	33	16.55	2.54	2.194	2	.334

scores	2	34	17.35	2.86
	3	36	17.67	3.31

There was no significant difference in the average C.A.T scores among the three experimental groups (H (2) =2.194, p=.334).

In order to ascertain how individual participants had gained from the revision sessions, pretest scores were subtracted from CAT scores to compute an approximate gain for each participant as shown in table **4.5.**

Table 4.5: ***Average gain from revision sessions per group***

Variable	**Exp. group**	**N**	**Mean**	**H-Value**	**df**	**P-value**
Average gain from revision	1	33	3.2	2.000	2	0.368
	2	34	4.1			
	3	36	3.4			

It was observed that on average, each participant in the Elaborative Concept Mapping group gained 3.2 score units from the revision sessions which was the least compared to 3.4 and 4.1 for the Retrieval Practice by Free recall and the Retrieval Practice by Concept Mapping groups respectively. A further analysis revealed that there was no significant difference in individual participants' gain from revision sessions among the three treatment groups. This outcome confirms the earlier finding that the groups achieved an almost similar performance in the C.A.T.

4.5 Chemistry Retention Test results

The present study sought to determine which of the three treatment procedures was more effective in enhancing learners' retention of chemistry concepts. A Chemistry Retention Test (CRT) was given three weeks after treatment to measure how much ideas units would be recalled by participants in each group. Results obtained favor the Retrieval Practice by Concept Mapping group which had the highest average idea units recalled ((Mean=17.3, Std.Dev. = 3.3). Elaborative Concept Mapping group scored the least on the retention test ((Mean=14.6, Std.Dev. = 2.3) and for the Retrieval Practice by Free Recall (Mean=16.7, Std.Dev. = 3.6) (see table **4.6**)

Table 4.6: ***Summary of Average Chemistry Retention Scores***

Variable	Exp. group	N	Mean	Std. Deviation	H-Value	df	P-value
CRT scores	1	33	14.45	2.36	15.037	2	.001
	2	34	16.68	3.63			
	3	36	17.25	3.26			

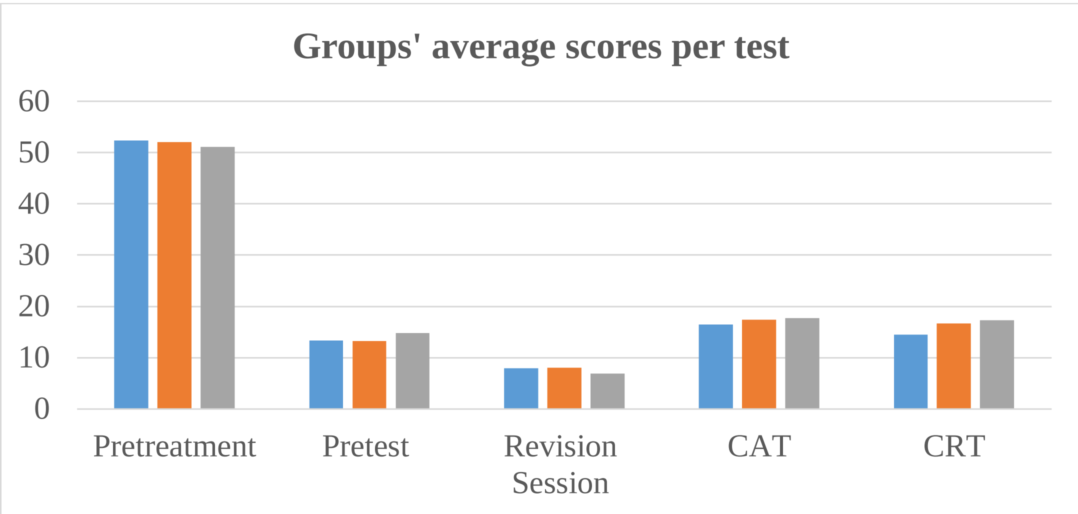
A Kruskal- Wallis H test for equality of means whose results (H (2) =15.037, p=.001) show that the difference among the groups in performance on recall test was indeed significant.

4.6 Summary

Table **4.7** provides a summary of findings by ranking the average scores for each experimental group on all the sets of data analyzed in this chapter. Fig **4.0** elucidates the summary in form of a bar chart.

Table 4.7: ***Position on ranked average score for various tests***

Exp. Group	Position and Score				
	Pretreatment	**Pretest**	**Revision Session**	**CAT**	**CRT**
1	1 (52.4)	2 (13.3)	2 (7.9)	3 (16.5)	3 (14.5)
2	2 (52.1)	3 (13.2)	1 (8)	2 (17.4)	2 (16.7)
3	3 (51.1)	1 (14.8)	3 (6.9)	1 (17.7)	1 (17.3)



Source (Field data).

