EFFECTS OF COMPUTER BASED COOPERATIVE MASTERY LEARNING ON SECONDARY SCHOOL STUDENTS' SKILLS ACQUISITION, MOTIVATION AND ACHIEVEMENT IN CHEMISTRY PRACTICALS IN BOMET COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

DECLARATION

This thesis is my original work and has not been presented for the award of any diploma or degree in this or any other university.

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RECOMMENDATION

This thesis has been submitted for examination with our recommendation as University Supervisors.

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DEDICATION

This work is dedicated to my wife, Milka and our lovely children; Timothy, Caleb and Elsie for their invaluable love, patience, company, support and encouragement throughout my studies. I cherish your devoted affection in my life. Special tribute goes to my late mum and dad; I salute you for encouraging me to love education and instilling in me a burning urge to pursue education right from my tender age. I will remain indebted to all of you for the rest of my life.

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ABSTRACT

Chemistry occupies a central position among science subjects in the secondary school curriculum. It also takes up a significant place in the curriculum because of its applications in everyday life and the role it plays in enabling students to develop affective intellectual, and practical skills. In spite of this increasing importance in the unfolding world, the academic performance of Kenyan students in the subject in secondary schools has remained poor over the years. The fundamental challenge facing the teaching of Chemistry in Kenyan secondary schools is how to enhance students' Skills Acquisition, Conceptual understanding and Affective characteristics associated with the teaching and learning process. Innovative, research-based, and learner-centred teaching methods engage the learners in the learning process. Such methods are not only effective for mastery of concepts but also promote Psychomotor, Cognitive, and Affective characteristics of learners. The present study focused on the use of Computer Based Cooperative Mastery Learning (CBCML) in enhancing students' Skills Acquisition, Motivation and Achievement in chemistry in Bomet County. The study was guided by cognitive constructivist theory advanced by Ausubel and social constructivist theory advanced by Vygotsky. The target population for the study was all students in secondary schools in Bomet County. However, the accessible population was form three students in all co-educational secondary schools in the County. The study used Solomon Four Non-equivalent Control Group Design. Four secondary schools were purposively sampled from the accessible population. Stratified random sampling was used to select one school from each of the four sub-counties of Bomet County. This ensured that the four schools were located far apart from one another to eliminate diffusion of information from the experimental groups to the control groups. This translated to a total of 238 students. The selected schools were randomly assigned to treatment and control conditions. Students in all the four groups were taught the same Chemistry content from the topic Volumetric Analysis. In the Experimental Groups, CBCML was used while Conventional Teaching Methods (CTM) were used in the Control Groups. Groups 1 and 2 were pre-tested prior to the implementation of CBCML treatment which lasted a period of six weeks. At the end of the treatment, all the four groups were post-tested using Chemistry Practical Skills Acquisition Test (CPSAT), Students' Motivation Questionnaire (SMQ) and Chemistry Achievement Test (CAT). The instruments were validated with the help of experts from the Department of Curriculum, Instruction and Educational Management of Egerton University and Examiners of Chemistry registered with Kenya National Examinations Council (KNEC). The three instruments were pilot-tested to estimate their reliability coefficient before they were used for data collection. The reliability coefficient of the SMQ was estimated using Cronbach's alpha coefficient while that of CPSAT and CAT were estimated using Kuder-Richardson (K-R21) formula. The reliability coefficients were found to be 0.76, 0.88, and 0.85 for CPSAT, SMQ and CAT respectively. The instruments were therefore suitable for use in the study because the minimum threshold of 0.70 was met. Data were coded and analysed using Statistical Package for Social Sciences (SPSS) version 20. Descriptive as well as inferential statistics were employed in data analysis. These statistics included the mean, t-test, ANOVA and ANCOVA. The findings of the study showed that CBCML has a positive significant effect on students' Skills Acquisition, Motivation, and Achievement in Chemistry when it is used in teaching Chemistry. Moreover, gender has no significant effect on students' skills acquisition, motivation and achievement in chemistry when CBCML is used to teach. The results of this study may be beneficial to Chemistry teachers, teacher trainers and curriculum developers in improving the teaching-learning process. Consequently, the level of skills acquisition, motivation and achievement in Chemistry is enhanced. The findings also form a frame of reference for further research on innovative teaching strategies that ensure active participation of learners during the teaching/learning process in Chemistry as well as other science subjects.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANCOVA:	Analysis of Covariance
ANOVA:	Analysis of Variance
ARCS:	Attention, Relevance, Confidence and Satisfaction
BOM:	Board of Management
CAT:	Chemistry Achievement Test
CBCML:	Computer Based Cooperative Mastery Learning
CBI:	Computer Based Instruction
CBML:	Computer Based Mastery Learning
CCE:	Cooperative Class Experiment
CCM:	Cooperative Concept Mapping
CDE:	County Director of Education
CIEM:	Curriculum Instruction and Educational Management
CL:	Cooperative Learning
CPSAT:	Chemistry Practical Skills Acquisition Test
CPTM:	Chemistry Practical Teachers' Manual
CTM:	Conventional Teaching Methods
DVD:	Digital Versatile Disk
EFA:	Education for All
FAWE:	Forum for African Women Educationists
GMR:	Global Monitoring Report
GoK:	Government of Kenya
HOD:	Head of Department
ICT:	Information and Communication Technology
IDEA:	Institute for Dynamic Educational Advancement
INSET:	In-service Education and Training
IT:	Information Technology
KCPE:	Kenya Certificate of Primary Education
KCSE:	Kenya Certificate of Secondary Education
KESSP:	Kenya Education Sector Support Programme
KICD:	Kenya Institute of Curriculum Development
KIE:	Kenya Institute of Education
KNEC:	Kenya National Examinations Council
MDG:	Millennium Development Goals
ML:	Mastery Learning

MLA:	Mastery Learning Approach
MOEST:	Ministry of Education Science and Technology
MTLC:	Motivation to Learn Chemistry
NACOSTI:	National Commission for Science, Technology and Innovation
NESC:	National Economic and Social Council
NESTA:	National Endowment for Science, technology and Arts
NRC:	National Research Council
PBL:	Project Based Learning
PSI:	Personalised System Instruction
PTA:	Parents and Teachers Association
RTM:	Regular Teaching Methods
SA:	Strongly Agree
SCORE:	Science Community Representing Education
SD:	Strongly Disagree
SDG:	Sustainable Development Goals
SDT:	Self-Determination Theory
SMASSE:	Strengthening of Mathematics and Science in Secondary Education
SMQ:	Student Motivation Questionnaire
SOW:	Scheme of Work
SPSS:	Statistical Package for Social Sciences
STI:	Science Technology and Innovation
TAT:	Thematic Apperception Test
UK:	United Kingdom
UNESCO:	United Nations Educational, Scientific and Cultural Organization
US:	United States

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Science and technology has become increasingly complex and more integrated into the contemporary social fabric in the 21st century. There is a great emphasis placed on science education because science and technology is seen as the basic tool for the growth and development of any nation (Abbas & Kan, 2007). According to Fensham (2004), the national performance of students in science subjects have implications for the part that country will play in tomorrow's advanced technology sector, and for its general international competitiveness. It plays important and dominant roles in spearheading technological advancement, promoting national wealth, improving health, and accelerating industrialization (Validya, 2003, Ogunleye & Babajide, 2011). Despite this critical role, the performance of students in science subjects in secondary schools globally has continued to be low for many years.

A study on international trends in performance in science shows that in the United States among 12th grades, the academic achievement in science is generally low compared to that of other subjects. Males have significantly higher achievement in science than females (Sjoberg, 2002). A higher percentage of male than female high school graduates express interest in Mathematics, and the same is true for interest in science (Ceci, Ginther, Kahn, & Williams, 2014).

Studies on students' performance across West Africa reveal that senior secondary school students' results in public examinations in science in Nigeria, Sierra Leone, Ghana, Liberia and Gambia had consistently been getting worse with time. Most often, at least 70% of candidates that registered for examinations have not been able to pass in science subjects (Njoku, 2007). Similarly, studies conducted in East Africa region show that the performance in science subjects is poor. National examination results have shown that boys outperform girls in science. In addition, girls show poor self confidence in their ability as most of them believe that boys perform better (Vermeer, Boekaerts, & Seegers, 2000).

Kenya, like other nations in the world, depends on what Science, Technology and Mathematics can offer for her national development. However, students' performance in science subjects at Kenya Certificate of Secondary Education (KCSE) level is still low (Musyoka, 2004). The performance in Mathematics and Science has been below average over the years (Changeiywo, 2000). It is important for students to be proficient in science subjects because they play an important role in career choices and professional development. Dismal performance in the Sciences limits students in competitive careers that are Science oriented (Njoku, 2007). According to Kerich, (2004), the proportion of students in Bomet County enrolling for science-based courses in institutions of higher learning is among the lowest in the country.

According to Keraro, Wachanga and Orora (2007), the teaching approach that a teacher adopts is a strong factor that can influence students' motivation to learn. Kolawole (2008), points out that Conventional Teaching Methods are still dominant in secondary schools. Conventional teaching or traditional teaching refers to a teaching method involving instructors and the students interacting in a face-to-face manner in the classroom. These instructors initiate discussions in the classroom, and focus exclusively on knowing content in textbooks and notes. Students receive the information passively and reiterate the information memorized in the exams (McCarthy & Anderson, 2000).

Science for a long time, is taught in most schools as a bundle of abstractions without practical experiences due to ill-equipped laboratories (Uwaifo, 2012). This has resulted in students' low acquisition of science process skills which has become more evident in mass failure of students in the subject in national examinations. Science education at the secondary school level is expected to be taught as a process of inquiry involving, developing in students' cognitive skills, affective skills and psychomotor skills of science (Adeyemo, 2009). Inability of students to carry out practical activities in chemistry results in poor performance especially in questions that test practical knowledge.

Since independence, Kenya's Ministry of Education Science and Technology (MOEST) has been advocating for the need to improve the teaching and learning of science. Its main objective is to create a foundation of a technologically oriented workforce in line with the national development (MOEST, 2003). The government recognizes the importance of science in technological development and is therefore committed to implementing strategies aimed at providing quality education to her citizens (MOEST, 2005). Despite the increase in provision in terms of resources and facilities, schools generally have not been able to make significant improvements in science.

The Government of Kenya recognizes the importance of Science and Mathematics in the attainment of Sustainable Development Goals (SDG) and realization of its vision 2030; to become a globally competitive and prosperous country by 2030 (Kerich, 2004). This is reflected in the amount of resources both human and otherwise that are channeled towards enhancing the teaching and learning of science and mathematics. Apart from providing trained teachers to handle the subjects, the Government has institutionalized in-service education and training (INSET) for science and mathematics teachers under strengthening of mathematics and science in secondary education (SMASSE). In spite of all these, one great challenge teachers are facing is how to improve students' performance nationally in Chemistry as its pass rates in KCSE examinations is the lowest compared to that of Biology and Physics (Barchok, 2006). Table 1 shows the overall performance nationally in KCSE for the three Science subjects from 2010-2014.

Table 1

Students' National KCSE Percentage Mean Scores in Chemistry, Biology and Physics from 2010-2014

Subject	**2010**	**2011**	**2012**	**2013**	**2014**	**Average**
Chemistry	24.89	23.65	27.93	24.83	32.16	**26.69**
Biology	29.20	32.44	27.21	31.63	29.84	**30.06**
Physics	36.11	36.64	37.86	40.10	38.29	**37.80**

Source: KNEC (2011- 2015)

The data in Table 1 shows that the performance in chemistry has been generally low compared to that of the other science subjects in all the five years considered. The highest mean score was 32.16% recorded in the year 2014 and the least score being 23.65% recorded in the year 2011. However, an improvement in performance from a mean of 24.83% in 2013 to 32.16% in 2014 was noted. This poor performance in Chemistry is likely to undermine the critical role that Chemistry plays in career choice and development.

The influence of gender on students' academic achievement in Chemistry has for a long time been of concern to many researchers but no consistent results have been established (Aluko, 2005). Gender disparity in performance in Chemistry examination is still common among students. The performance of girls has been low compared to that of boys. Several initiatives have been undertaken to attract girls and women in science and technology education, including continuous sensitisation and lobbying of policymakers and legislators; promoting gender mainstreaming in policy and gender related programmes; incentives such as scholarships, award systems; special internships for female students; career guidance and mentoring in institutions of learning, adaptation of curricula, and interaction of teachers and parents (Ceci et al., 2014). However, boys have continued to outperform their female counterparts in the subject. Table 2 indicates the national KCSE performance by gender in Chemistry from the year 2011 to 2014.

Table 2

National KCSE Performance in Chemistry for the Years 2011-2014 by Gender

YEAR	ALL		FEMALE		MALE	
	No. Sat	Mean %	No. Sat	Mean %	No. Sat	Mean %
2011	403,107	23.66	179,645	21.47	223,462	25.42
2012	427,303	27.93	193,426	25.95	237,293	29.54
2013	439,941	24.83	200,735	23.08	239,306	26.30
2014	477,393	32.16	221,659	30.18	255,734	33.88

Source: KNEC (2012- 2015)

The data in Table 2 shows that the performance of girls in the Chemistry is relatively low as compared to that of boys. The data further shows that over a span of the four years considered in the study, boys consistently performed better than girls in the subject. In addition, the number of girls enrolled for chemistry each year is lower than that of boys. However, a discrepancy was noted in number of students who sat for the Chemistry examination in the year 2012 and 2013. The total number of boys and girls were 430, 719 in 2012 but is reflected as 427, 303 while the figure adds up to 440, 041 but is reflected as 439, 941 in 2013. The deficit in the figures could be cases of absentees who failed to sit the exam. The low enrolment and poor performance in Chemistry by girls could be due to lack of motivation or poor teaching methods that perceive learners as a mere recipients of knowledge instead of constructors of knowledge as suggested by proponents of constructivism.

In Kenya, secondary school Chemistry examinations usually test students' understanding of facts, concepts and general principles in chemistry (KNEC, 2008). The subject is examined using three papers: paper one (233/1) and two (233/2) test theory while Paper three (233/3) tests the practical part of the subject. The theory papers are marked out of 80 marks each while the practical paper is marked out of 40 marks. This translates to a total of 200 marks. KCSE Examinations are set based on the three domains of learning objectives as proposed by Blooms; cognitive, psychomotor and affective domains. Table 3 shows the national KCSE candidature and performance per paper in Chemistry from the year 2010 to 2014.

Table 3

National KCSE Performance per Paper in Chemistry for the Years 2010-2014

Year	Paper	Candidature	Maximum Score	Mean Score	Standard Deviation
2010	1		80	18.78	14.48
	2		80	16.19	13.25
	3		40	14.87	5.60
	Overall	**347,364**	**200**	**49.79**	**31.57**
2011	1		80	18.43	14.86
	2		80	16.99	13.95
	3		40	11.91	6.30
	Overall	**403,070**	**200**	**47.31**	**33.51**
2012	1		80	22.36	14.17
	2		80	17.18	14.50
	3		40	16.34	6.73
	Overall	**427,386**	**200**	**55.86**	**34.10**
2013	1		80	16.68	13.89
	2		80	18.31	14.25
	3		40	14.67	5.68
	Overall	**439,847**	**200**	**49.00**	**32.10**
2014	1		80	25.44	15.79
	2		80	21.33	13.46
	3		40	17.57	6.19
	Overall	**477,393**	**200**	**64.31**	**35.63**

Source: KNEC (2011-2015)

The data in Table 3 shows that the performance in all the three papers improved in 2014 compared to that of 2013. The performance in Paper 1 (233/1) with a maximum score of 80 improved from a mean of 16.68 in 2013 to 25.44 in 2014. The performance in Paper 2 (233/2) with a maximum score of 80 improved from 18.31 in 2013 to 21.33 in 2014 while paper 3

(233/3) with a maximum score of 40 improved from a mean of 14.67 in 2013 to 17.57 in 2014. The overall performance in the subject improved from a mean of 49.00 in 2013 to 64.31 in 2014 out of a maximum score of 200. It is also notable that the candidature in the subject increased gradually over the years. However, the performance is still below average in all the three papers (KNEC, 2014).

Table 3 shows that the candidates' performance in practical examinations has been below average over the years with the highest mean of 17.57 in 2014. This shows that the candidates had little or no exposure to practical work (KNEC, 2014). The practical paper is mandatory for a student to be considered to have passed chemistry (MOEST, 2005). This requirement shows the importance attached to practical work in chemistry. Practical work plays an important role in the teaching and learning of science and chemistry in particular. Apart from helping students to gain insight into scientific knowledge, it also helps them to acquire a number of scientific skills, both cognitive and psychomotor, not to mention the motivation it creates among students. The concepts that the students learn in practical work are tested across all the three papers.

The investments that Kenya as a country has made in science practical work justify its relevance. Kenya's Vision 2030 aims at making Kenya a newly industrialized, "middle income country providing high quality life for all its citizens by the year 2030" (NESC, 2007). It also aims at capitalizing on knowledge in Science, Technology and Innovation (STI) in order to function more efficiently, improve social welfare, and promote democratic governance. Vision 2030 recognises the role of STI in modern economy, in which new knowledge plays a central role in wealth creation, social welfare and international competiveness.

Effective pedagogy is at the heart of improving the quality of practical work in science. If well planned and effectively implemented, practical work stimulates and engages students' learning at varying levels of inquiry challenging them both mentally and physically in ways that are not possible through other science education experiences (Millar, 2004). Learning, according to Taber (2009), is a personal activity and each student has to construct his or her own knowledge. For meaningful and effective learning to be realized, students should reflect on what is taught; develop interest on subject matter and construct new knowledge based on their understanding of the concepts. Science teaching therefore, ought to be proactive and student-centred.

The importance of practical work in science is widely accepted and it is acknowledged that good quality practical work promotes the engagement and interest among students. It also helps in developing a range of skills, science knowledge and conceptual understanding (Lunetta, Hofstein, & Clough, 2007). However, KNEC, 2014 KCSE report points out that the candidates tend to show certain weaknesses in practical examinations; inability to follow instructions hence ending up with wrong observations, inability to make accurate observations and if they did, the results were not recorded in the spaces provided. Also the interpretations made were inaccurate leading to inaccurate conclusions (KNEC, 2015).

The theoretical aspect of Chemistry present students with concepts and principles that are abstract thus making it difficult for them to concretize. The use of practical work in teaching therefore helps in making the theoretical aspects of chemistry more concrete (Lunetta et al., 2007). The attainment of goals depends to a large extent on the active participation of students in laboratory work. Effective participation can only be obtained if students practise the various scientific skills to a desired level of competence with the guidance of the teacher who is the facilitator of the learning process.

The performance of students in Chemistry at KCSE level in Bomet County is no exception. It has been relatively low compared to that of the other science subjects over the years. Table 4 shows the examination report on performance at KCSE level from 2010-2014 in the three science subjects obtained from the County Education Office.

Table 4

Bomet County KCSE Performance in Chemistry, Biology and Physics from 2010-2014

	MEAN POINTS					
Subject	**2010**	**2011**	**2012**	**2013**	**2014**	**Average**
Chemistry	3.967	4.020	4.384	3.954	4.920	**4.249**
Biology	4.961	4.815	5.066	4.998	5.670	**5.102**
Physics	4.590	4.778	4.500	4.691	5.260	**4.764**

Interpretation of Mean Point with Equivalent Grade
A = 12, A- = 11, B+ = 10, B = 9, B- = 8, C+ = 7, C = 6, C- = 5, D+ = 4, D = 3, D- = 2, E = 1

Source: Bomet County KCSE results analysis (2010-2014)

The data in Table 4 shows that the performance of students in Chemistry between the year 2010 and 2014 has remained low. The highest mean score was 4.920 points out of 12 in the year 2014 while the least score is 3.954 points in 2013. This performance is below average since the average mean point in performance is 6. Although the performance in Biology and Physics is also below average in the county, the average mean point is slightly better than that of Chemistry. In view of this, the use of CBCML in teaching, aims at finding a solution to the perennial poor performance in the subject.

Chemistry is divided into two main areas of study; theory and practical work. The theoretical aspect of chemistry presents students with abstract concepts and principles that make it difficult to concretise. The use of practical work in teaching makes the theoretical aspect of chemistry more concrete. Practical work covers all the three domains of learning as suggested by Blooms in his taxonomy of learning objectives. Olaewe (2005), argues that the cognitive, psychomotor and affective domains of learning cannot be isolated from each other because almost all learning activities involve more than one domain.

The attainment of stated instructional objectives in Chemistry teaching and enhancing of students' performance is a collective responsibility of both teachers and students (Udo, 2011). The selection of appropriate instructional strategy enhances smooth delivery and effective achievement of instructional objectives. Adesoji and Olatunbosun (2008) maintain that Chemistry teaching can be result-oriented if students are willing to learn, and appropriate methods are used by teachers. Thus the method of instructional delivery is a significant variable in the teaching-learning process. It can arouse and sustain learners' interest thereby ensuring result oriented teaching-learning session. The goal is to develop critical thinking and problem-solving skills by posing and investigating relevant questions whose answers must be discovered. Eventually meaningful learning is realized.

Conventional Teaching Methods (CTM) such as lecture method of instruction are less effective than interactive approaches (Knight & Wood, 2005). According to Harlen (1993), use of appropriate teaching methods by the science teachers could play a key role in helping children develop their ideas and science process skills such as observing, hypothesizing, predicting, investigating, drawing conclusions and communicating. This can be possible if teachers play their role well and select appropriate teaching methods which facilitate meaningful learning of school science (Grabe & Grabe, 2007). It is with this in mind that this study was set to investigate the effects of CBCML on students' Skills Acquisition, Motivation and Achievement in Chemistry practical.

Access to Information and Communication Technology (ICT) provides one of the best educational facilities necessary to prepare young people to play their roles in contemporary society and to contribute to a knowledge economy (Barak, 2005). However, not all teachers are convinced that ICT should be an integral part of their teaching strategies (Galanouli, Murphy, & Gardner, 2004). Resisting change is a state of mind for many teachers, and it is one of the most difficult barriers to effective ICT integration (Crawford, 2000). Pedagogical integration of ICT includes the use of technology in schools to improve learning and to facilitate educational development. It implies a process of appropriate, regular, and regulated use of interactive technology with incurred beneficial changes in school practices and student learning.

The use of computer technology for teaching in Kenyan schools is a relatively new approach that is currently being included in the school curriculum. This new intervention has proved effective in the teaching of both science and art subjects. A study by Tanui, Kiboss, Walamba and Nassiuma (2003) observed that the use of Computer Based Instruction (CBI) proved successful in teaching difficult concepts in Business Studies. Another study by Kiboss, Wekesa, and Ndirangu (2006) observed that Computer Based Instruction improved students' understanding and perception of Cell Theory in Biology. In addition, Ronoh, Wachanga and Keraro (2013) found out that learners taught Biology using Computer Based Mastery Learning outshined their counterparts taught using Conventional Teaching Methods. Research on computer use by students in science shows that their self-esteem is enhanced (Alves-Martins, Peixoto, Gouveia-Pereira, Amaral, & Pedro, 2002). This may also account for the increased interest in science by lower achieving students who have computers incorporated into their curriculum.

ICT has become one of the fundamental building blocks of modern society. Many countries now regard the mastering of the basic skills and concepts of ICT as an inevitable part of the core of education (Collier, 2004). Various new models of education are evolving in response to the new opportunities that are becoming available by integrating ICT and in particular Web-based technologies, into the teaching and learning environment. Collier (2004) found out that instruction supplemented by properly designed CBI is more effective than instruction without

CBI. The effective integration of such applications however, depends to a large extent on teacher's familiarity and ability with the Information Technology (IT) learning environment. Science teachers need to know exactly how ICT is used as a teaching and learning tool, for their own purposes and to help students to use them.

Technology makes a rich learning environment in which students can grow their curiosity and stimulate learning, which helps students explore, identify, and concretize their ideas and thoughts. Hence, technology can create a constructivist classroom in which students actively experience mathematics and science (Thioune, 2003). This study addressed the effects of CBCML on students' skills acquisition, motivation and achievement in Chemistry.

Alessi and Trollip (2001) pointed out that there are four major types of CBI programmes namely: Tutorials, Drills and practice, instructional games and simulations. CBI motivates children to learn better by providing them with the immediate feedback and reinforcement and by creating an exciting and interesting game-like atmosphere. The studies in the field reveal that the students' achievements increase when the CBI technique is provided as a supplement to the classroom instruction. CBI is more effective on less successful children. The reason for this is that the computer-based instruction enables learners to progress at their own pace and provides them with appropriate alternative ways of learning by individualizing the learning process (Senemoglu, 2004). It is on this basis that computer simulations were adopted in this study.

Mastery Learning Approach (MLA) on the other hand is an instructional method where students are allowed unlimited opportunities to demonstrate mastery of content taught (Guskey, 2007). It is a remedial process aimed at bringing students to a level of mastering a concept before moving to another. MLA involves breaking down the subject matter to be learned into units of learning, each with its own objectives. Results from research on MLA shows that there is better retention and construction of knowledge. This yields greater interest and more positive attitudes among learners (Wachanga & Mwangi, 2004).

In this study, the elements of Mastery Learning and CBI simulations were incorporated into the Cooperative Learning Groups for use during lesson introduction, explanation of procedures and self-check tests. The simulations used are contained in the Form 3 Chemistry data DVD developed by Kenya Institute of Curriculum Development (KICD). Most of the lessons during the intervention involved carrying out practical work in the laboratory while some were presented using computers. During computer based instruction lessons, students went through the simulations in the topic Volumetric Analysis as explained in the Chemistry Practical Teachers Manual (Appendix D). At the end of each lesson topic are self-check questions. The students were required to answer and upon attaining 80% individually, they were allowed to move to the next lesson topic.

The intervention involved using cooperative learning groups and mastery learning facilitated by computer technology. This approach was referred to as Computer Based Cooperative Mastery Learning (CBCML). This study sought to determine the effect of this approach on students' skills acquisition, motivation and achievement in Chemistry. The study also sought to find out whether there is any gender disparity in skills acquisition, motivation to learn chemistry and achievement in Chemistry.

1.2 Statement of the Problem

Chemistry is a core subject for students to pursue competitive science-based courses in institutions of higher learning. In Kenya, every student is required to pass in the subject to qualify for admission into tertiary institutions to pursue science-based courses such as Medicine, Engineering, and Pharmacy. However, the poor performance of candidates in the subject as reflected by the KCSE examination results has continued to trigger a lot of concern among educationists and other stakeholders nationally and also in Bomet County over the years.

Chemistry is a practical oriented subject. Meaningful learning of concepts in the subject heavily relies on harmony between theory and practical. Moreover, practical work enhances students' understanding of theoretical concepts in Chemistry by making them concrete. Previous studies indicate that most schools teach science subjects as a bundle of abstractions without adequate practical experiences due to ill-equipped laboratories and failure by teachers to embrace change in the teaching approaches they use in science classes (Ugwu, 2007).

Effective teaching empowers the learner to create knowledge individually and gain mastery of concepts together with others in cooperative learning groups. However, most teachers continue to use Conventional Teaching Methods of teaching. Such methods ignore the harmony between theory and practical work in the Teaching/Learning process hence poor performance as reflected by KCSE examination results nationally and also in Bomet County.

Innovative teaching approaches that involve the learners and consequently motivate them to learn could be an important remedy to enhance Science Process Skills Acquisition and improve students' academic achievement in Chemistry at all levels of learning. Realization of Vision 2030 and attainment of Sustainable Development Goals (SDGs) in Kenya requires innovative teaching approaches in science that embrace ICT integration in the teaching and learning process. Wachanga (2005) expressed teaching as an experimental process in which all techniques should be examined routinely and revised if necessary.

The present study investigated the use CBCML in enhancing students' Skills Acquisition, Motivation and Achievement. The approach creates an enabling environment for learners to create knowledge and gain mastery of concepts when they learn in small groups through the use of computer technology and practical work.

1.3 Purpose of the Study

The study was designed to determine the effects of using CBCML on students' skills acquisition, motivation and achievement in Chemistry practical in Bomet County, Kenya.

1.4 Objectives of the Study

The specific objectives of the study were:

(i) To compare Skills Acquisition in Chemistry between students taught through CBCML and those taught through Conventional Teaching Methods (CTM).

(ii) To compare students' Motivation to learn Chemistry between those taught through CBCML and those taught through Conventional Teaching Methods (CTM).

(iii) To compare students' Achievement in Chemistry between those taught through CBCML and those taught through CTM.

(iv) To investigate whether gender affects Skills Acquisition in Chemistry when students are taught through CBCML.

(v) To find out whether gender affects Motivation to learn Chemistry when students are taught through CBCML.

(vi) To determine whether gender affects Achievement in Chemistry when students are taught through CBCML.

1.5 Hypotheses of the Study

The study was guided by the following hypotheses:

$H_0$1 There is no statistically significant difference in students' Skills Acquisition in Chemistry between those exposed to CBCML and those taught using CTM.

$H_0$2 There is no statistically significant difference in students' Motivation to learn Chemistry between those exposed to CBCML and those taught through CTM.

$H_0$3 There is no statistically significant difference in Achievement in Chemistry between students exposed to CBCML and those taught through CTM.

$H_0$4 There is no statistically significant gender difference in Skills Acquisition in Chemistry among students exposed to CBCML.

$H_0$5 There is no statistically significant gender difference in Motivation to learn Chemistry among students exposed to CBCML.

$H_0$6 There is no statistically significant gender difference in Achievement in Chemistry among students exposed to CBCML.

1.6 Significance of the Study

The teaching approach that a teacher uses determines the effectiveness of learning in Chemistry. Perennial dismal performance witnessed in past KCSE performance in Chemistry indicates a missing link between theory and practical work in the subject. In an effort to improve the teaching and learning of Chemistry, CBCML approach to teaching was used. The study embraces integration of technology in teaching and learning process. The study provides data on the effectiveness of using CBCML on enhancing skills acquisition, motivating students to learn chemistry and consequently improve their level of achievement in the subject.

(i) The results of this study are valuable to teachers who are the implementers of the curriculum because; they could incorporate and adopt the approach in teaching of practical work in Chemistry and other science subjects. The study could provide a framework for teachers on which they could re-evaluate their instructional strategies during practical work in the subject for the enhancement of effective teaching and learning.

(ii) The information is useful in production of Chemistry teaching materials that embrace CBCML. Curriculum developers and policy makers may also benefit from the results of the study especially on the kind of practical experiences in chemistry needed for sound understanding of scientific concepts and principles.

(iii) Learners also benefit in that, the skills acquired may be transferred to other new areas of application. This includes other practical work in chemistry as well as the other science subjects. In addition, the knowledge and skills acquired may help the learners to solve problems in everyday life.

(iv) The study will serve as a frame of reference for further research on more innovative teaching approaches in science education that embrace ICT integration in the teaching and learning process.

(v) The results of this study will provide a framework for the KNEC to re-evaluate their goals and objectives with regard to the current practices in secondary school Chemistry practical. This could in turn help the council and KICD in tailoring the curriculum to suit the students' demands.

(vi) The findings of the study could be an eye opener for teacher trainers so that appropriate strategies are put in place for enhancement of adequate teacher preparation during pre-service and in-service training in Chemistry.

Practical work covers all the three domains of learning as proposed by Blooms in his taxonomy of learning objectives. All these three domains are tested in the Kenya Certificate Secondary Examinations (KCSE) theory and practical exams. If the learners master practical skills, their performance is likely to improve. Consequently, the problems of poor performance in Chemistry as well as that of gender disparity may be solved.

1.7 Scope of the Study

The study was conducted in Bomet County, Kenya. The study focussed on the effects of CBCML strategy on secondary school students' science process Skills Acquisition, Motivation and Achievement in Chemistry. The experimental groups were taught using CBCML while the control groups were taught using Conventional Teaching Methods. The topic selected for use in the study is that of Volumetric Analysis as presented in the approved KICD syllabus of 2002 by KIE. It focused on the practical aspect of secondary School Chemistry. The topic was chosen bearing in mind its relevance in helping learners acquire Science Process Skills in the subject and its application in real life situations. Moreover, the students' performance in the topic has been dismal (KNEC, 2015).

Understanding of The Mole and its concepts is critical for learners since it involves a lot of practical work which requires a high degree of accuracy. Active participation of learners in the learning process enhances skills acquisition, motivates them and raises their level of achievement in the subject. The objectives related to hands-on laboratory work are conceptual understanding, design skills, professional skills and social skills (Elawady & Tolba, 2009).

The study focussed on County Co-educational Secondary Schools in the County. The teachers involved, especially Experimental Groups were trained on implementation of CBCML for three days and issued with the manual (Appendix D). These were the research assistants who helped the researcher. Generalization of findings has been narrowed to form three Chemistry students in County Co-educational Secondary Schools in the County.

1.8 Limitations of the Study

The following are considered as the main study limitations:

(i) Since the sample was drawn from some selected co-educational secondary schools in Bomet County the effects that were found were mainly reflecting the situation in the county. Hence, the findings may not be representative of all secondary schools in Kenya.

(ii) The study was limited to County Co-educational Secondary Schools within Bomet County. The other categories of public schools including Sub-county, Extra County and National schools were excluded.

(iii) The content covered was limited to the practical concept from one topic in form 3 chemistry; The Mole. The study should have covered other topics as indicated in the Chemistry syllabus. However, the study would have been expensive in terms of time and resources.

1.9 Assumptions of the Study

In this study it was assumed that:

(i) the information collected from the respondents is true and frank response of their feelings about the learning of chemistry with regard to the aspect of motivation.

(ii) the events taking place during the intervention period other than the treatment did not cause any difference in students' Skills Acquisition, Motivation and Achievement in Chemistry Practicals.

1.10 Operational Definitions of Terms

The terms that were used in the study are defined constitutively and operationally as follows:

Achievement: This is the ability to perform tasks in the areas of low and high order skills (Osborne & Wittrock, 2003) as an outcome of an instruction process. In this study achievement meant the competence of a student that enables him/her to perform well in all chemistry tasks from all the three domains of learning and was measured using the Chemistry Achievement Test (CAT) (see Appendix C).

Affective Perspective: The affective element refers to emotions, moods and feelings. The Affective domain includes feelings, values, appreciation, enthusiasms, motivations, and attitudes. In this study the aspect of motivation to learn chemistry when CBCML was used in instruction was considered.

Assessment: According to Gega (2006), it is the systematic collection of information about student learning, using the time, knowledge, expertise, and resources available, in order to inform decision about how to improve learning. In this study Assessment is the process of gathering and discussing information from multiple and diverse sources in order to develop a deep understanding of what students know, understand, and can do with their knowledge as a result of their educational experiences or instruction.

Cognitive perspective: This is an approach to learning which considers mental and computations processes that support guide and extend the thinking processes of the users. Cognitive tools are external to the learner and engage the learner in meaningful processing of information. In this study CBCML is a cognitive tool.