Figure 4. 1: A column bar chart comparing group performance on various tests.

From table **4.7** and Figure **4.0**, the three treatment groups were apparently equal on the outset of the experiment in terms of acquisition of chemistry concepts. This is evidenced by the almost identical pretreatment scores across the groups. Additionally, the pretest scores confirm that the groups were near equivalent and that there was no significant difference in chemistry performance ability among them. This meant that the groups were homogenous hence suitable for the study. The outcome of revision sessions indicates that the RBCM (group 3) had the least average score but scored the highest on both the CAT and CRT. Another pattern observed from the summary is that apart from the pretest, the ECMG was inferior to both RPFR and RBCM groups in all the other tests. This implies that Retrieval Practice as a study skill was more superior to elaborative Concept Mapping in enhancing performance and retention of Organic Chemistry concepts. Between free recall and Concept Mapping as Retrieval Practice activities, it was found that the RBCM group scored highest in pretest, CAT and CRT compared to RPFRG. It can be concluded that Concept Mapping was a better Retrieval Practice activity than Free Recall in the study of Organic Chemistry material by form three students at TGSS.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter gives a summary of the findings and conclusions. Recommendations from the study and suggestions for further research are also presented here.

5.1 Summary of the Study Problem and Methodology

The problem under investigation was poor performance by learners in chemistry at KCSE. The purpose of the study was find out if RBCM as a study technique can be effective in enhancing achievement and retention of chemistry concepts. The following objectives were used to address the intention of the study;

i) Examine the efficiency of Retrieval Practice relative to Concept Mapping in enhancing information retention and performance in chemistry among form three students at Turkana Girls' Secondary School.

ii) Establish the most suitable Retrieval Practice activity between Concept Mapping and Free Recall in enhancing retention of information and performance in chemistry among form three students at Turkana Girls' Secondary School.

5.2 Findings

The present study found out that students who studied Organic Chemistry concepts by Retrieval Practice scored better in the CAT and the CRT compared to those who studied by elaborative Concept Mapping. The results show that Retrieval Practice is better in enhancing achievement and retention of information than Concept Mapping when used to study Organic Chemistry concepts. These findings are in agreement with the outcome of a related study by Karpicke and Blunt (2011) in which retrieval practice was found to produce more learning than elaborative studying with concept maps. Similar results were obtained in a study by Larsen, Butler and Roediger (2013) where it was concluded that repeated testing is generally more effective than generating self -explanations (an elaborative study technique) in producing superior long term retention and transfer of knowledge.

The second objective was to find out which Retrieval Practice activity between free recall and Concept Mapping was more superior to the other in terms of fostering performance and retention of chemistry concepts. Results obtained in the current study indicate that learners who practiced retrieval by Concept Mapping performed significantly better than their colleagues who practiced retrieval by free recall. This finding suggests that Concept Mapping as a retrieval practice activity is better than free recall. The outcome differs from that obtained in a similar study by Blunt and Karpicke (2014) which discovered that practicing retrieval either by concept mapping or by writing the material in paragraph format were both equally effective in enhancing long term retention of information.

The outcome of revision sessions indicates that the RBCM group had the least average score among the three groups. A further analysis of the amount of gain from the revision session scores revealed that the RBCM group had the highest amount of gain from treatment as measured by the difference between the CAT and revision session scores. The implication of these findings is; the group that generated the least proportion of ideas during study sessions benefited the most from those sessions. The elaborative concept mapping group had the least gain despite doing well during revision. Although the difference in learning gain between the groups was not significant, these results seem to approve a suggestion by Karpicke and Smith (2012) that elaborative studying improves initial encoding when it occurs prior to the first recall of an item. This means that there was no significant learning with regard to items that had been successfully retrieved during the pretest and this seems to explain the small learning gain by the Elaborative Concept Mapping group. On the other hand, the discovery that the group with the least proportion of ideas generated during study sessions ended up producing the best result on both the CAT and RAT could be linked to the difficulty inherent in encoding and retrieving knowledge which according to Larsen, Butler and Roediger (2013) leads to more durable learning.

Lehman et al (2014) in supporting the same idea allude that retrieval tasks which provide the fewest cues yield the greatest benefit because information is not readily available requiring an extensive search of memory which leads to most elaboration. In general, the pattern of results obtained in the present study seems to support the constructive retrieval hypothesis whose key tenet is that retrieval is most successful if it involves constructive elaboration of the material being learnt. Basing on the retrieval hypothesis, Endres, Carpenter, Martin, and Renkl (2016) encourage the use of teaching and learning tasks that combine elaboration and retrieval.