Computer Based Cooperative Mastery Learning (CBCML): Computer Based Cooperative Mastery Learning is defined as an approach to teaching in which learners learn in small groups to attain mastery of concepts in chemistry while using computer technology to supplement the available teaching and learning resources. It is unique in the sense that learners work together in groups to accomplish given tasks. Technology appeals to many senses hence encouraging stimulus variation and consequently meaningful learning was realized. Computers generate data at the students' request to illustrate relationships in models of social or physical reality, execute programs developed by the students, or provide general support in a relatively unstructured exercise designed to stimulate and motivate students.

Computer Based Instruction (CBI): Computer Based Instruction (CBI) refers to teaching and learning through computer-based programs that mostly involve computer simulation activities offered either by themselves or as supplements to traditional and teacher-directed instruction (Sjoberg, 2000). It enables the students to learn by self-evaluation and reflection on their learning process. CBI can provide an effective supplement to the teacher's instruction.

Constructivism: This is a theory of knowledge which argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. In this study constructivism refers to the idea that the learner constructs meaning in his/her learning either individually or socially in the groups assigned. Meaningful learning was also realised through interaction with and through the e-learning module.

Conventional Teaching Methods: Conventional teaching methods or traditional teaching refers to a teaching method involving instructors and the students interacting in a face-to-face manner in the classroom. These instructors initiate discussions in the classroom, and focus exclusively on knowing content in textbooks and notes. Conventional Teaching Methods (CTM) implied a teaching method which involves the directed flow of information from teacher as source of knowledge to a student who is a passive recipient of the knowledge. In this study CTM was used to imply the teaching methods that are popular among teachers with the main aim of delivering the content.

Cooperative Learning (CL): is defined as the instructional use of small groups to promote students working together to maximize their own and each other's learning (Johnson, Johnson, & Holubec, 2008). This is a teaching strategy in which small groups, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject. Elements of cooperative learning include; positive interdependence, individual accountability and personal responsibility, promotive interaction, appropriate use of social skills and group processing.

Data DVD: A DVD is a type of optical media used for storing digital data. It is the same size as a CD, but has a larger storage capacity. Some DVDs are formatted specifically for video playback, while others may contain different types of data, such as software programs and computer files. In this study the data DVD refers to the Form 3 Chemistry DVD developed and distributed by KICD.

Effect: this is generally a condition, situation or occurrence that happens because of a cause or a combination of causes. In the study effects implied the condition of students' level of competence in science process skills, motivation and achievement after teaching them through CBCML compared to the use of Conventional Teaching Methods.

Gender: according to Yang (2010), refers to the social attributes and opportunities associated with being male and female and the relationship between women and men; girls and boys, as well as the relationship between women and those between men. Okeke (2008), describes gender as a socially culturally constructed characteristics and role which are ascribed to males and females in any society. In this study, gender was taken to refer to socially constructed roles, behaviours, activities, and attributes that a given society considers appropriate for men and women. Consequently, resulting in society assigning different roles to Boys and Girls (FAWE, 1997).

Information and Communication Technology: is an extended term for information technology (IT) which stresses the role of unified communications and the integration of telecommunications, computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.

Likert Scale: A scale developed by Likert for measurement of motivation. In this study a 5-point Likert Scale ranging from Strongly Agree (SA) to Strongly Disagree (SD) was used. The items on this scale were scored ranging from 1 to 5 for positive statements and 5 to 1 for negative statements.

Mastery Learning (ML): ML refers to a pedagogical approach that combines the qualities of conventional group-based teaching and one-to-one individual tutoring to achieve better academic performance in a more realistic manner. Mastery learning was used in the study to mean a teaching approach in which students are helped to master each learning unit before proceeding to a more advanced learning task in small groups.

Meaningful Learning: in this study meaningful learning is taken to mean a non-arbitrary, non-verbatim, substantive incorporation of new symbolically expressed ideas to relevant aspects of the current knowledge structure in a conscious manner. This learning occurs when individuals choose to relate new knowledge to relevant concepts and propositions they already know (Novak, 1998).

Motivation: Motivation is the process whereby goal-directed activity is instigated and sustained (Schunk, Pintrich & Meece, 2008). Motivation is a process rather than a product. As a process, we do not observe motivation directly but rather we infer it from actions. It is a psychological process which energizes, directs and sustains behaviour reflected in personal investment and in cognitive, emotional and behavioural engagement in school activities (Sandra, 2002). In this study, the term has been used to mean the students effort put in as a result of their desire to learn chemistry. A Student Motivation Questionnaire (SMQ) was used to measure students' motivation in chemistry learning. (See Appendix B)

Paradigm Shift: this refers to a fundamental change in an individual's or society's view of how things work. In this study it means the change in the teaching approach from teacher-centred to learner centred. It also includes the use of practical activities and computer simulation to encourage active participation among learners for meaningful learning to be realized.

Pedagogy: Quality teaching is defined as pedagogical practices that facilitate for diverse children, their access to knowledge, activities and opportunities to advance their skills in ways that build on previous learning assist in learning how to learn and provide a strong foundation for further learning in relation to the goals of the curriculum (Farquhar, 2003). In this study, pedagogy refers to the methods, techniques, strategies and approaches used in the teaching and learning of science in secondary schools.

Personalised Learning: Personalized learning is intended to facilitate the academic success of each student by first determining the learning needs, interests, and aspirations of individual students, and then providing learning experiences that are customized to a greater or lesser extent for each student. In this study personalised learning is focusing in a more structured way on each child's learning in order to enhance progress, achievement and participation.

Practical Work in Science: According to Millar (2010), practical work refers to any science teaching and learning activity which at some point involves the students, working individually or in small groups, in observing or manipulating objects to develop understanding. In this study, practical work refers to teaching and learning activity which involves students working in small groups, observing or manipulating apparatus to develop understanding. Its' importance in improving students' understanding of science, development of practical skills and development of scientific enquiry was considered.

Psychomotor Perspective: The psychomotor domain includes physical movement, coordination, and use of the motor-skill areas. Development of these skills requires practice and is measured in terms of speed, precision, distance, procedures, or techniques in execution. This is an approach to learning which can be assessed by having the learner to perform a set of tasks that lead to the achievement of a goal. In this study, skills acquisition in chemistry was measured using CPSAT.

Rote/Pseudo-Learning: This is an arbitrary, verbatim, non-substantive incorporation of new ideas into the cognitive structure with no specific relevance to the existing propositional framework. Such knowledge retained only for short time. In this study this term refers to rote learning in which students cram concepts instead of understanding hence, poor retention of the knowledge acquired.

Science Process Skills Acquisition: refers to a variety of abilities that affect the acquisition, retention, understanding, organization or use of verbal and/or non-verbal information. Science process skills acquisition in a generic term refers to a heterogeneous group ability manifested in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities, or of social skills (Hallahan & Mercer, 2007). In this study science process skills acquisition was referred to as skills acquisition. It refers to the ability of the learner to carry out given tasks in chemistry practical with competence and accuracy hence acquire Science Process Skills. This includes both basic and integrated skills that are helpful in meaningful learning of science. In this study, a Chemistry Practical Skills Acquisition Test (CPSAT) was used to measure students' Skills Acquisition in Chemistry. (See Appendix A)

Social Interdependence: This refers to the ability of individuals to work together as a team towards achieving a common goal (Bandura, 1997). In this study social interdependence refers to students' efforts to achieve, develop positive relationships, adjust psychologically, and show social competence during learning.

Twelfth Grade: in the United States this is a grade or level of schooling in which students are in the final year of high school. It is the last and fourth year of secondary school education referred to as Senior High School. It is equivalent to form four in our Kenyan education system.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter documents the review of literature relevant to the study. Sections dealt with in this chapter include Science Education in Kenya since independence, role of practical work in Chemistry, students' skills acquisition, motivation, and achievement in Chemistry, relationship between psychomotor skills acquisition, motivation and achievement in chemistry, effects of gender on science process skills acquisition, motivation and achievement when CBCML was used in teaching relative to the use of Conventional Teaching Methods. It also covers the integration of ICT in Cooperative Mastery Learning, the theoretical foundations of CBCML as well as the conceptual framework of the study.

2.2 Science Education in Kenya since Independence

Right from independence, the Government of Kenya has consistently shown a keen interest in the promotion of science education as a means to achieving the country's manpower requirement (Bogonko, 1992). The Presidential Working Party on the Second University in Kenya noted that the National Council of Science had conducted research and found out that there was a shortage of trained manpower in the fields of Science and Technology by the time the Mackay Commission was constituted (GoK, 1981, Szajna & Mackay, 1995). Following the findings, Moi University was designed specifically to offer courses in technology and related sciences (Bogonko, 1992).

Another strategy that was also put in place to promote science education was the upgrading of nineteen secondary schools into Technical Training Colleges in 1986 (Bogonko, 1992). The basic admission requirements to Science based faculties in the Universities was reduced to six points while the entry point for arts based courses remained at ten points. All these efforts are consequential steps following what transpired in education at Secondary school level. The implication clearly suggests that Science subjects were neither popular nor being performed well.

Following the situation, and the need to meet international standards, Science at Primary school level developed from general Science curriculum which was merged with other social subjects under one umbrella subject identified as a General Paper in the old system of education, to an independent Science subject. At this level, science was performed comparatively better than other subjects. In the secondary school sector, the general science subject was divided into three: Physics, Chemistry and Biology.

Prior to the introduction of 8-4-4 system of Education, three forms of Science were offered at Secondary School level: First was General Science which was an integration of all the three science subjects and emphasis was laid on theory and rote learning through lectures. The second was the Physical Science which was also integration of two subjects but with some element of practical approach through teacher demonstration. The final category was Pure Science where each of the Science subjects was done as an independent entity with a practical orientation and usually referred to as 'pure science'. Pure Science was largely a preserve for well-endowed schools while General Science was for schools without science equipment. Physical Science was an interface between two subjects; Physics and Chemistry.

Under the 8-4-4 system of education, General Science was removed. Emphasis was laid on Science subjects without any regard to the school's endowment in facilities. In reality, all schools did Pure Science. This might partly explain the continued general poor performance in the Sciences in Secondary schools in Kenya (Njeru, 2003). The stakeholders' pressure on the Government following the performance in the sciences led to a series of revision of the Science curriculum. In Chemistry, for example, some topics such as colloidal Chemistry were removed on the grounds that they were above the level of the learners (KIE, 2002).

The re-introduction of General Science and Alternative B Mathematics in the secondary school curriculum by 2009 set a new paradigm shift in secondary science education in Kenya. To many, it is a reverse step towards the curriculum prior to the introduction of 8-4-4 system of education. It is argued that because performance in science education has not been good compared to most of the other subjects done in secondary schools, there is need to simplify the content and give the students what they can understand. Several strategies have been taken meant to counter the declining performance. All Science teachers were awarded better salaries through a Presidential decree in 1997 as a way of motivating and retaining them in the teaching service. This privilege remained in force until 2003 when it was lifted. The Government under the Kenya Education Sector Support Programme (KESSP) gave laboratory grants for equipment to ten schools per district in the country. For example, seven hundred schools received the grant from the government in 2004 alone (Kisangi, 2006). Another major strategy that the Kenya government put in place to improve science education was the introduction of an in-service course for all the science teachers under the SMASSE (Kisangi, 2006).

Currently, investments in educational technologies have increased on many campuses (Cuban, Kirkpatrick, & Craig, 2001; Ficklen & Muscara, 2001) in the hope that teachers could integrate them into their classroom instruction to enhance student learning. However, reports indicate that teachers are not using technology in ways that could make a difference in teaching their students (Anderson & Becker, 2001). Further, there is an alarming gap between educational technology's presence in higher educational institutions and its effective integration into classroom instruction (Cuban et al., 2001). In line with these new developments, this study intends to investigate the effects of CBCML on skills acquisition, motivation and achievement in chemistry learning in secondary schools.

2.3 Practical Work in Chemistry

Chemistry is a practical subject well-endowed with several activities and experiments which engage the learners on hands on activities. Each of the science subjects is divided into two main components: theory and practical. The theoretical aspect of Chemistry for example, presents students with abstract concepts and principles and concepts that make it difficult to concretise. The use of practical work in teaching makes the theoretical aspect of Chemistry more concrete (Nwosu, 2006). Practical work covers all the three domains of learning as suggested by Blooms in his taxonomy of learning objectives.

2.3.1 Definition of Practical Work

According to Millar (2010), practical work refers to any science teaching and learning activity which at some point involves the students, working individually or in small groups, in observing or manipulating objects to develop understanding. Definition of practical work in science includes investigation/enquiry and laboratory/fieldwork procedures and techniques. SCORE (Science Community Representing Education) produced A framework for practical science in schools (SCORE, 2009a), defining practical work in science as 'a "hands-on" learning experience which prompts thinking about the world in which we live'. The associated report (SCORE, 2009b) has a list of activities that could be considered to be practical work. These fall into two main categories:

Core activities: Investigations, laboratory procedures and techniques, and fieldwork. These ‘hands-on’ activities support the development of practical skills, and help to shape students’ understanding of scientific concepts and phenomena.

Directly related activities: Teacher demonstrations, experiencing phenomena, designing and planning investigations, analysing results, and data analysis using ICT. These are closely related to the core activities and are either a key component of an investigation, or provide valuable first-hand experiences for students.

A range of activities were also identified which complement, but should not be a substitute for, practical work. These complementary activities include science-related visits, surveys, presentations and role play, simulations including use of ICT, models and modelling, group discussion, and group text-based activities (Resta, 2005). They have an important role to play supporting practical work in developing understanding of science concepts.

Practical work in chemistry can be taught through class experiment method, demonstration method, fieldwork and academic trips or use of project work. Recent research on chemistry practical shows that teachers attach a lot of value to practical work in Chemistry instruction. However, a great percentage of the teachers commonly use demonstration method to teach Chemistry practical work despite acknowledging that class experiments would produce better learning of chemistry concepts. Moreover, Project work was rarely used by the teachers (Abrahams & Millar, 2008).

2.3.2 Purposes of Practical Work

Practical work puts the students at the center of learning where they can participate in, rather be told about Chemistry. One of the features of chemistry as a subject in school is that it involves experiments that engage students in learning activities. Most of these experiments should be open-ended. Important general goals in secondary education include creativity, problem-solving skills, and critical and independent thinking. Many science educators (Hofstein, Shore, & Kipnis, 2004) have called for more open-ended experiments to address these general goals.

Different researchers have presented overviews of the main goals for practical work. Hofstein and Lunetta (2004) suggest that the principal aims of practical work are to enhance students’:

- understanding of scientific concepts;

- interest and motivation;
- scientific practical skills and problem solving abilities;
- scientific habits of mind and
- understanding the basics of the nature of science.

Based mainly on Hofstein & Lunetta (2004) this study focussed on the effects of CBCML approach on students' skills acquisition, motivation and achievement when the approach is used in teaching Chemistry.

Lunetta et al. (2007) have suggested that engaging in scientific practical work provides simulation experiences which situate students" learning in states of inquiry that require heightened mental and physical engagement. This engagement leads to better understanding and improved performance. One of the aims of practical work is to foster conceptual understanding or theoretical aspects treated in the classroom (Hofstein,2004). However, some current researchers on practical work argue that there is little evidence that practical work can contribute to conceptual understanding of a science (Johnstone & Al-Shualili, 2001; Anderson et al., 2001).

It is argued that practical activities develop not only manipulative or manual dexterity skills, but also promotes higher-level, transferable skills such as observation, measurement, prediction and inference. These transferable skills are said not only to be valuable to future scientists but also to possess general utility and vocational value. Achimugu, (2012) stated the objectives of practical activities in chemistry as follows:

i. It helps students develop science process skills such as observing, classifying, predicting, measuring, drawing, recording data, hypothesizing, etc.
ii. It promotes the development of scientific attitudes such as objectivity, honesty, curiosity, patience, open-mindedness, etc.
iii. It helps students to understand and appreciate the spirit and methods of science such as problem solving, analytic minds and methods of science.
iv. It is used to reinforce what is learnt in the theory class and hence encourages the spirit of experimentation.
v. It arouses and maintains interest and curiosity in chemistry.
vi. It helps students to develop manipulative skills and proficiency in writing reports.
vii. It enhances students better understanding of concepts and principles and by so doing, significantly contributes to students' achievements in chemistry.

viii. It encourages students to be active in the class, in other hand, discourages abstraction, rote memorization and inattentiveness in the class.

ix. It leads to fundamental and applied research in chemistry at all levels of education.

x. It helps to verify laws and theories that the students have already learnt.

Based on the objectives of practical activities stated above the researcher used CBCML approach to teach volumetric analysis in chemistry in order to examine its impact on skills acquisition, motivation and achievement in chemistry among secondary school students in Bomet County, Kenya.

Most practitioners would agree that good quality practical work can engage students, help them to develop important skills, help them to understand the process of scientific investigation, and develop their understanding of concepts. A further consequence of experiencing practical work, particularly in chemistry, is the acquisition of an understanding of hazard, risk and safe working (SCORE, 2009a). These are just some of the many different reasons for choosing to use a practical activity in a lesson. The Framework for practical science in schools also identifies a multitude of ways in which practical work can support learning in science, from 'Personal, learning and thinking skills' to 'how science works'. Any single activity might focus on one or more of these purposes (Millar, 2004). Figure 1 shows how practical work supports learning of Chemistry.

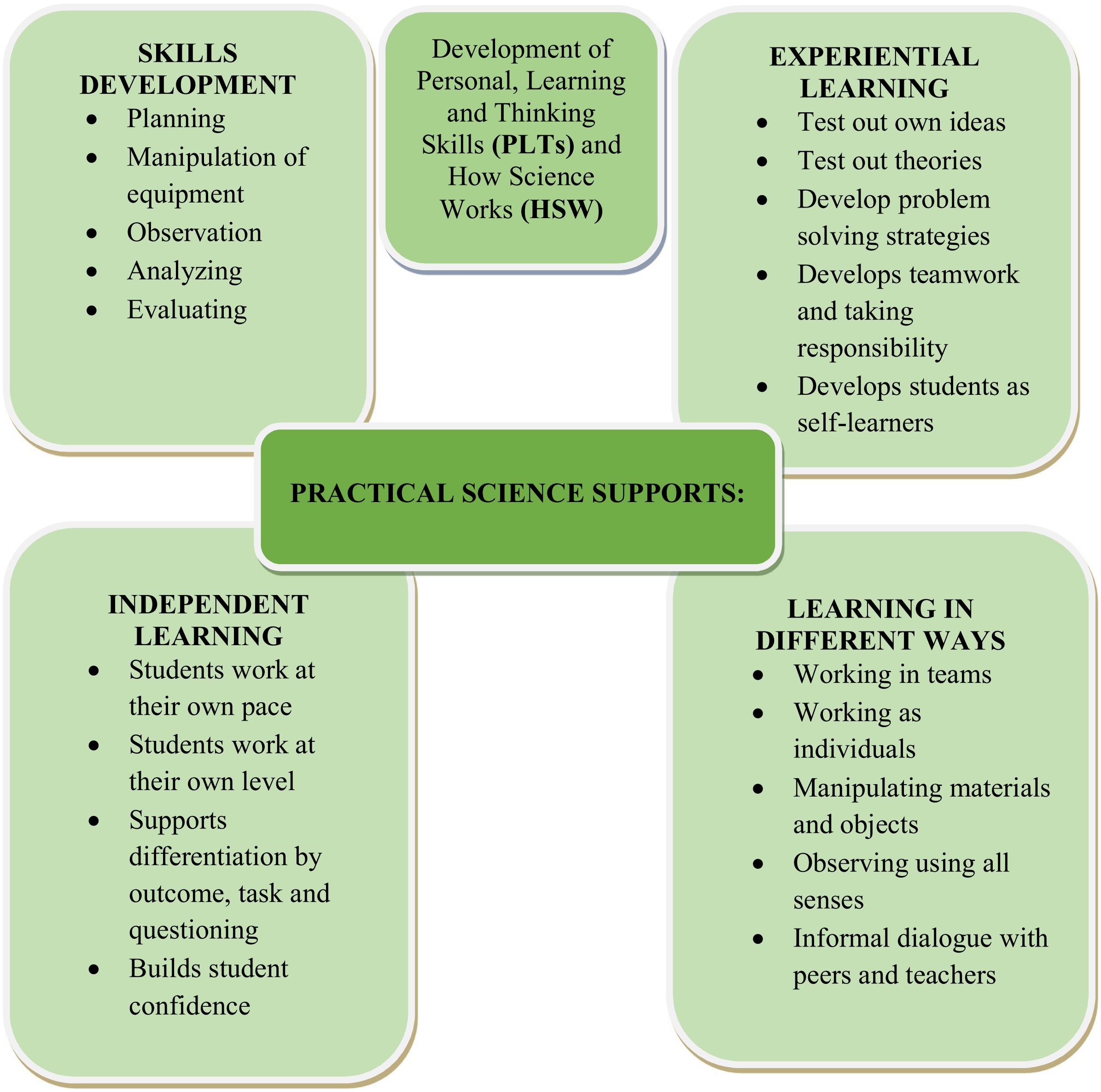

Figure 1. How practical work supports Science (From getting practical: a framework for practical science in schools)

Source: Adapted from SCORE (2009a)

Teaching Chemistry practical through learner-centered methods of teaching enhances active participation of learners in the teaching learning process. It develops curiosity, increases intellectual potency, intrinsic motivation, memory retention, learner self-confidence and permits time for students to mentally assimilate and accommodate information and develop multiple talents (Millar, 2004). Vygotsky (1978), points out that meaningful learning takes place if the learning environment encourages self-motivated and self-driven learning. This can be achieved through learner-centred investigative activities (Jorgenson, 2001).

Over the past few decades, a paradigm shift in curriculum has occurred where a teacher acts as a facilitator in a student-centred classroom (Blumberg, 2008). Various terms have been used to describe these activity-based instructional approaches. These include; constructivism, inquiry approaches, active learning, learner-centred and student-centred approach (Bender, 2003).

A good practical task is one that achieves its aims of effectively communicating a clearly defined set of ideas which sometimes can be difficult to achieve. Teachers' identified outcomes can often be quite different from the outcomes that students perceive (Millar, 2010). With any activity, communicating its purpose and learning objectives to the students can increase its effectiveness as a learning experience and enable the students to get the most out of it. If the goals and objectives are not expressed in terms of being able to apply scientific knowledge, understanding and skills there is a danger of students simply following 'recipes' during practical activities. When done well, practical work can stimulate and engage students' learning at different levels, challenging them mentally and physically in ways that other science experiences cannot (SCORE, 2009b).

A good question to consider before carrying out any practical activity is: What do I expect the students to learn by doing this practical task that they could not learn at all, or not so well, if they were merely told what happens? (Millar, 2010). Asking this question will help to define the objectives of the activity, and justify its relevance in the learning of science. Effective practical activities enable students to build a bridge between what they can see and handle (hands-on) and scientific ideas that account for their observations (brains-on). Making these connections is challenging, so practical activities that make these links explicit are more likely to be successful (Millar, 2004). In planning an activity, the task should be tailored to achieve the identified aims, for example through discussion between students. Allowing time for students to use the ideas associated with observed phenomena, rather than seeing the phenomena as an end in themselves, is vital if students are to make useful links.

There are many espoused purposes for doing practical work in school science. some of the most frequently stated by teachers are to encourage accurate observation and description; make phenomena more real; arouse and maintain interest; to promote a logical and reasoning method of thought; teach skills; motivate learners; encourage enquiry; teach concepts; provide pupil enjoyment; show how science works; link practical to theory; provide science contexts; encourage creativity; encourage group work and understand investigation processes (SCORE, 2009b).

2.3.3 Improving Practice in Chemistry

As part of the SCORE project on Practical Work in Science, the Association for Science Education led a new programme of professional development, called 'Getting Practical'. The programme was designed to support teachers, technicians and teaching assistants in improving the effectiveness of practical work through using, tailoring and managing practical activities to meet particular aims (SCORE, 2009a; Millar, 2010).

The aims of the programme were to improve the:

- clarity of the learning outcomes associated with practical work;
- effectiveness and impact of the practical work;
- sustainability of this approach for ongoing improvements;
- quality rather than the quantity of practical work used.

This programme aimed to increase the quality rather than the quantity of timetabled practical work, unless a school feels that more practical work is needed. Bringing together the programme's aims develops teachers' abilities to assess the way they teach Chemistry practical at all levels and increase their confidence in producing good-quality lessons for the benefit of the young people (SCORE, 2009a).

2.3.4 The Impact of Practical Work on Learning

Practical work plays an important role in the learning of science. In general, teachers and students are positive about 'practical work'. For example, inquiry learning has a positive impact on student performance and attainment (Davies, 2007). The quality of practical work varies considerably but there is strong evidence, from this country and elsewhere, that when well-planned and effectively implemented, science education laboratory and simulation experiences situate students' learning in varying levels of inquiry requiring students to be both mentally and physically engaged in ways that are not possible in other science education experiences (Lunetta et al. 2007).

Evidence of effective practice in the use of practical work comes from a range of studies. For example, a study by Lunetta et al. (2007) indicates that ‘students must manipulate ideas as well as materials in the school laboratory’. There is a growing body of research that shows the effectiveness of ‘hands on’ and ‘brains-on’ activities in school science inside and outside the laboratory. There is evidence that practical work can increase students’ sense of ownership of their learning and can increase their motivation. Furthermore, there is evidence that the teacher’s role in helping students to compare their findings with those of their peers and with the wider science community is critical.

Abrahams and Millar (2008) argue that teachers need to devote a greater proportion of the lesson time to helping students use ideas associated with the phenomena they have produced, rather than seeing the successful production of the phenomenon as an end in itself. This finding has implications for pre-service and continuing professional development for teachers. Students and their teachers need to understand something about the nature of science if they are to appreciate the limits and value of practical activities. The evidence suggests that teachers appear to adapt their practices slowly when faced with new curricula such as *Twenty First Century Science* (SCORE, 2009b). This finding also has implications for pre-service and continuing professional development of teachers.

2.4 Skills Acquisition, Motivation and Achievement in Chemistry

In 1956, Benjamin Bloom along with a group of like-minded educators developed a framework for classifying educational goals and objectives into a hierarchical structure representing different forms and levels of learning (Bloom, 1984). His taxonomy of learning objectives has become a key tool in structuring and understanding the learning process. This framework was published as Bloom’s Taxonomy of Educational Objectives and consisted of the following three domains:

- **The Cognitive Domain** – knowledge-based domain, consisting of six levels, encompassing intellectual or thinking skills
- **The Affective Domain** – attitudinal-based domain, consisting of five levels, encompassing attitudes and values
- **The Psychomotor Domain** – skills-based domain, consisting of six levels, encompassing physical skills or the performance of actions

Each of these three domains consists of a multi-tiered, hierarchical structure for classifying learning according to increasing levels of complexity. In this hierarchical framework, each level of learning is a prerequisite for the next level, that is, mastery of a given level of learning requires mastery of the previous levels (Anderson & Krathwohl, 2001). Consequently, the taxonomy naturally leads to classifications of lower- and higher-order learning. Bloom's taxonomy has stood the test of time, has been used by generations of curriculum planners and has become the standard for developing frameworks for learning, teaching, and assessment (Krathwohl, Bloom, & Masia, 1973). Figure 2 shows the three psychological domains of learning proposed by Blooms.

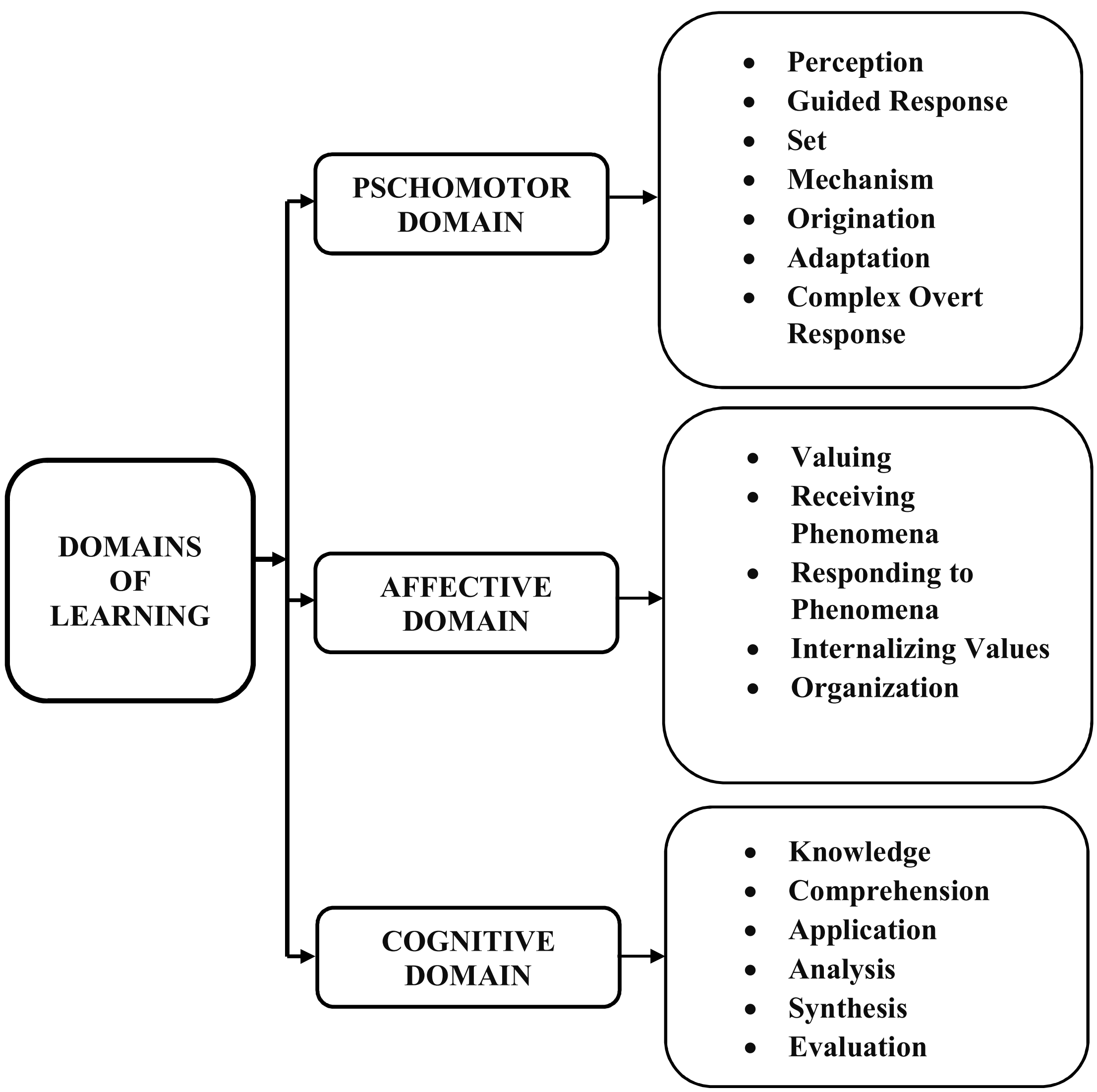

Figure 2. The three Psychological Domains of Learning proposed by Bloom

Source: Bloom (1984)

Benjamin Bloom developed a taxonomy of educational learning objectives. He identified three domains of learning: Cognitive Domain, Affective Domain, and Psychomotor Domain. According to Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Pintrich, Raths, & Wittrock, (2001), it is important to understand the six levels of Blooms Taxonomy and see what type of learning each level can address:

Knowledge: this represents the lowest level of knowledge of imparting knowledge that needs to be recalled or recognized. Learners are assessed on their ability to recall or recognize facts

Comprehension: this involves imparting knowledge that needs to be assimilated in order to interpret and make some decisions. It assumes recall of facts (Level 1) has been mastered. Learners are assessed on comprehension and the resulting ability to make a decision in a given situation

Application: this is used to teach skills for application in various circumstances. It assumes recall of facts (Level 1) and assimilation have been mastered (Level 2). In this case learners are assessed on their ability to apply a skill in a new situation

Analysis: Used to teach analysis of a situation to arrive at a decision/compare/differentiate. It assumes recall of facts, assimilation, and application (Level 3) have been mastered. Learners are assessed on their ability to analyze, compare, differentiate, or justify

Synthesis: this is used to teach how to create new entities from known information/objects/facts. It assumes mastery of all previous cognitive levels. Learners are assessed on their ability to combine, summarize, organize

Evaluation: evaluation is used to teach knowledge that will enable learners to make judgments. It considers all previous levels of knowledge. Learners are assessed on their ability to evaluate new entities

By creating learning objectives and assessments at the appropriate Bloom's level we can make our courses truly effective. Based on this taxonomy of educational objectives, this study investigated the effect of CBCML on students' skills acquisition (Psychomotor Domain), motivation (Affective Domain) and achievement (Cognitive Domain) in chemistry practical in Bomet County.

2.4.1 Students' Skills Acquisition in Chemistry

Science process skills are activity-based skills which can be acquired through training and direct experience. Studies have indicated that students exhibit poor skills acquisition in science (Nwosu, 2006). This poor acquisition of skills has been attributed to a number of factors such as teacher variable, that is, the teachers' method of teaching. Njelita (2007) in his study on Volumetric Analysis in Chemistry found out that innovative teaching strategy such as inquiry, problem solving, cooperative and demonstration methods are better than the CTM in acquisition of science process skills.

In the cause of learning science and technology, it is expected that both process and products be acquired to enable the individual to apply them to solving problems for the improvement of society (Padelford, 1984). It is instructive to refer to processes and skills since the skills arise from the various processes. Gega (2006), presents science skills as process based. An examination of science curricula, especially the primary science curriculum, shows that the under listed actions and behaviours define the skills expected from science learners. He defined what each pupil should be able to do at the end of learning primary science. The skills through a series of activities are carefully designed and implemented.

Scientific Skills include observing, classifying, measuring, recording, hypothesizing, designing experiments, controlling variables, manipulating, interpreting data, inferring, concluding, generalizing and predicting. The behaviour changes expected from learners of science are specified in terms of what learners can do as to provide a clear focus for teachers who may be in doubt as to what to teach or teachers who may be tempted to produce themselves in the pupils they teach (Ivowi, 2001). The skills listed can be acquired and demonstrated by a primary school child if appropriate activities are designed and presented to the school learners. In this study science process skills that were focussed on include observing, classifying, measuring, recording, controlling variables, manipulating, interpreting data, inferring, and predicting.

While science skills can be referred to as process based, technology skills can be referred to as manipulative based. This is because technologists are mostly engaged in overt actions, which involve a lot of manipulation of materials and machines to create an effect (Okwelle, 2011). The skills acquired from technology are however not exclusive of the skills from science.