5.3 Conclusions

The study revealed that Retrieval Practice is a better study technique compared to Concept Mapping in supporting achievement in chemistry and retention of learnt concepts. Moreover, Concept Mapping as a format to implement Retrieval Practice during study is more superior to Free Recall in terms of enhancing achievement and retention of chemistry concepts. It can therefore be concluded that Retrieval Based Concept Mapping (RBCM) is an effective study strategy that can help learners to achieve better and retain and retrieve chemistry concepts compared to conventional study techniques. From the aforementioned conclusion, learners and teachers of chemistry are encouraged to adopt RBCM study technique as one way of improving performance in the subject. CEMASTEA should consider adopting RBCM as a teaching and learning model to be incorporated in SMASSE training for teachers of science.

5.4.1 Recommendations of the Study

From the findings of this study, the following recommendations are made;

1. Learners and teachers of chemistry are advised to adopt RBCM as a study technique as one way of improving performance in the subject.
2. CEMASTEA should consider adopting RBCM as a teaching and learning model to be incorporated in SMASSE training for teachers of science.
3. There is need to conduct more research into innovative teaching strategies.

5.4.2 Recommended Areas for Further Study

The following recommendations provide future directions on the way to further investigating the benefits of RBCM in T/L of chemistry;

1. This study can be replicated with a bigger sample that is more representative and gender sensitive. This is owing to the fact that the present sample was drawn from one school of the same gender.
2. A similar study can be done to find out if the findings obtained in the present study hold for different types of chemistry material. This is based on the fact that chemistry content fits in three different levels of thought (symbolic, submicroscopic and macroscopic). Different topics that fit each level can be considered for investigation.
3. Further research is warranted that will entail manipulation of aspects the elaborative and context reinstatement theoretical accounts of Retrieval Practice.

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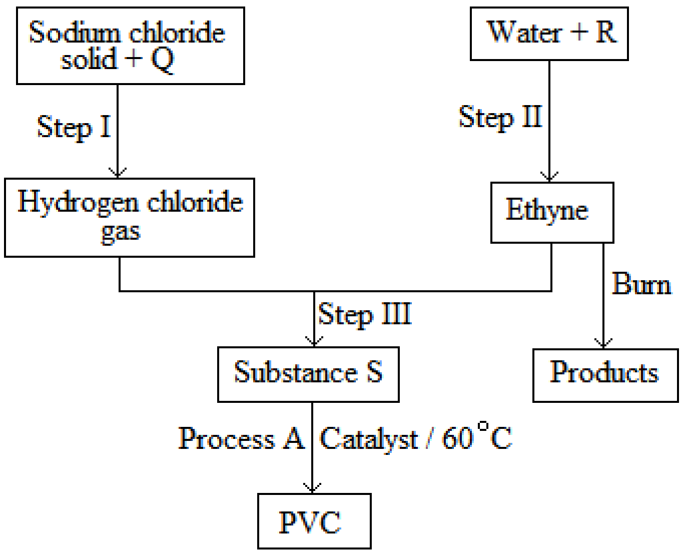
APPENDICES

APPENDIX I- CHEMISTRY PRETEST

Instructions: Answer ALL questions in the spaces provided.

Duration: 1 hour. **CODENO. ________________**

1. (a) Study the flow chart below and answer the questions that follow



(i) **Identify** substances Q and R

Q .... (1mk)

R .... (1mk)

(ii) Using a chemical equation, **show** how R reacts with water. (1mk)

(iii) **Name** and **draw** the structure of substance S. (2mks)

(iv) **Name** process A. (1mk)

(v) **State two** uses of PVC (2marks)