Most of the skills listed are observable behaviours which come about as a result of some form of manipulation of tools, equipment and machines (Okwelle, 2011). A lot of activities abound in the environments from which appropriate experiences for the acquisition of the skills can be drawn. It is left for the technology teacher to ensure that the activities being presented to the pupils are those that are characterized by the skills pupils are expected to acquire. As should be noted, the skills are in hierarchy and even for a particular skill; it has different levels of sophistication or difficulty. Ivowi (2001) stated that a skill is usually accepted to have been acquired if it can be demonstrated correctly at least every two out of three occasions when demand is made.

This two-thirds rule is required in terms of quality and at least for a start. Far more demand is made in later stages as skill demonstration improves with time and practice. A learner-centred approach is highly recommended for the teaching and learning of science and technology since the envisaged content mastery and attitudinal changes are geared towards the learner. So, the focus is the learner, and consequently, we need to encourage them.

In science teaching, teachers need to create experiences which enable students to acquire the basic concepts and process skills. In this way, there is stimulation in the students' learning ability, and this type of learning is in line with the Constructivist Learning Model (Teetito, 2000). The model explains that knowledge can never be observer independent. It requires; a personal commitment to question, a personal commitment to explain, and to test explanations for validity. Each learner is expected to put together ideas and structures that have personal meaning for learning to take place.

According to Gemayel (2010), the effective use of the constructive model involves the use of teaching practices with the following specific procedures: Planning activities, Classroom strategies, Students' activities and Teaching technique. These strategies are organized by constructivist teachers into four categories: Invitation, Exploration, proposing explanation and solution as well as taking action

The important position of skills acquisition in education calls for application of every effort to create the desire to acquire skills among the learners. The best plan of the teacher may fail to result in successful learning unless learners are physically and mentally ready to learn (Okwelle, 2011). This state of readiness must develop in learners from within and cannot be forced by a teacher. What successful teachers do is to merely take the advantage of such state when it is presented. This of course does not suggest that a teacher should wait until some whim of learner induces him to readiness for learning before learning can be presented.

Importantly, learners need careful supervision by a teacher when they are practicing the skill. There is the tendency for some teachers to act as though demonstration, provision of tools, materials and operation sheet are all that learners need to practice a skill. Learners practicing a skill need careful observation, correction, questioning, and guidance (Ficklen, & Muscara, (2001). These can be done only if a teacher is present when learning and practicing the skill. Often time, teachers forget that they can be charged with negligence of duty if during a skill practicing session, learners receive bodily injuries or if any other avoidance incidence occurs.

2.4.2 Students' Motivation to Learn Chemistry

Motivation, a force that energizes and directs behaviour towards a goal could certainly be perceived as one of the most important psychological concepts in education (Eggen, Kauchak, & Harder, 1994; Aire & Tella, 2003). Self-determination theory (SDT) is one of the useful theories developed for understanding individuals' motivation (Deci & Ryan, 2000). SDT suggests that the impetus of motivated behaviour is having the experience of autonomy and competence.

Motivation is one of the most important impulsive power sources which gives some guidance to behaviour of students in school and determines behaviour's strength and stability (Spaulding, 1992). It is a repulsive power to attain a certain goal and being able to do necessary actions in particular conditions, giving energy and a guide to behaviour causing an affective advance. Senemoglu, (2004) also defines motivation as an internal state that arouses, directs and sustains behaviour. It is a power gaining state to reach certain goals.

Chemistry education reform is under way in many countries. An important reason for this reform is the growing dissatisfaction with the position of many Chemistry curricula: quite isolated from students' personal interest, from current society and technology issues, and from modern Chemistry (Jong, 2006). According to Holbrook (2005), the stress on conceptual understanding and appreciation for the nature of science, tends not to be relevant for functionality in our lives. Sirhan (2007) found that students engage more easily in problems that are embedded in challenging real-world contexts that have apparent relevance to their lives. If the problems are interesting, meaningful, challenging, and engaging they tend to be intrinsically motivating to students. Motivation to learn is an important factor controlling the success of learning. However, teachers face problems when their students do not have the motivation to seek to understand (Sirhan, 2007).

Cooperative learning situations enable students to work together by themselves most of the times. This in turn maximises learning and motivates students. Motivated students make the teacher's job of managing instruction program simpler. When students are academically motivated, their teacher often becomes professionally motivated (Spaulding, 1992).

All ARCS conditions should exist in a good learning environment. The use of CBCML is likely to improve the four conditions discussed above by improving the attention of students as the work together in the cooperative learning groups. Since group goals were set in advance, the students felt that the chemistry content is valuable to them. Furthermore, the encouragement from fellow group members boosted the students' confidence. It is also expected that the achievement of the set goals resulted in a sense of satisfaction in the students.

2.4.3 Students' Achievement in Chemistry

The achievement of students in chemistry in Kenya has been generally low over the years. The poor performance of students in the subject in KCSE 2013 was attributed to poor performance in practical. The report points out that the candidates had little or no exposure to practical work (KNEC, 2014). This therefore implies that practical work in chemistry determines the overall performance of the learners in the subject.

Well planned and effectively implemented quality of practical work in chemistry laboratories situate students' learning in varying levels of inquiry requiring students to be both mentally and physically engaged in ways that are not possible in other science education experiences (Lunetta et al., 2007). Research shows that 'hands-on' and 'brains-on' activities in school science inside and outside the laboratory are effective in enhancing achievement. Practical work can increase students' sense of ownership of their learning and can increase their motivation. Consequently, their achievement in science improves.

Practical activities increase the interest for chemistry and to support learning (Millar, 2010). In addition, they contribute to a student-directed and inquiry-based learning environment in contrast to more teacher-directed learning (Hofstein & Lunetta, 2004). Practical work is an essential aspect of everyday practice in the chemistry classroom. Through practical work teachers get to ‘engage’ all five senses of a student (Petrusevski & Najdoski, 2000)

2.5 Gender and Performance in Chemistry

Gender, as a concept in research, has captured a lot of interest among science educators across the world, especially now that gender equity is being emphasized in secondary school science. The ABC of Women's Rights and Gender Equality (2000) defines gender as the socially constructed differences and relations between males and females. According to the document the term “gender” is not interchangeable with the term “sex”, which refers exclusively to the biological differences between men and women, which are universal and do not change. Gender characterizes the different roles, responsibilities, constraints, opportunities and needs of females and males in all areas and in any given social context.

Fatokun and Odagboyi (2011) noted that the roles of women are despised in most societies thus preventing them from participating in, and benefitting from development efforts. They added that some subjects such as Science and Mathematics are branded masculine, while others like Home Economics, Secretarial Studies are branded feminine. Nwona and Akogun (2015) similarly noted imbalance against women in Science, Technology and Mathematics. These subjects are perceived as masculine and therefore boys are always expected to perform better than girls.

A number of studies on gender differences and students’ achievement have been done. While some of these studies observed gender disparity in science in favour of males (Ekeh, 2004); others report females' superiority and others still report, zero disparity (Udo, 2011). Hence, studies on gender and students' performance in science have conflicting and inconclusive findings. Researchers reporting male dominance explain their observations in terms of cultural factors and gender stereotyping. Owuamanam and Babatunde (2007) in a study on gender role stereotypes and career choice of secondary school students observed that boys showed interest on brain tasking careers while girls were more interested on courses that do not require much brain work.

Findings from research show that gender affects the enrolment and the learning of Science. One of the Millennium Development Goals (MDGs) was to attain gender equality. Moreover, the idea of the Sustainable Development Goals (SDGs) has quickly gained ground because of the growing urgency of sustainable development for the entire world (UNDG, 2013). The fourth goal of SDGs aims at ensuring inclusive and equitable quality education and promoting life-long learning opportunities for all. One of its priorities is to eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations. In addition, the fifth goal aims at Achieving gender equality and empowering all women and girls through the use of enabling technology, in particular information and communications technology, to promote the empowerment of women (UNDG, 2013).

Findings from Research have shown that different teaching methods produce different results (Crawford, 1999). The identification of the best teaching strategy for a given set of students must be done if the best result must be achieved. To ensure learner-friendly learning environment, effective instructional methods that involves hands-on activities with students should be encouraged. In addition to the study of the effects of CBCML on students' skills acquisition, motivation and achievement in chemistry practical, this study examined how gender affects skills acquisition, motivation and achievement in chemistry practical when CBCML is used in teaching.

2.5.1 Gender and Students' Skills Acquisition in Chemistry

Education in science and technology has become a dominant factor of the current society and thus meaningful learning of science should include the acquisition of science process skills. This is because they are the tools needed for learning and problem-solving in science. Many studies have found out that female students under-achieve in science in relation to male counterparts (Nwona & Akogun, 2015). The difference in performance has been attributed to biological or sex differences in process of socialisation and schooling.

According to Dareng (2001), traditional methods of teaching deny girls the opportunity to interact with science related activities which helps them to acquire science and technology skills. It is only through innovative teaching approaches that boys and girls irrespective of gender are armed with appropriate tools and abilities needed to explore their environment and solve challenging problems in science. The acquisition of science process skills is of utmost importance in science education (Nwosu, 2006). This means that science learning irrespective of gender requires the development of rational critical thought process among students to enable them explore, invent, discover and develop some skills relevant in science careers.

Science process skills acquisition is basic for science inquiry and the development of intellectual skills and motivation needed to excel in science and occupy science oriented careers after schooling. Nwosu (2006) points out that girls possess as much intellect and creative abilities as to participate in science, technology and mathematics. Ibe (2004) further stressed that education in the future will equip the individual with the power to adapt to change irrespective of gender. This should be the most important goal of education of any society in the 21st century and beyond that wants to progress. It is with this in mind that this study investigated the effect of gender on skills acquisition in chemistry when CBCML is used in teaching.

2.5.2 Gender and Motivation in Chemistry

Motivation to learn has increasingly been viewed as an integral part of education, together with cognition, in the recent past. Motivation is defined by Glynn and Koballa (2006) as an internal state that arouses, directs, and sustains students' behaviour. Improving student motivation to learn has become an important role for improving classroom teaching and learning (Meece, Glienke, & Burg, 2006). For the cognitive point of learning, it consists of knowledge, skills and abilities. Studies in science education (Zusho, Pintrich, & Coppalo, 2003; Simpkins, Davis-Kean & Eccles, 2006) reveal that motivation to learn positively affects students' performance in learning science. According to Reeve, Hmm and Nix (2003), when students believe they have some degree of control over their learning, their motivation is increased.

Motivation is a significantly important factor for academic learning and achievement across childhood through adolescence (Glynn & Koballa, 2006). It is generally agreed that motivation has positive impact on learning; it stimulates, sustains and give directions to an activity. Highly motivated students often require little guidance from teachers and are capable of doing many higher degree of complicated work independently. Usually environmental condition can motivate students other mother motivational factors include parental pressure, classroom environment, teacher and peer approval may contribute to the motivation of the child (Glynn & Koballa, 2006).

Since motivation to learn has an effect on student achievement, it is crucial to investigate how gender affects students' motivation to learn chemistry. Therefore, the purpose of this study was to determine how gender affects students' motivation to learn chemistry when CBCML is used in teaching chemistry.

2.5.3 Gender and Achievement in Chemistry

Over the years, there has been renewed debate on the controversial issue of gender differences in math and science achievement. This debate currently focuses on why women are not seeking careers in information technology occupations (Glynn & Koballa, 2006). The most comprehensive reviews of the research in the area of gender differences have shown very few true differences between math and verbal abilities between men and women (Halpern, 2005). There are several questions whether gender differences still exist in academic achievement yet many researchers are still finding differences in performance as well as general interest in areas related to math and science (Opare, 1996).

Even though women have made great strides in science and technology, very few can be found in professions in maths, computer science or information technology jobs (Jacobs & Eccles, 2002). Many ideas have been put forth on why high achieving women may not be entering these professions including discrimination, gender-typed socialization, and self-concept of ability in these areas, and the value and interest that women have in these professions (Jacobs & Eccles, 2002). The focus of this study was to examine how gender affects achievement when CBCML is used in teaching Chemistry.

The issue of female underachievement in science has received some welcome attention in recent research in science education (Jacobs, 2005). Evidence from past studies show that achievement levels of girls and women in science are considerably below that of their male counterparts, especially in secondary school enrolment in Chemistry and those choosing careers in chemistry. In line with this, a number of scholars have directed their attention towards understanding this phenomenon and towards suggesting methods to reduce these inequalities (Jacobs & Eccles, 2002; Steinmayr & Spinath, 2008). It is with this in mind that the study sought to investigate whether gender affects achievement in chemistry when boys and girls are taught chemistry through CBCML.

2.6 Conventional Teaching Methods mostly used by Teachers in Chemistry Instruction

Over the years, effective teaching and learning of Chemistry content in Kenya has been affected by a number of factors. Mondoh (1994) identifies teacher's effectiveness as the most significant variable of students' achievement. Wachanga (2002) supported this view by arguing that the teaching effectiveness may be influenced by the teaching method that the teacher uses. The conduct of education in the 21st century has been witnessed with a paradigm shift from face-to-face teaching environment to a more technology-based learning environment. Technology in education is not something new in today's classrooms. However, many education systems are still using Conventional Teaching Methods during instruction (Laurillard, 2013). Many teachers are still teaching their students the way they were taught (Anglin & Anglin, 2008). Most teachers out of lack of adequate preparation and the wide syllabus opt to teach students using traditional teacher-centred approaches.

While innovative methods of teaching could be good in the aspect of student involvement hence meaningful learning, most teachers prefer teacher-centred approaches which enables them to use little time to cover a wide content without much concern on whether the objectives of the lesson have been attained or not (Laurillard, 2013). This could be one of the reasons why the academic performance in Chemistry at KCSE level has not only remained low but has also continued to decline over the years in Kenya. The attainment of concepts, skills and competencies can only be achieved by adopting practical approach in teaching the subject (KNEC, 2018)

Innovative teaching approaches that involve the learners and consequently motivate them to learn could be an important remedy to ensure a high level of academic achievement in Chemistry. Wachanga (2005) expressed teaching as an experimental process in which all techniques should be examined routinely and revised if necessary. The following methods have been identified and used by chemistry educators (Ayot & Patel, 1987) and in this constitute the Conventional Teaching Methods (CTM) in this study.

2.6.1 Lecture Method

This is the process of verbally delivering a body of knowledge according to a pre-planned scheme (Wachanga, 2002). The main feature of this method is the direct transmission of knowledge from teacher to student. This is a teacher-centred method since the student is passive. However, the method can be improved or made student-centred by blending it with questioning technique leading to informal lecture or discussion.

The strengths of the lecture method include the fact that it stimulates thinking to open discussion and is therefore useful for large groups. It also presents factual material in direct, logical manner and contains experience which inspires (McCarthy, 1992).

The lecture method has a number of drawbacks. Firstly, very little learnt knowledge is retained by the pupils as there is practically little understanding of the chemistry concepts. During the process pupils go through rote learning or memorisation. The method also ignores experimentation which is the basis of modern scientific knowledge neither does it give students the opportunity to exercise their intellectual abilities. It absolutely denies them active participation in the class during the teaching/learning process. Moreover, it provides no opportunities for students to clarify misunderstanding and there is little feedback to the teacher on the effectiveness of his or her presentation or achievement of the stated objectives.

Lectures are not suited for teaching high order thinking skills such as application, analysis, synthesis or evaluation; for teaching motor skills, or for influencing attitudes or values. This method also fails to provide instructors with feedback about the extent of student learning. Consequently, its use leads to rote learning encouraging cramming of concepts instead of understanding.

2.6.2 Teacher Demonstration Method

In a teacher demonstration experiment, a teacher as a facilitator performs the experiment for the large group. This approach is used when there is shortage of apparatus or when safety is a priority. It is also appropriate when a particular attention is needed in certain areas of the experiment which might be overlooked when learners do it alone. Many schools have a shortage of apparatus and chemicals hence they opt to use teacher demonstrations and not class experiments. However, teachers should note that overdoing demonstrations can make students passive with time since the learners have no opportunity to manipulate the learning materials (Nayak & Sigh, 2007; KIE, 2006).

Adequate planning ensures the success of teacher demonstrations. Demonstrations must always be rehearsed before they are performed during a lesson. This implies that a teacher should get the necessary apparatus and chemicals and arrange them in the order they are supposed to be used. The apparatus to be used for the purpose of a demonstration should be large and simple so as to improve the visibility of the demonstration. Finally, a teacher should ensure that all pupils are able to watch the demonstration and therefore contribute in the discussion thereafter.

2.6.3 Class Experiment Method

In this method students handle the apparatus and carry out the experiments themselves either individually or in small groups. Students' participation or activity is enhanced in that they learn by doing rather than by observing the experiments done by somebody else. In addition, when students handle an experiment themselves the experience is impressed more firmly in their minds than when they see or listen. This enables them to gain scientific skills (Mohanty, 2003)

Chemistry is a practical subject and therefore experimentation is an integral part of the programme. Experimentation trains students in scientific method. In secondary school students do experiments individually or in small groups depending on the nature of the experiment and availability of the apparatus, reagents, materials, the age and ability of the students.

After every class experiment, it is necessary to make a follow up on what has been done. Follow ups were important in the sense that the observations made are still fresh in their minds hence they participated more actively in the discussion. Also, the apparatus and chemicals used for the experiment are still within reach hence any controversy with respect to the observations can readily be resolved by carrying out the experiment in front of the class. Moreover, it enables students to have a complete and comprehensive record of the content covered in a particular chemistry lesson.

2.6.4 Questioning Method

The questioning technique is a useful method in chemistry teaching because it can be used on its own, or as part of another method. It should always accompany the lecture method which then results to a class discussion (Wachanga, 2005).