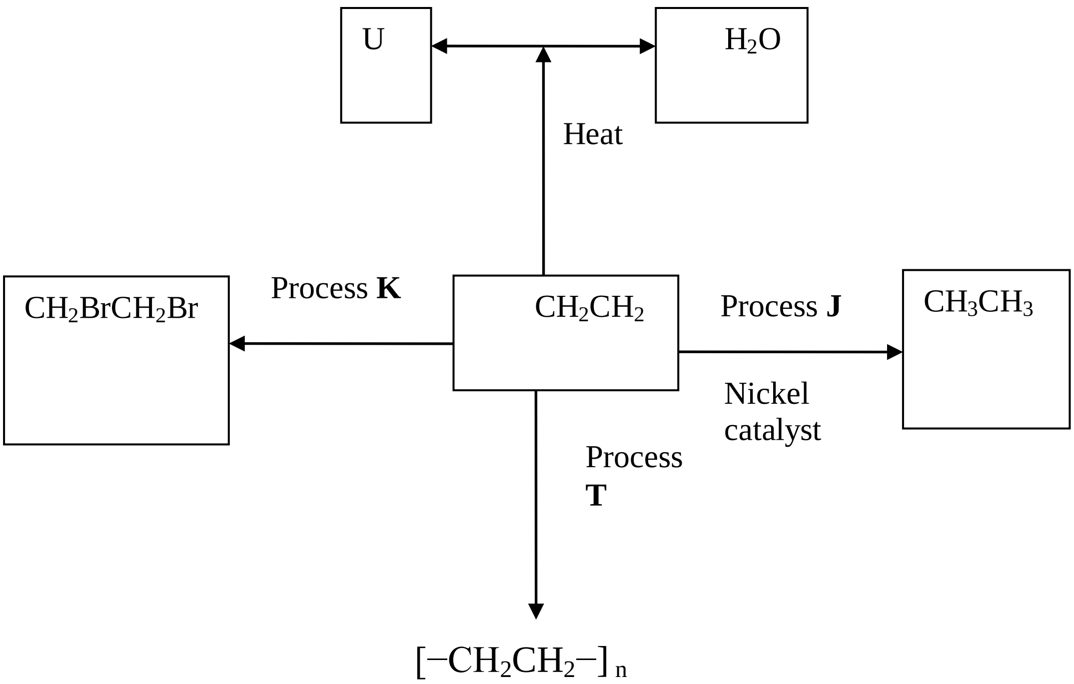
2. (a) Alkynes form homologous series.

i. What is the general formula of the alkyne series? (1mark)

ii. What type of chemical bond is characteristic of alkynes? (1 mark)

iv. Show the structural formula and name of the first for homologous series of alkynes. (1 mark)

3. Use the flow chart below to answer the questions that follow:



(a) What observation would be made in process **K**? (1 mark)

(b) Name another condition necessary for process **J** to take place. (1 mark)

(c) Give the name of substance **U** . (1 mark)

4. Bromine will react with both alkenes and alkanes.

a) What condition if any is necessary for a reaction to take place with:

i) Alkane? (1 mark)

ii) Alkene? (1 mark)

b) What happens to bromine in each case for it to react with:

i). Alkane? (1 mark)

ii) Alkene? (1 mark)

c) Which species is more reactive than the other from the answer you have given in b (i) and (ii) above? (1 mark)

5. In petrol chemical industries, long chain alkanes are broken down in to simpler substances in a process called cracking.

a) Why is cracking necessary? (1 mark)

b) State the **two** conditions required in cracking. (2 marks)

c) Draw the structure of 1-chloro-2, 2-dimethylpropane. (1 mar

6. In a reaction, an alcohol **K** was converted to hex-1-ene.

a) Name reagent and condition necessary for the reaction above to occur.

(2 marks)

b) Write an equation for the reaction taking place. (1 mark)

7. a) State three uses of alkenes. (3 marks)

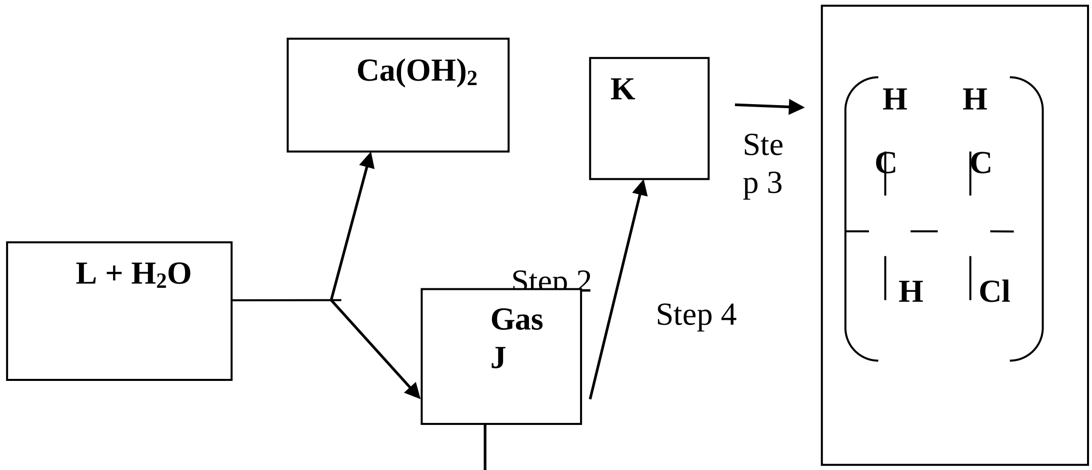
b) What are hydrocarbons? (1 mark)