Questions have various aims. For instance, they help to get feedback for the teacher as well as the pupils. They also help to understand the entry behaviour of pupils. They also help in promoting interest and the change in activity helped to sustain interest during a lesson. Consequently, the motivation of the learners is enhanced to a certain degree. A teacher should guide and summarise learners' questions and responses to focus on the lesson objective (Nayak & Singh, 2007)

However, the method cannot be used entirely in a lesson but can best be used blended with another method. This is due to the fact that monotony was likely to arise in the sense that learners mechanically get engaged in receiving a question and then search for the answer repeatedly. The method does not pay attention to stimulus variation which is an integral component for meaningful learning.

2.6.5 Discussion Method

A problem, an issue, a situation in which there is a difference of opinion, is suitable for discussion method of teaching. Ideas are initiated; there is exchange of opinion accompanied by a search for its factual basis; speech is free and responsible. The participants; the teacher and students, are inter-related in a process of competitive co-operation. Discussion, in fact, is an ordered process of collective decision making. It seeks agreement, but if not reached, it has the value of clarifying and sharpening the nature of agreement, (Kochhar, 1992)

Discussion, as a method of teaching, may be used for a number of purposes. This includes laying plans for new work, making decisions concerning future actions, sharing information, obtaining and gaining respect for various points of view, clarifying ideas, inspiring interest and evaluating progress.

Much of the success of this method of teaching depends entirely on the person in charge, in this case the teacher who is the facilitator. The teacher should be able to motivate the students, energise a sagging discussion, bring each student into active participation, keep the discussion focused on the problems, make both periodic and final summaries and stimulate questions from the class (Kochhar, 1992).

2.6.6 Project Work

This approach is a unique application in the teaching-learning process which provides students with the opportunity to undertake investigations for the solutions of problems hence the transfer of chemical knowledge to solving problems encountered in day-to-day experiences (Wachanga, 2005). Project work is therefore concerned with the application of acquired chemistry knowledge. It encourages students to practise their personal skills of discovery learning. This method of teaching therefore strives to individualise instruction in science. The success of any modern chemistry curriculum rests upon the presentation of concepts and ideas of the course through experiments. It is therefore necessary to integrate projects into the physical sciences curriculum to supplement class experiments.

Project work arouses curiosity among the learners and enables them to gain confidence in manipulative skills. Students get the chance to demonstrate their abilities, attitudes and skills towards originality, creativity and presentation of scientific information in a logical manner. However, those who choose to use this method should note that it is expensive to use and time consuming.

2.7 ICT Integration and Paradigm Shifts in Science Teaching

Education around the world is experiencing major paradigm shifts in educational practices of teaching and learning under the umbrella of ICT enabled learning environment (Aggarwal, 2004). Whereas learning through facts, drill and practices, rules and procedures was more adaptive in earlier days, learning through projects and problems, inquiry and design, discovery and invention, creativity and diversity, action and reflection is perhaps more fitting for the present times (Zhu, 2003). The major hallmark of this learning transition is from teacher centred to learner focused paradigm.

2.7.1 Educational Environment

During the last three decades, the changes in educational environment have been phenomenal (Glenn, 2004). The model, focus, role of a learner and technology has been changed drastically from traditional instruction to virtual learning environment as depicted in Figure 3. Shifting the emphasis from teaching to learning can create a more interactive and engaging learning environment for teachers and learners. This new environment also involves a change in roles of both teachers and learners (Lambert & McCombs, 1998). The role of teachers will change from knowledge transmitter to that of facilitator, knowledge navigator and sometime as co-learner. The new role of teachers demands a new way of thinking and understanding of the new vision of learning process (Zhu, 2003). Learners will have more responsibilities of their own learning as they seek out, find, synthesize, and share their knowledge with others (Resta, 2002). ICT provides powerful tools to support the shift from teacher centred to learner centred paradigm and new roles of teacher, learner, curricula and new media (Holbrook, 2011).

All the changes taking place in teaching and learning process demand a new learning environment to effectively harness the power of ICT to improve learning. ICT has the potential to transform the nature of education: where, when, how and the way learning takes place (Witfelt, 2000). It facilitates the emergence of responsible knowledge society emphasizing lifelong learning with meaningful and enjoyable learning experiences. This is in accordance with the expectations of all the stakeholders in the education sector. The major shifts have been described in Figure 3.

Changes in Teaching-Learning Environment

MODEL	FOCUS	ROLE OF LEARNER	TECHNOLOGY
TRADITIONAL	TEACHERS	PASSIVE	CHALK & TALK
INFORMATION	LEARNERS	ACTIVE	PERSONAL COMPUTER
KNOWLEDGE	GROUP	ADAPTIVE	PC + NETWORK

Changes in Teachers' Roles:

From:	To:
Transmitter of Knowledge	Guide & Facilitator of Knowledge
Controller of Learning	Creator of Learning Environment
Always an Expert	Collaborator & Co-Learner
Learning to Use ICT	Using ICT to Enhance Learning
Didactive/Expository	Interactive/ Experiential/ Exploratory

Changes in Learners' Roles:

From:	To:
Passive Learner	Active Learner
Reproducer Of Knowledge	Producer of Knowledge
Dependent Learner	Autonomous Learner
Solitary Learner	Collaborative Learner
Solely Learning Content	Learning to Learn/Think/Create & Communicate

Changes in Curricula & Delivery:

From:	To:
Memorizing facts	Inquiry based
Artificial teaching exercises	Authentic learning
Rigid delivery	Open & flexible delivery
Single path progression	Multi path progression

Changes in Media Applications:

From:	To:
Single Sense Stimulation	Multi-Sensory Stimulation
Single Media Application	Multimedia Application
Delivery of Information	Exchange of Information
Monologue Communication	Dialogue & Collaborative
Analogue Resources	Digital Resources

Figure 3. ICT Integration in Education and Major Paradigm Shifts in Teaching-Learning
Source: Adapted from Witfelt (2000).

2.7.2 Creating New Cultures

The integration of ICT into teaching and learning, places pedagogy over technology by making learning to be learner-centred (Allesi & Trollip, 2001). It is not the only concern to master ICT skills, but rather it involves using ICT to improve teaching and learning. The major emphasis of ICT infusion in pedagogy should be such that it tends to improve learning, motivate and engage learners, promote collaboration, foster enquiry and exploration, and create a new learner centred learning culture (Anderson & Becker, 2001). It permits the move from reproductive model of teaching and learning to an independent, autonomous learning model that promotes initiation, creativity and critical thinking with independent research. Learners are expected to collect, select, analyse, organize, extend, transform and present knowledge using ICT in authentic and active learning paradigm (Witfelt, 2000).

According to Zhu (2003), teachers are expected to create a new flexible and open learning environment with interactive, experiential and multimedia based delivery system. Barak (2005), argues that ICT should help teachers and learners to communicate and collaborate without boundaries, make learners autonomous and allow teachers to bring the whole world into classroom activities. Wanjiku (2008), points out that it is ultimately important to understand the roles of ICT in promoting educational changes. A basic principle is that the use of ICT changes the distribution and ownership of information resources in the space of teaching and learning and thus changes the relationship among educational participants (Zhu, 2003). While designing any innovative teaching and learning environment using ICT, the teacher should always keep the learning at the centre of all activities, pedagogy should be at the heart and integration of pedagogy-technology should be the central focus.

2.7.3 Pedagogical Practices using ICT

Mere learning of ICT skills is not sufficing, but using ICT to improve the teaching and learning of science is the key for pedagogy-technology integration (Majumdar & Park, 2002). But the question is how we can combine these two. To start with, teachers need to prepare lesson plans and compile lesson materials for the classroom lecture in advance. To prepare such materials one has to go through the act of drafting phase, editing phase, revising phase and finally publishing the lesson plans and course contents. Word processor can be a great help to accomplish this task in a professional and productive way to avoid repetition, duplication of manual work and concentrate on quality of the course materials.

Teachers also need to make lists of the names of the students for monitoring and recording their academic performance and to analyse and perform a statistical analysis to take some corrective measure if any, in the lesson plan, delivery of instruction (Crawford, 2000). Spreadsheets can be a good choice for creating class lists, recording their performance and executing statistical analysis upon them.

While delivering the class lectures, any innovative teacher needs to draw diagrams, show pictures, animate some objects to explain critical concepts, even play some video clipping of real time operation (Crawford, 1999). All these multimedia applications can assure very productive, interesting, motivating, interactive and quality delivery of classroom instruction (Rosenberg, 2001). Presentation software like power point can be a good choice for teachers for performing such tasks.

In spite of the best efforts of teachers, there will be a number of learners who will not be satisfied with the pace of instruction of teachers. There may be a fast learner, average learner and slow learner. In a classroom environment it is impossible to satisfy all categories of learners with their specific learning styles. It is in these situations, teachers become helpless in a conventional teaching and learning environment. One way to solve such situations is to create interactive multimedia based instructional materials where learner is given control to review the topic at their own pace and in accordance to their individual interests, needs and cognitive processes (Witfelt, 2000). As such, multimedia courseware can be of great help to teachers to meet the challenges of such situation.

Witfelt (2000) points out that with availability of user friendly authoring tools, it is now possible to develop multimedia courseware by any young teachers to support drill and practice to master basic skills, simulate complicated situations, produce individualized instruction with multimedia elements with built-in evaluation questions and scores. Such multimedia courseware can produce profound changes in the learning outcomes when it is being used along with face-to-face instruction.

Learners always look for flexibility in time, space, place, content selection and delivery of instructions. It was quite impossible to satisfy such requirements in earlier times due to the non-availability of proper tools. It is now feasible and possible to implement open & flexible learning strategies using ICT as tools (Williams, Coles, Richardson, Wilson, & Tuson, 2000).

Flexible access to content and learning resources via network across conventional class rooms, homes and community centres is the defining characteristic of what has come to be known also as distributed learning.

Learning anytime, anywhere with synchronous and asynchronous communication across space, time and pace is the key to web based instruction (Barak, 2005). With the availability of online tools, it is now possible to create content websites, online education to support and assist face to face instruction in an innovative way. Communication with e-mail, searching for information, locating a proper website is now the key to success. Developing online and offline learning resources using various learning management system software/tools will become one of the key competencies of modern day teachers (Anderson & Becker, 2001). Searching, locating and categorizing knowledge and information via internet has opened a new dimension in implementation of flexible learning strategies.

As such starting from the productivity software to specialized educational software, there are numerous examples of various applications of the ICT tools in the teaching and learning system (Barak, 2005). Therefore, preparation of teachers to face the challenges of an ICT enriched teaching and learning environment is crucial. First teachers need to be equipped with the fundamentals of ICT tools and sufficient understanding on the integration of these tools in teaching and learning and secondly efforts must be oriented towards changing mind set and developing positive attitudes towards ICT application in teaching and learning (Ficklen & Muscara, 2001). Understanding the changing role of teachers from instructor to facilitators, teacher lead instruction to learner-centred instruction is the key for successful implementation of pedagogy-technology integration for teacher development.

In designing learning materials using ICT productivity tools certain pedagogical principles needs to be considered carefully. Mere ICT tools by themselves do not make good pedagogy (Grabe & Grabe, 2007). The moot question is how should the learning environment is designed using ICT as tools? What pedagogical principles would take the advantages of the best practices and unique environment afforded by this new ICT tools. These were the central questions which need to be addressed.

The use of ICT should satisfy the diverse needs of all kinds of learners characterized by all kinds of socio-cultural conditions including the diversity of multiple intelligences. Teachers should continue to learn through their lives new ways of using technology for the growth of their learners as well as the very systems of education (Ivowi, 2001). The critical question in education is- in what ways ICT can enhance learning and teaching practices.

Broadly, ICT tools help to open up opportunities for learning by enabling four key processes in transforming teaching and learning as follows: Access ideas and information from diverse sources through searching, locating, selecting, and authenticating material in a wide range of multimedia forms; Extend ideas and information through processing, manipulating, analysing & publishing material in different multimedia forms; Transform ideas and information into new or different forms through synthesizing, modelling, simulating and creating material in many multimedia styles and formats; and Share ideas and information across local, national and international networks by interacting electronically with others in actual and/or delayed time (Ozmen, 2008). Access, extend, transform and share represent key processes by which students learn and become independent learners and self-starters. Through the processes learners express their creativity and imagination. These processes can be applied in all areas of learning and in all levels of education.

There are three broad categories of educational software namely, Generic tools for learning, Content-based resources and Interactive instructional courseware. Starting from productivity tools to simulation & modelling, there are various generic tools that help learners to access, extend, transform and share information (Ivowi, 2001). Content-based resources help learners to access a vast source of educational resources that effectively can be integrated with the curriculum objectives. Interactive instructional courseware comprises of basically self-paced learning materials. These programs are helpful to learners to control their learning at their own place and convenience.

Ozmen (2008) argues that the integration of ICT in teaching and learning has produced some of the significant positive gains in learners' knowledge, skills and attitudes by providing the following key advantages:

- Exploration and representation of information dynamically and in many forms by learners
- Learners become socially aware and more confident
- Increase motivation among learners
- Enables learners to communicate effectively about complex processes
- Development of better understanding and broader view of processes and systems

• Learners acquire greater problem solving and critical thinking skills.

In view of these advantages, the study integrated the use of ICT into the cooperative mastery learning, not to replace the practical work in science, but to enrich learning by increasing their level of active participation in class during learning. The use of Computers to enhance learning changes teachers' roles to interactive, experiential and exploratory while that of learners changes to a collaborative, learning to learn, think, create & communicate ideas and concepts in science. Eventually, meaningful learning of science is realised by all the learners.

2.8 Computer Based Cooperative Mastery Learning (CBCML)

Conventional Teaching Methods of instruction focus on the mastery of content, with little development of the skills and attitudes necessary for scientific inquiry. The teacher transmits information to students, who receive and memorize it. Assessment of knowledge typically involves one right answer. The curriculum is loaded with many facts and a large number of vocabulary words, which encourages a lecture format of teaching (Leonard & Chandler, 2003). This kind of teaching approach encourages rote learning.

Science classrooms are becoming more diverse with differences in terms of learning environment, students' background, students' interest, and abilities. Motivation is a key driving force for students to learn meaningfully. A study by Okoyefi and Nzewi (2013) showed that students perform well when they are exposed to methods that interest them during the teaching-learning process. Hence, innovative instructional strategy which are learner-centred, could be used to reduce the decline of students' interest in chemistry. When such methods are used, the teacher acts as a facilitator, creating a suitable learning environment in which students actively engage in experiments, record and represent results, interpret and explain data, discuss and harmonize their findings with peers.

Computer Based Cooperative Mastery Learning (CBCML) is defined as an approach to teaching in which learners are put in small groups of five learners each. Each learner is assigned roles to play within the group for individual success through mastery learning and that of the rest of the members through cooperative learning. During the group learning activities, computer technology is used to supplement the teaching and learning resources. It is unique in the sense that learners work together in groups to accomplish given tasks. Technology appeals to many senses hence encouraging stimulus variation and consequently meaningful learning was realized. Computers generate data at the students' request to illustrate relationships in models of social or physical reality, execute programs developed by students, or provide general support in relatively unstructured exercises designed to stimulate and motivate students. Eventually, mastery of content is achieved by the learners.

CBCML approach to the teaching and learning of Chemistry practical is a hybrid of two approaches facilitated by computer technology. Therefore, is expected to enhance meaningful learning through active involvement of the learners in hands-on activities as well as their self-determination to attain mastery of content and science process skills. Furthermore, the shared responsibility and interaction are likely to generate better inter-group relations, and result in better self-images for students with histories of poor achievement (Joyce & Weil, 1980). Science teachers should use different strategies as there is no single universal approach for specific class. Lack of good strategies in the teaching of science is affecting student performance and at long run affects student enrolment (Oladejo, Olosunde, Ojebisi, & Isola, 2011). Therefore, the use of CBCML in the teaching and learning of chemistry could be a remedy to this persistence problem of poor performance in science.

2.8.1 Computer Based Instruction (CBI)

Computer Based Instruction (CBI) refers to teaching and learning through computer-based programs that mostly involve drill and practice, tutorial and computer simulation activities offered either by themselves or as supplements to traditional and teacher-directed instruction (Stennet, 1985).

Computer Based Instruction (CBI) provides individualized instruction and therefore learning occurs at learners own pace and time (Munden, 1996). Perhaps this explains why recent studies show that the use of computers in the classroom is bringing in new roles into the instructional practice (Kiboss, 2000). Such changes brought about by ICT integration in pedagogy includes changes in the roles of both learners and teachers, changes in curricula and delivery as well as changes in media application. Consequently, the teaching-learning environment changes as to ensure active learner participation. However, the introduction of CBI in Kenyan schools is still a challenge. Most teachers are battling with the issue of whether to accept the idea of students being given the opportunity to interact actively with the instructional material in the classroom (Kiboss, 2000). Alessi and Trollip (2001) emphasized that there are four major types of CBI programmes namely: Tutorials, Drills and practice, instructional games and simulations.

CBI motivates children to learn better by providing them with the immediate feedback and reinforcement and by creating an exciting and interesting game-like atmosphere. The studies in the field reveal that the students' achievements increase when the CBI technique is provided as a supplement to the classroom education. CBI is more effective on less successful children (Barak, 2005). The reason for this is that the computer-based instruction enables the children to progress at their own pace and provides them with appropriate alternative ways of learning by individualizing the learning process (Senemoglu, 2004). It is on this basis that CBI simulations were adopted in this study.

CBI makes it easier to cover the chemistry syllabus since many practical activities are already simulated and learners can replay them even in the absence of the teacher (Senemoglu, 2004). A study by Amadalo, Shikuku, and Wasike, (2012) showed a positive relationship existing between syllabus coverage and performance at National Examinations level in Mathematics.

CBI can provide an effective supplement to a teacher (Cepni, Tas & Kose (2006). However, a study by Wragg (2000) indicate that most teachers feel threatened by the computer because it forces them to organize their classrooms differently. This reduces their control and makes their normal approach of monitoring progress difficult to implement. In spite of these, a lot of research and studies have been done on CBI teaching and most of them recommend it as a very useful instructional tool. Capper and Copple (1985) indicate that the single-best-supported finding in the research literature is that the use of CBI as a supplement to traditional teacher-directed instruction produces achievement effects superior to those obtained with traditional instruction alone.

Dalton and Hannan (1988) indicate that while both traditional and computer-based delivery systems have valuable roles in supporting instruction, they are of greatest value when complementing one another. As such, the successful integration of CBI into the teaching and learning of science depends on teachers embracing the new innovation, making informed judgments about the suitability of CBI to meet their particular teaching and learning goals, and considering CBI in their search for new instructional approaches (Ozmen, 2008). There was therefore a great need to investigate the effects of introducing CBI into science instruction in Kenyan secondary schools.

2.8.2 Cooperative Learning (CL)

Cooperative learning is a student-centred, instructor-facilitated instructional strategy in which a small group of students is responsible for its own learning and the learning of all group members (Okoli, 2006). Students interact with each other in the same group to acquire and practice the elements of a subject matter in order to solve a problem, complete a task or achieve a goal (Bandura, 2001).

Cooperative learning is a process of working together in a group to accomplish shared goals (Okoli, 2006). The use of cooperative learning strategy enhances students' ability of working together hence students maximize their own and each other's' learning. Many principles have been proposed for cooperative learning. Below is one list of eight such principles.

1. **Heterogeneous Grouping.** This principle means that the groups in which students do cooperative learning tasks are mixed on one or more of a number of variables including sex, ethnicity, social class, religion, personality, age, language proficiency, and diligence.

2. **Collaborative Skills.** Collaborative skills, such as giving reasons, are those needed to work with others. Students may lack these skills, the language involved in using the skills, or the inclination to apply the skills. Most books and websites on cooperative learning urge that collaborative skills be explicitly taught one at a time.

3. **Group Autonomy.** This principle encourages students to look to themselves for resources rather than relying solely on the teacher. When student groups are having difficulty, it is very tempting for teachers to intervene either in a particular group or with the entire class (Johnson & Johnson, 1998). We may sometimes want to resist this temptation, because as Roger Johnson writes that teachers must trust the peer interaction to do many of the things they have felt responsible for themselves.

4. **Simultaneous Interaction.** Simultaneous Interaction was advocated by Kagan (1994). In classrooms in which group activities are not used, the normal interaction pattern is that of sequential interaction, in which one person at a time – usually the teacher – speaks. In contrast, when group activities are used, one student per group is speaking.

In a class of 40 divided into groups of four, ten students are speaking simultaneously, for instance 40 students divided into 4 students per group.

5. **Equal Participation.** Equal Participation was advocated by Kagan (1994). A frequent problem in groups is that one or two group members dominate the group and, for whatever reason, impede the participation of others. Cooperative learning offers many ways of promoting more equal participation among group members.

6. **Individual Accountability.** All students in a group must be accountable for contributing their own share of the work and mastering all of the material to be learned to the group's success (IDEA, 2010; Johnson & Johnson, 1999). Teachers should encourage individual accountability in groups, with hope that every learner will try to learn and to share their knowledge and ideas with others.

7. **Positive Interdependence.** This principle lies at the heart of CL. When positive interdependence exists among members of a group, they feel that what helps one member of the group helps the other members and that what hurts one member of the group hurts the other members (Johnson & Johnson, 1992). It is this "All for one, one for all" feeling that leads group members to want to help each other, to see that they share a common goal.

8. **Cooperation as a Value.** This principle means that rather than cooperation being only a way to learn, that is, "the how of learning", cooperation also becomes part of the content to be learned, in this case, "the what of learning". This flows naturally from the most crucial cooperative learning principle, positive interdependence (Jones & Brickner, 1996). Cooperation as a value involves taking the feeling of "All for one, one for all" and expanding it beyond the small classroom group to encompass the whole class, the whole school, on and on, bringing in increasingly greater numbers of people and other beings into students' circle of ones with whom to cooperate (IDEA, 2010).

Cooperative learning groups can consist of two to five students, but groups of three to four are also effective. Classes can be divided up into several groups. The groups should contain high achievers and low achievers (Jacobs, Power & Loh, 2002). These common features enhance the effectiveness of cooperative learning groups. Figure 4 shows the importance of cooperative learning.

Figure 4. Importance of Cooperative Learning
Source: Adapted from Ormrod (2004)

When activities are designed and structured appropriately, cooperative learning can be very effective. According to Ormrod (2004), students of all ability levels show higher academic achievement; females, members of minority groups, and students at risk for academic failure are especially likely to show increased achievement (Johnson, Johnson & Stanne, 2002). This learning concept can promote advanced level of thinking skills:

- Students essentially think aloud.
- Students are able model various learning and problem solving strategies for one another.
- Students are able to develop a greater meta-cognitive awareness as a result.

Cooperative learning allows a teacher to actively involve students in discovering knowledge through a new learning process (Johnson, Johnson & Stanne, 2000; Robinson, 2002). The learning process takes place through dialogue among the students. Dialogue can be achieved through formulated questions, discussions, explanations, debates, writings, and brainstorming during class (Institute for Dynamic Educational Advancement (IDEA), 2010). Projects that require a wide range of talents and skills can be assigned to each group member, contributing to the group's overall success (Ormrod, 2004). Assigning different roles to different students and providing scripts for interaction is another application of cooperative learning.

2.8.3 Mastery Learning Approach (MLA)

Mastery Learning Approach (MLA) is an instructional method where students are allowed unlimited opportunities to demonstrate mastery of content taught (Guskey, 2007). It is a remedial process aimed at bringing students to a level of mastering a concept. MLA involves breaking down the subject matter to be learned into units of learning, each with its own objectives. Results from research studies on MLA shows that there is better retention and transfer of material, yields greater interest and more positive attitudes (Wachanga & Mwangi, 2004).

MLA focusses on students reaching a pre-determined level of mastering a unit before moving to another. A study by Abakpa and Iji (2011) affirms that MLA enhances students' academic achievement and retention in integrated science and mathematics than CTM. According to Adepeju (2003), MLA is an innovative strategy designed to make students perform beautifully well in an academic task. It involves:

(i) Involving learners in relevant hands-on, hearts-on and heads on activities;
(ii) Frequent assessment and feedback;
(iii) Corrections with emphasis on cues;
(iv) Motivation;
(v) Allotment of more time on tasks; and
(vi) Reinforcement through assignments.

In this study, the elements of Mastery Learning Instruction and CBI simulations were incorporated into the Cooperative Learning Groups. The simulations to be used are contained in the Form 3 Chemistry DVD developed by KICD. Lessons were presented using computers and students went through the simulations in the topic Volumetric Analysis. At the end of each objective in the lesson were quizzes. The students were required to answer and upon attaining 80% they could be allowed to move to the next topic. This approach was referred to as Computer Based Mastery Learning (CBML).

CBCML teaching strategy is one kind of an approach that puts together mastery learning, Cooperative Learning approaches and the use of computer technology. It is therefore a hybrid of the three approaches and therefore, likely to motivate the students by not only appealing to their cognitive domain but also their affective domain as well as the psychomotor domain. This will consequently promote students' achievement.

According to Johnson, Johnson, & Stanne (2000), learner-cetred approaches to teaching offers many potential benefits including enhanced skills acquisition, motivation and achievement. These benefits include increased self-esteem, greater liking for school, enhanced inter-ethnic ties, and improved complex thinking (Johnson, Johnson, & Stanne, 2000). CBCML being a hybrid offers one ray of hope that we can move away from the all-too-present unhealthy forms of conflict and competition that plague our world today and learn cooperatively in groups.

In CBCML, the teacher acts as a facilitator creating learning conditions in which students actively engage in experiments, interpret, explain data and negotiate understanding of findings with co-experimenters and peers (National Research Council, 2005). Through this, learners gain mastery of concepts in chemistry practical with the help of simulations from computer technology.

2.8.4 Classroom Implementation of CBCML

The Cooperative learning used in implementation of the intervention through CBCML in this study involves the instructional use of small groups to promote students working together to maximize their own and each other's learning (Johnson, et al., 2008). Each individual student in the group work hard to achieve a desired level of mastery of chemistry concepts. In this case, they were expected to score 80% and above in the weekly mastery quiz before proceeding to the next lesson topic through the help of computer simulations. Cooperative learning is characterized by positive interdependence, where students perceive that better performance by individuals produces better performance by the entire group (Johnson, et al., 2014). It can be formal or informal, but often involves specific instructor intervention to maximize student interaction and learning. It is infinitely adaptable, working in small and large classes and across disciplines, and can be one of the most effective teaching approaches in Chemistry teaching.

Cooperative learning groups can be either formal, informal or base groups. In this study, formal cooperative learning groups were used in which small heterogeneous groups of five students each were formed. In formal cooperative learning students work together for a period of six weeks to complete a joint task or assignment (Johnson et al., 2014). There are several features that can help these CBCML groups to work well:

- The instructor defines the learning objectives for the activity and assigns students to groups.
- The groups are typically heterogeneous, with particular attention to the skills that are needed for success in the task.
- Within the groups, students may be assigned specific roles, with the instructor communicating the criteria for success and the types of social skills that will be needed.
- Importantly, the instructor continues to play an active role during the groups' work, monitoring the work and evaluating group and individual performance.
- Instructors also encourage groups to reflect on their interactions to identify potential improvements for future group work.

In formal group learning, it is helpful for the instructor to form groups that are heterogeneous with regard to particular skills or abilities relevant to group tasks. For example, groups may be heterogeneous with regard to academic skill in the discipline or with regard to other skills related to the group task for example design capabilities, programming skills, writing skills, organizational skills (Johnson et al, 2014). Groups from 2-6 are generally recommended, with groups that consist of three members exhibiting the best performance in some problem-solving tasks (Johnson et al., 2008; Heller & Hollabaugh, 1992). To avoid common problems in group work, such as dominance by a single student or conflict avoidance, it can be useful to assign roles to group members (e.g., manager, skeptic, educator, conciliator) and to rotate them on a regular basis (Heller & Hollabaugh, 1992). Assigning these roles is not necessary in well-functioning groups, but can be useful for students who are unfamiliar with or unskilled at group work.

The use of cooperative learning groups in instruction is based on the principle of constructivism, with particular attention to the contribution that social interaction can make. In essence, constructivism rests on the idea that individuals learn through building their own knowledge, connecting new ideas and experiences to existing knowledge and experiences to form new or enhanced understanding (Bransford, et al., 2000). Vygotsky extended this work by examining the relationship between cognitive processes and social activities, developing the sociocultural theory of development. The sociocultural theory of development suggests that learning takes place when students solve problems beyond their current developmental level with the support of their instructor or their peers. Thus both the idea of a zone of proximal development, supported by positive group interdependence, is the basis of cooperative learning (Davidson & Major, 2014; Johnson, et al., 2014).

Cooperative learning used in the intervention follows this idea as groups work together to learn or solve a problem, with each individual responsible for understanding all aspects. The small groups are essential to this process because students are able to both be heard and to hear their peers, while in a traditional classroom setting students may spend more time listening to what the instructor says. Cooperative learning uses both goal interdependence and resource interdependence to ensure interaction and communication among group members. Changing the role of the instructor from lecturing to facilitating the groups like in the case of CBCML helps foster this social environment for students to learn through interaction with others, striving to attain mastery and enhancement of learning through the use of computer simulations.

David Johnson, Roger Johnson, and Karl Smith performed a meta-analysis of 168 studies comparing cooperative learning to competitive learning and individualistic learning in college students (Johnson et al., 2008). They found that cooperative learning produced greater academic achievement than both competitive learning and individualistic learning across the studies, exhibiting a mean weighted effect size of 0.54 when comparing cooperation and competition and 0.51 when comparing cooperation and individualistic learning. In essence, these results indicate that cooperative learning increases student academic performance by approximately one-half of a standard deviation when compared to non-cooperative learning models, an effect that is considered moderate. Importantly, the academic achievement measures were defined in each study, and ranged from lower-level cognitive tasks (e.g., knowledge acquisition and retention) to higher level cognitive activity (e.g., creative problem solving), and from verbal tasks to mathematical tasks to procedural tasks.

George Kuh and colleagues also conclude that cooperative group learning promotes student engagement and academic performance (Kuh et al., 2007). Springer, Stanne, and Donovan (1999) confirmed these results in their meta-analysis of 39 studies in university STEM classrooms. They found that students who participated in various types of small-group learning, ranging from extended formal interactions to brief informal interactions, had greater academic achievement, exhibited more favourable attitudes towards learning, and had increased persistence through STEM courses than students who did not participate in STEM small-group learning.

In view of the perceived benefits of cooperative learning, mastery learning and use of computer simulations in facilitating the learning of chemistry, this study investigated the effects of CBCML (as a hybrid teaching/learning approach) on skills acquisition, motivation and achievement in chemistry. The study also investigated whether the gender affects skills acquisition, motivation and achievement in chemistry when CBCML is used in teaching and consequently whether it can successfully be used to bridge the gender disparity in achievement in chemistry.

2.9 Theoretical Foundations of Computer Based Cooperative Mastery Learning

Constructivism is one of the theories of learning developed in the recent years and has become one of the most significant and dominant perspectives in science education (Taber, 2009). Constructivist model focus on construction of knowledge in the learners' mind. Every student has different experiences; therefore, a teacher has to be aware that knowledge is constructed differently in the learners' mind. Students have their own pre-existing knowledge based on their experiences that is constructed in their mind (Taber, 2009).

Most studies show the advantages of using this theory of knowledge in the learning process regarding to recognize students' alternative conceptions. Moreover, according to Mulford & Robinson (2002), alternate conceptions play important role in learning chemistry than simply producing inadequate explanations to questions. Therefore, as chemistry educators, it is important to understand the role of students' alternative conceptions in learning chemistry. Constructivism plays an important role to improve teaching and learning in chemistry and develop the research area in chemistry education. The teaching and learning strategies informed by constructivism are powerful to create the meaningful learning processes in chemistry. The meaningful learning process help students to understand the chemistry concepts through the active learning process.

According to constructivists, learning takes place when individuals participate actively in meaningful activities. Learning is an active process in which a learner is engaged in constructing meaning whether from text, dialogue or physical experiences (Osborne &

Wittrock, 2003). Emphasis is laid on students' development of knowledge through active discussion processes that link new knowledge to prior knowledge. Constructivist theories includes; cognitive constructive theory advanced by David Ausubel, social constructivist theory advanced by Lev Vygotsky and social learning theory advanced by Bandura.

Vygotsky's perspective explains social constructivism as playing important role in the construction of meaning from experience (Prince & Felder, 2006). However, in order to have effective teaching in the classrooms the importance of teachers' understanding of constructivist theory, principles and pedagogy should also be emphasized. Since the construction is the process of learning, teachers have a big role including: (a) to influence, or create motivating conditions for students, (b) take responsibility for creating problem situations, (c) foster acquisition and retrieval of prior knowledge, (b) create the process of learning not the product of learning (Olsen, 1999). Rahimi and Hematiyan (2012) points out that great burden is on the teachers' shoulder; because, he/she as an instructor who is supposed to pave way to have a creative classroom and make the students motivated (Rahimi & Hematiyan, 2012). The constructivist teacher is aware that it is crucial to take these ideas into account, otherwise teaching will not be effective (Stephenson & Warwick, 2002).

According to Okere (1996), cognitive constructivists view learners as active constructors of meaning from input by processing it through existing cognitive structures and then retaining it in the long-term memory. The cognitive approach to learning tries to understand individuals thought process by studying the structure of thinking and remembering. On the other hand, social constructivism emphasizes on how meaning and understanding grows out of social interactions (Vygotsky, 1978). For social constructivists, culture gives the child the cognitive tools such as cultural history, social context and language needed for development.

In the constructivists' model, students actively mediate the input by trying to make sense of it and relating it to what they already know about the topic (Wachanga, 2005). This constructivist process is important because students build their own representation of new learning which would otherwise have been retained as relatively meaningless and inert rote memory (Good & Brophy, 1995).

Views of constructivism include the fact that knowledge can never be totally transferred to another person; knowledge is as a result of a person's interpretation of experiences influenced by factors such as age, gender, race or knowledge base (Ozmen, 2004). In essence some aspects of it are lost during translation when knowledge is transferred. Secondly, individuals make observations, test hypotheses and draw conclusions about events that are consistent with one another. This leads to consensus about different people's view of the world. Thirdly, it has to do with the formation and changing of knowledge structures, addition to, deletion from and modification of these interpretations. The process of concept formation involves identifying and enumerating the data that are relevant to the problem, grouping those items according to some basis of similarity and developing categories and labels for the groups (Joyce & Weil, 1980).

The aim of constructivist teaching is not to provide 'direct' instruction or 'minimal' instruction, but optimum levels of instruction (Duffy & Jonassen, 1992). Constructivist pedagogy therefore involves shifts between periods of teacher presentations and exposition and periods when students engage with a range of individuals and particularly group-work, some of which may seem quite open-ended. However, even during these periods, the teachers' role in monitoring and supporting is fundamental. Constructivism as a learning theory suggests that effective teaching needs to be both student-centred and teacher directed (Duffy & Jonassen, 1992). Figure 5 shows the association of the two dimensions.