APPENDIX II -CHEMISTRY ACHIEVEMENT TEST

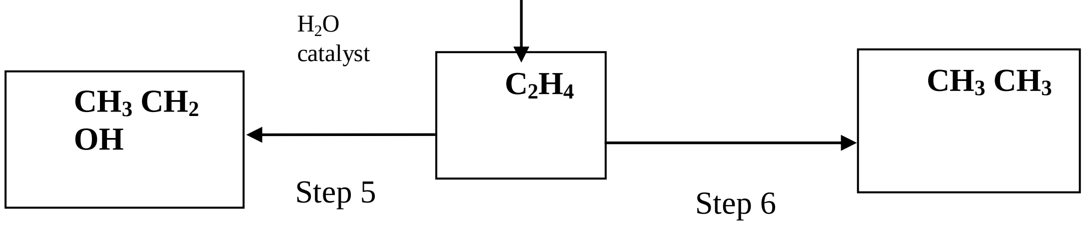
Instructions: Answer ALL questions in the spaces provided.

Duration: 1 hour. **CODE NO._________________**

1. a). Study the flow chart below and answer the questions that follow:



(i) . Identify reagent **L**. (1mk)



(ii). Name the catalyst used in step 5. (1mks)

(iii). Draw the structural formula of gas **J** (1mk)

(iv). Name the process in: (3mks)

Step 3……………………………………………………………

Step 5……………………………………………………………

Step 6……………………………………………………………

(v). State **one** commercial application of the process which takes place in step 6. (1mk)

(vi).Write equations for the reaction in:

Step 2 (1mk)

Step 4 (1mk)

2. The lists below are for organic compounds. Use it to answer the questions that follow:

K1	$CH_3CH_2CH_2OH$
K2	$CH_3\ CH_2\ CH_3$
K3	$CH_3\ CH_2\ CH_2\ C(=O){-}OH$
K4	$CH_3\ CH_2\ CH_2\ CH{=}CH_2$
K5	$CH_3\ CH_2\ CH_2\ CH_3$

(i)Select **two** compounds which:

I. Are not hydrocarbons. (1mk)

II. Belong to the same homologous series. (1mk)

3. From analysis it shows that the molecular formula of a hydrocarbon is C_6H_{14}. The hydrocarbon can be converted into two similar hydrocarbons as shown by the equation below:

$$C_6H_{14} \longrightarrow W + C_3H_8$$

a) Draw and name the possible structural formula of W.

i) Structural formula (1mark)

ii) Name (1 mark)

b) State and explain the observation that would be made if a few drops of bromine water were added to a sample of W. (2 marks)

c) Write an equation for the complete combustion of C_3H_8. (2 marks)

4. (a) State three uses of alkynes (3 marks)

(b) The reaction between bromine vapour and ethyne is faster than with ethane, explain. (2 marks)

c.) List three properties of a homologous series. (3marks)

5. a.) What is meant by the term isomers? (1 mark)

b) Draw and name two isomers of pentane (C_5H_{12}). (2marks)

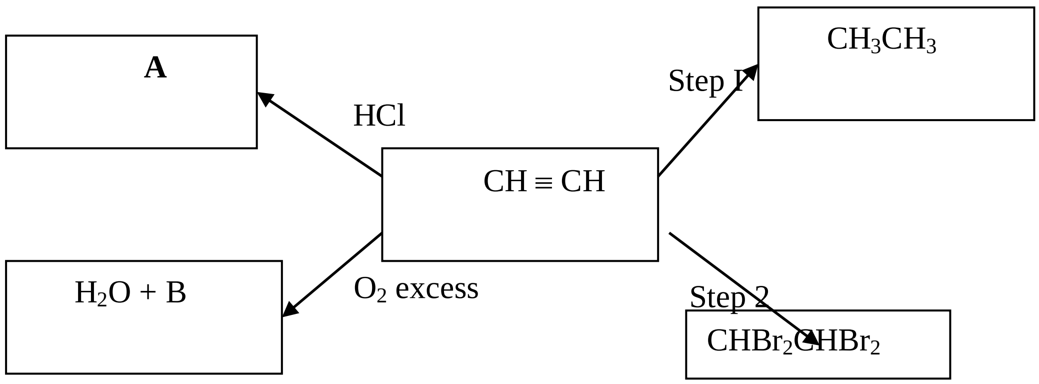
c.) Explain why an organic compound with formula C_3H_6 burns with a sootier flame than C_3H_8. (2 marks)

APPENDIX III-CHEMISTRY RETENTION TEST

Instructions: Answer ALL questions in the spaces provided.

Duration: 1 hour. **CODE NO.__________________**

1. Study the flow chart below and answer the questions that follow: -



(i) Give the name of the substance CH ≡ CH. (1mark)

(ii) To which group of hydrocarbons does the substance in (i) above belong? (1 mark)

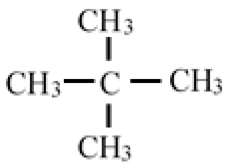
(iii) Give **two** reagents that can be used to prepare the substance named in (i) above. (2 marks)

(iv) Give the names to the process in step I and 2. (2 marks)

(v). Write an equation to show how substance **A** is formed. (1 mark)

(iv) Identify substance **B.** (1 mark)

2. a) Give the names of the following compounds:

(i)  (1 Mark)

(ii) $CHC \equiv CCH_2CH_3$ (1 Mark)

(b) How would the compounds in (a) above respond to acidified potassium manganate (VII) solution? (1 Mark)

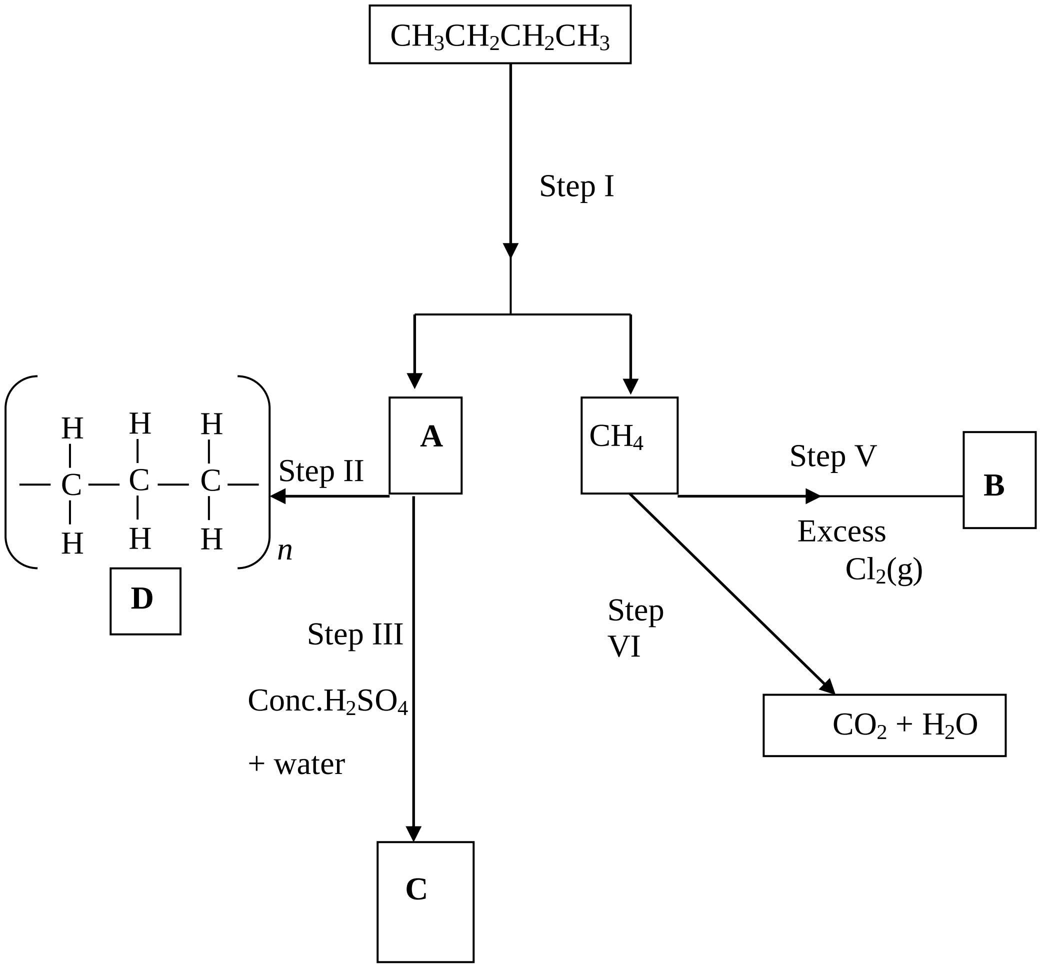
(c) Distinguish between thermal cracking and catalytic cracking. (2marks)

(d) State three uses of alkanes. (3marks)

c.) What is meant by the term isomerism? (1 mark)

d.) State two types of isomerism. (2 marks)

2. The following is a reaction scheme starting with butane. Study it and answer the questions that follow.



a) Write down the formulae of compounds A, B and C. (3mks)

b) State the types of reactions represented by Step I, Step II and Step III. (3mks)

c) To what class of compounds does D belong? (1mk)

d) Give one disadvantage of continued use of substances belonging to the class of compounds to which D belongs. (2 marks)

4. Draw the structural formula of: (2 marks

a) 3- methylbut-1-ene.

b) 1- chloro- 2- methylpent-1-ene.

APPENDIX IV - ORGANIC CHEMISTRY CONCEPT AREAS

Focus question: What are Alkanes?

Key concepts:

General formula of alkanes

Saturated hydrocarbons

Nomenclature of straight chain alkanes

Branched alkane - Alkyl groups

Nomenclature of branched alkanes-rules (open and condensed structural formulae)

Isomerism in alkanes

Occurrence of alkanes

Separation of alkanes from petroleum- fractional distillation of crude oil

Cracking of alkanes -Thermal cracking, Catalytic cracking

Laboratory preparation of alkanes

Physical properties of alkanes

Chemical properties:

Combustion

Halogenation

Uses of alkanes

Focus question- What are alkenes?

Key concepts:

General formula of alkenes

Nomenclature

Isomerism in alkenes

Laboratory preparation of alkenes

Obtaining alkenes by:

Catalytic cracking of long chain alkanes

Direct heating of clear polythene

Physical properties of alkenes

Chemical properties of alkenes:

Combustion, addition reactions- halogenation, hydrogenation, reaction with hydrogen halides

Self- addition reactions, reaction with acidified $KMnO_4$, hydration of alkenes

Test for unsaturation

Uses of alkenes

Focus question: What are Alkynes?

Key concepts:

General formula of alkynes

Nomenclature of alkynes -rules

Isomerism in alkynes -Positional and structural isomers

Laboratory preparation of ethyne

Physical properties of alkynes

Chemical properties of alkynes:

Combustion

Addition reactions- hydrogenation, halogenation, reaction with hydrogen halides

Reaction with bromine water

Reaction with silver nitrate

Test for alkynes

Uses of alkynes

APPENDIX V - ORGANIC CHEMISTRY TEACHING SCHEDULE

WK	LSN	CONTENT	DURATION
1	1 -2	Introduction to Organic Chemistry Definition of terms: Organic Chemistry Hydrocarbons Organic compounds Reasons why carbon forms a large number of compounds Hydrocarbons Homologous series Properties of homologous series Alkane homologous series General formula Saturated hydrocarbons Nomenclature of straight chain alkanes	80 minutes
	3	Branched alkanes Alkyl groups Nomenclature of branched alkanes (condensed and open structural formulae) Isomerism of alkanes	40 minutes
	4	Occurrence of alkanes Separation of alkanes from petroleum Cracking of alkanes Thermal cracking Catalytic cracking	40 minutes
	5	Laboratory preparation of alkanes Physical properties of alkanes Chemical properties	40 minutes

		Combustion Halogenation Uses of alkanes	
	6	REVISION OF WEEK 1 CONTENT	1 hour 20 minutes
2.	1-2	Alkene homologous series General formula Nomenclature Isomerism- structural and positional Laboratory preparation – dehydration of alcohols using conc. Sulphuric (VI) acid or Aluminium oxide.	80 minutes
	3	Obtaining alkenes by: Catalytic cracking of long chain alkanes Direct heating of clear polythene Physical properties of alkenes	40 minutes
	4	Chemical properties of alkenes: Combustion, addition reactions- halogenation, hydrogenation, reaction with hydrogen halides	40 minutes
	5	Self- addition reactions, reaction with acidified KMnO4, hydration of alkenes, test for unsaturation Uses of alkenes	40 minutes
	6	REVISION OF WEEK 2 CONTENT	1 hour
3	1-2	Alkyne homologous series General formula Nomenclature Isomerism in alkynes Positional and structural isomers Laboratory preparation of ethyne Physical properties of alkynes	80 minutes
	3	Chemical properties of alkynes	40 minutes

		Combustion Addition reactions- hydrogenation, halogenation, reaction with hydrogen halides	
	4	Reaction with bromine water Reaction with silver nitrate Test for alkynes	40 minutes
	5	Uses of alkynes Review of key concepts of Organic Chemistry 1	40 minutes
	6	Revision of week three content on alkynes	1 hour

APPENDIX VI – RESEARCH PERMIT

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CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MR. KELVIN MBAKO MUKANIA
of MOI UNIVERSITY, 0-30500 BUNGOMA,has been permitted to conduct research in *Turkana County*

on the topic: *THE EFFECTS OF CONCEPT MAPPING ON INFORMATION RETRIEVAL AND ACHIEVEMENT IN CHEMISTRY AMONG FORM THREE STUDENTS AT TURKANA GIRLS SECONDARY SCHOOL*

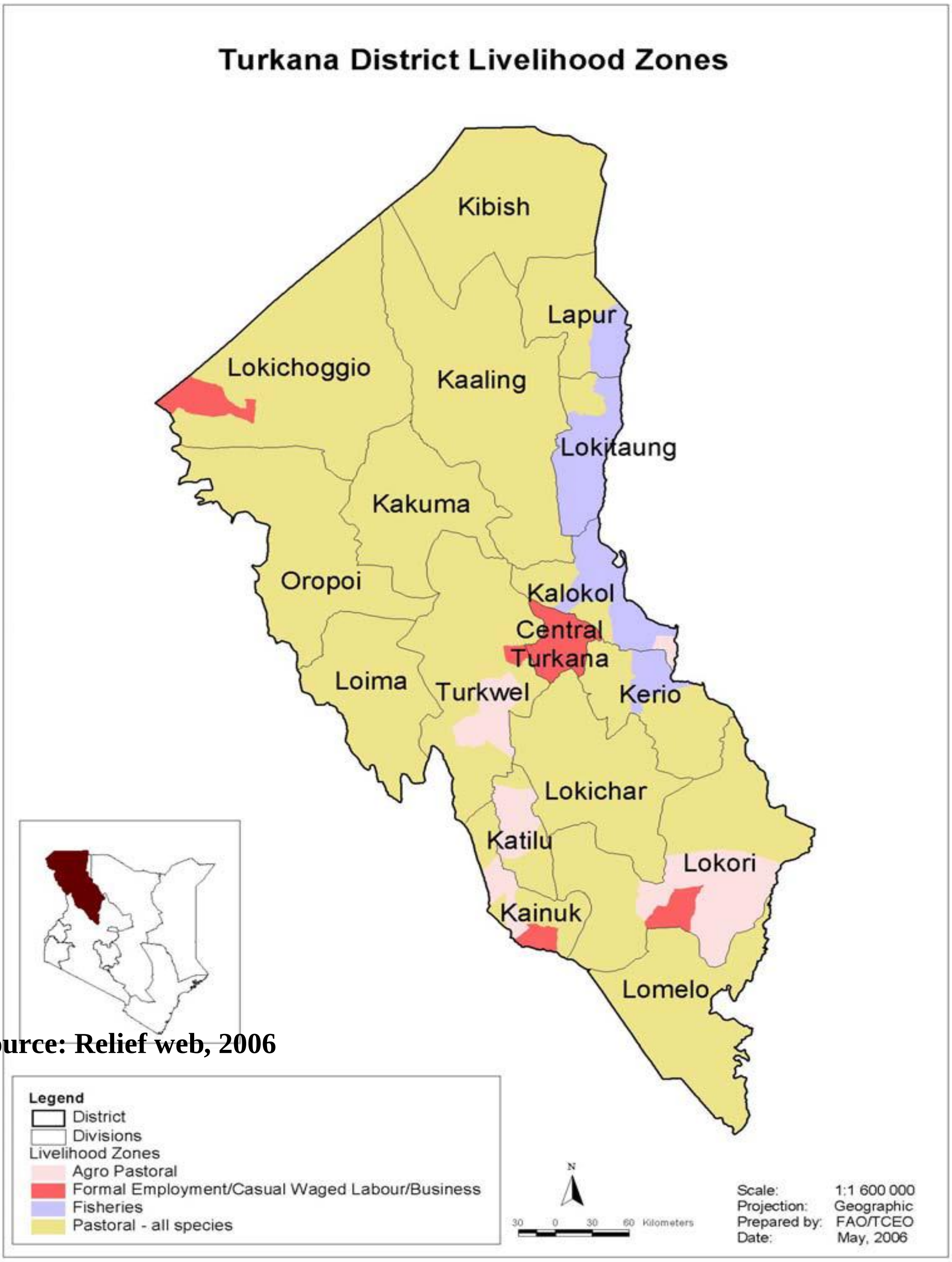
for the period ending:
30th May,2019

Permit No : NACOSTI/P/18/21553/22616
Date Of Issue : 31st May,2018
Fee Recieved :Ksh 1000

....
Applicant's Signature

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

APPENDIX VII: MAP OF TURKANA COUNTY



Source: Relief web, 2006