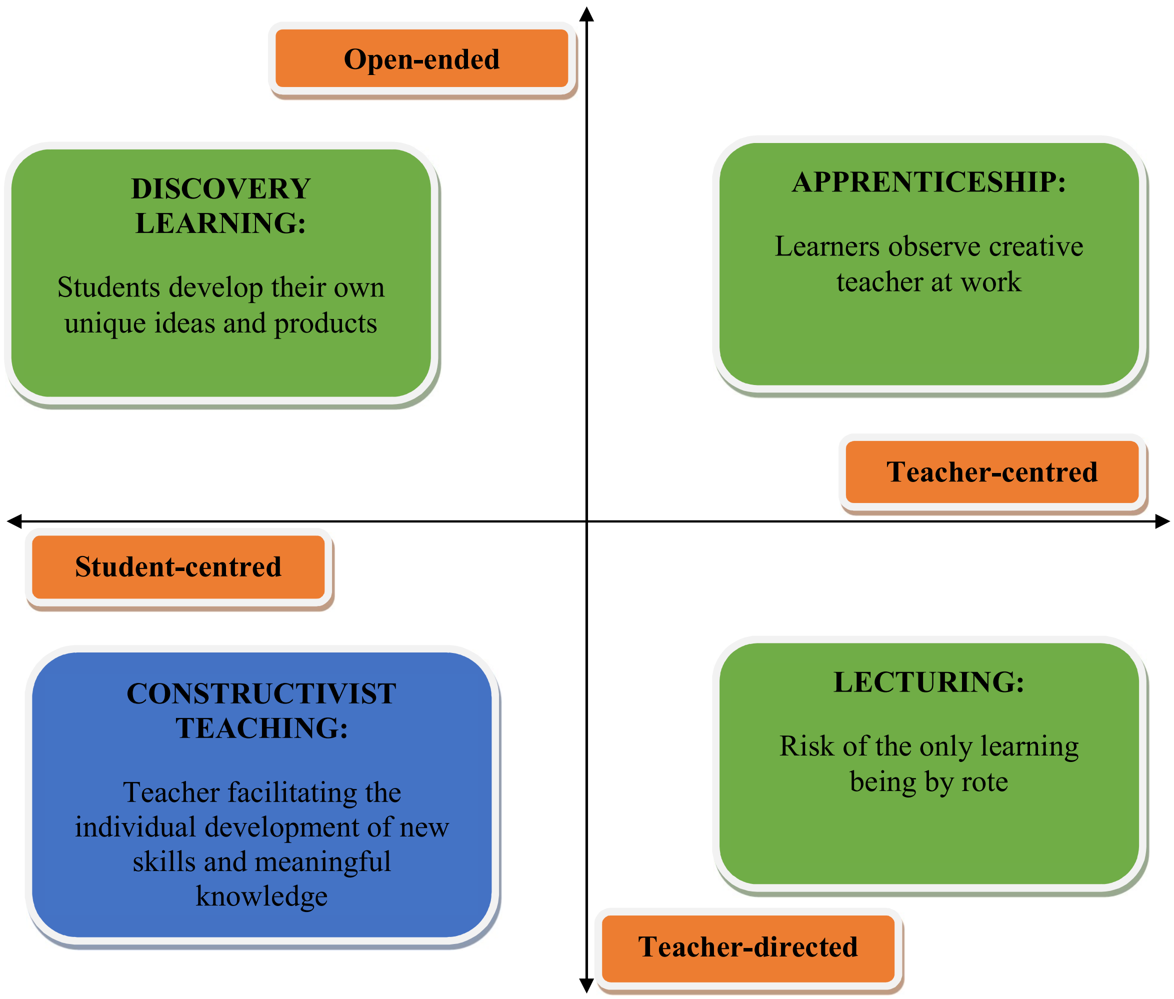

Figure 5. Teaching informed by Constructivist Theory is both Student-centered and Teacher-directed.
Source: Adapted from Teetito (2000).

Although constructivism is a learner-centred theory of teaching, a constructivist teacher works to monitor and direct students learning from a perspective that understands how learning is contingent upon each individual's existing conceptual structures. Constructivist theory informs the teacher that each learner needs time, space and suitable experiences to support the learning process; but also that minimal guidance during learning is unlikely to lead to desired outcomes (Duffy & Jonassen, 1992).

The social learning theory of Bandura emphasizes the importance of observing and modelling the behaviours, attitudes, and emotional reactions of others. According to Bandura (1997), social learning theory explains human behaviour in terms of continuous reciprocal interaction between cognitive, behavioural, and environmental influences. The component processes underlying observational learning are:

(1) Attention, including modelled events (distinctiveness, affective valence, complexity, prevalence, functional value) and observer characteristics (sensory capacities, arousal level, perceptual set, past reinforcement),

(2) Retention, including symbolic coding, cognitive organization, symbolic rehearsal, motor rehearsal),

(3) Motor Reproduction, including physical capabilities, self-observation of reproduction, accuracy of feedback, and

(4) Motivation, including external, vicarious and self-reinforcement (Bannan-Ritland, Dabbagh, & Murphy, 2000).

Because it encompasses attention, memory and motivation, social learning theory spans both cognitive and behavioural frameworks (Brooks & Brooks, 2001). Bandura's work is related to the theories of Vygotsky which also emphasize the central role of social learning.

The highest level of observational learning in constructivism is achieved by first organizing and rehearsing the modelled behaviour symbolically and then enacting it overtly. Coding modelled behaviour into words, labels or images results in better retention of the concepts learnt. Individuals are more likely to adopt a modelled behaviour if it results in outcomes they value (Bandura, 1997). They are also more likely to adopt a modelled behaviour if the model is similar to the observer and has admired status and the behaviour has functional value.

CBCML is one example of a group task in which students can work together and through the use of computer simulations to accomplish a given task. Through this approach, students are expected to learn in their cooperative groups to achieve a certain level of mastery of the content by constructing knowledge about a topic. The students work on a given task until all group members have successfully understood and when the task is over the teacher evaluates the academic success of each student, (Wachanga, 2002). The knowledge learnt, should enable them to apply in real life situations and show how it affects people in their daily lives. The approach is therefore likely to motivate students by engaging them in a group task in which they are expected to realise that they are mutually responsible for one another's learning and academic success.

CBCML is a learner-centered approach that utilizes computer technology. Learning in this sense is an active, self-regulated, constructive, situated and social process (Bransford, Brown & Cocking, 2000; Bandura, 1997). This means that learning has a procedural and active character, which must lead to construction of knowledge by the learner on the background of the learners' individual experience and knowledge (Sun, Williams & Liu, 2003). ICT provides access to rich sources of information, encourages meaningful interactions with content and brings people together to challenge support or respond to each other (Rosenberg, 2001; Wanjiku, 2008). Here, the teacher is required to provide guidance to allow students to create their own meaning otherwise it does not guarantee meaningful learning (Novak, 2002).

Constructivists believe that a teacher should serve as a facilitator who attempts to structure an environment in which learners organize meaning at a personal level (Cooper & Robinson, 2002). The study was based on the assumption that a teaching strategy that involves students actively is more likely to lead to enhance meaningful learning through active involvement as opposed to Conventional Teaching Methods.

In order to use the CBCML approach effectively in science teaching, teachers need to create situations where students will need basic concepts and process skills. In this way, there is stimulation in the students' learning ability and this type of learning is in line with the Constructivist Learning Model (Teetito, 2000). The model explains that knowledge can never be observer independent. It requires a personal commitment to question; a personal commitment to explain, and to test explanations for validity. Moreover, each learner is required to put together ideas and structures that have personal meaning for learning to take place.

2.10 Conceptual Framework

The conceptual framework used in this study is based on the constructivist theory of learning. In this theory, a teacher serves as a facilitator who attempts to structure an environment in which the learner organises meaning at a personal level (Cooper, Jackson, Nye & Lindsay, 2002). In addition, the Systems Approach holds that the teaching and learning process has inputs and outputs. To achieve good results then, the inputs must have suitable materials (Joyce & Weil, 1980). The study was also based on the assumption that the blame for a students' failure rests on the quality of instruction and not lack of student's ability to learn (Bloom, 1981; Levine, 1985). The framework is represented diagrammatically in Figure 6.

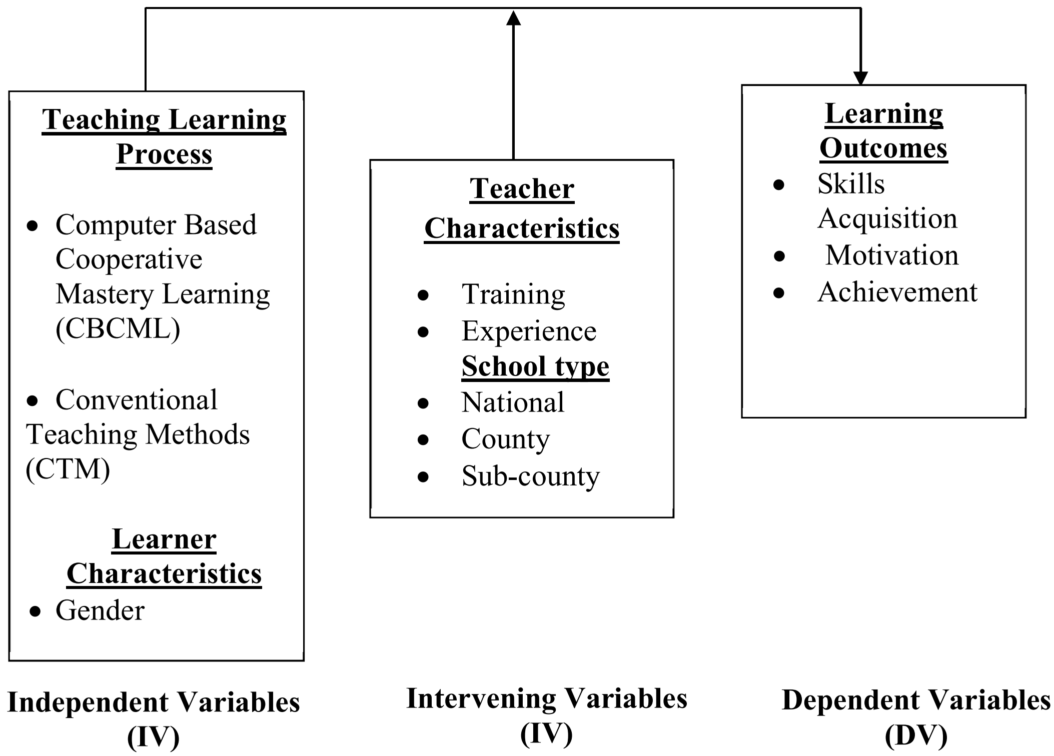

Figure 6. Conceptual Framework for determining the Effects of CBCML on Students' Skills Acquisition, Motivation and Achievement in Chemistry

Figure 6 shows the relationship of variables for determining the effects of using CBCML on secondary school students' skills acquisition, motivation and achievement in Chemistry. Learning outcomes are influenced by various factors. These include: teacher characteristics, classroom environment and learner characteristics as shown in the figure. These are the intervening variables which should be controlled.

Teacher training determines the teaching approach a teacher uses and how effective the teacher uses the approach (Collier, 2004). learners' age, gender, entry behaviour and hence their class determine what they are to be taught. The type of school as a teaching environment affects the learning outcomes. Therefore, only county co-educational secondary schools were selected for the study. To control for teachers' characteristics as a source of internal validity, teachers of equivalent training and experience were chosen due to the assumption that they teach at the same level. Form Three students who were approximately of the same age were involved in the study to avoid the threat of maturity to internal validity. It was therefore assumed that their age difference could not affect the study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter documents the procedures followed while conducting the study. The chapter describes the research design and specifies the target and accessible population as well as its characteristics. It also outlines the sampling procedures, sample size, instrumentation, development of instructional materials, data collection procedures and finally the statistical methods that were used in data analyses.

3.2 Research Design

Secondary school classes exist as intact groups and school authorities do not allow the classes to be dismantled and reconstituted for research purposes (Njoroge, Changeiywo, & Ndirangu, 2014). Since classes exist as intact groups, the study used Solomon's Four Non-equivalent Control Group Design which is rigorous enough hence appropriate for quasi-experimental studies (Wachanga & Mwangi, 2004). Quasi-experimental researches are widely used in the evaluation of teaching interventions. The design also controls for all major threats to internal validity except those associated with interaction of selection and history, selection and maturation, and selection and instrumentation (Cook & Campell, 1979).

In this study, the Experimental Groups were exposed to the treatment (Computer Based Cooperative Mastery Learning) for a period of six weeks while the Control Groups were taught using Conventional Teaching Methods. For both the pre-test and post-test, Chemistry Practical Skills Acquisition Test (CPSAT), Students Motivation Questionnaire (SMQ) and Chemistry Achievement Test (CAT) were used as data collection tools. The performances of the two groups in each of the three dimensions considered were then compared to determine whether there are any treatment effects as a result of the two different teaching styles on the same contents taught.

The research design enabled the researcher to determine the cause and effect of the treatment on learners' achievement and motivation. A researcher who decides to use this design must be certain of the independent and dependent variables and must guard against the influence of the extraneous variables (Kombo & Delno, 2006; Orodho & Kombo, 2002). This design involved a random assignment of intact classes to four groups. The design is shown in Figure 7.

Group 1	O_1	X	O_2	E1
Group 2	O_3	____	O_4	C1
Group 3	___	X	O_5	E2
Group 4	___	___	O_6	C2

Key: Pre-tests: O_1 and O_3 Treatment: X

Post-tests: O_2, O_4, O_5 and O_6 No pre-test or no-treatment: ___

Experimental groups: E_1 and E_2 Control groups: C_1 and C_2

Non-equivalent control groups: --------------------------------

Figure 7. Solomon's Four Non-Equivalent Control Group Research Design.

The groups were organised as follows; Group 1 received a pre-test, treatment (X) and then a post-test while Group 2 received a pre-test and post-test. On the other hand, Group 3 was not given a pre-test but received the treatment (X), followed by a post-test while Group 4 received the post-test only as shown in Figure 7. This implies that in the study, Groups 1 and 3 were taught through the CBCML and therefore were the Experimental Groups while Groups 2 and 4 were taught through the CTM and were therefore the Control Groups.

The selected groups were randomly assigned to Control and Experimental groups. To control for interaction between selection and instrumentation, it was ensured that the conditions under which the instruments were administered were kept as similar as possible in all the schools (Gall, Borg & Gall, 2003; Johnson & Onwuegbuzie, 2004). Also, the effect of maturation was taken care of by the short period of six weeks that the study took.

Teachers' gender, training and experience were controlled by choosing teachers of equivalent training, the same gender and teaching experience. Therefore, teachers from the selected schools were male graduates with a minimum of five years teaching experience. According to Gall, Borg and Gall, (2003), Solomon's Four Non-equivalent Control Group Design helped the researcher to achieve four main purposes. The design helped to assess the homogeneity of the groups before administration of the treatment and the effect of the experimental treatment relative to control condition. It also enabled the researcher to assess the interaction between pre-test and treatment condition and the effect of the pre-test relative to non-pre-test.

3.3 Population of the Study

The study was conducted in four County Co-educational Secondary Schools drawn from the four sub-counties of Bomet County, Kenya. The target population for the study was all students in secondary schools in Bomet County. Preliminary information from the statistics obtained from the County Education Office indicated that 16,134 students from all co-educational secondary schools in the county are in form three. This was the accessible population for the study. Preliminary information collected further indicated that 21 county co-educational secondary schools have well equipped computer laboratories and therefore suitable for use in the study especially in the implementation of the intervention in the Experimental Groups. These schools had a total population of about 1,565 Form Three students.

Table 5 shows the target and accessible population. The table also shows total number of students in the target and accessible population.

Table 5

Target and Accessible Population of the study

Population Type	**Description**	**Total Number of Students (N)**	**Number of Schools**
Target Population	Number of students in secondary schools in Bomet County	64,536	258
Accessible Population	Number of Form 3 students in the County Co-educational Secondary Schools	16,134	87

It was assumed that by the beginning of the third year in secondary school, the students have developed stable perception of chemistry content after their exposure to the subject for two years and voluntarily selected chemistry to be one of the two examinable science subjects as required by KNEC. At this level also, the students are assumed to have developed a stable internal motivation towards chemistry learning. These conditions were necessary to allow for manipulation of intervention (CBCML) and determine the effect of the intervention on students' Skills Acquisition, Motivation and Achievement in Chemistry.

3.4 Sampling Procedures and Sample Size

The office of Bomet CDE provided a list of all secondary schools in the county and the demographic characteristics of chemistry teachers teaching in each of the schools. The unit of sampling was secondary schools rather than individual learners because secondary schools operate as intact groups (Gall, Borg & Gall, 2003). The county has 87 established county co-educational secondary schools with approximately 16,134 Form Three students. Nkapa (1997) argues that there is no strict rule for obtaining a sample size. However, Fraenkel and Wallen (2000), recommended at least 30 subjects per group.

In the present study, 238 students from 4 county co-educational secondary schools were selected for the study, with each school having approximately sixty students. Four schools namely Mulot Secondary School (59 students), Kaboson Mixed Secondary School (60 students), Simoti Secondary School (52 students) and Kamureito Secondary School (67 students) were involved in the study. Practical activities that used CBCML were targeted to form three students in the Experimental Groups while CTM were employed to teach students in the Control Groups. The sampling techniques used in the study for selection of schools and students to participate included purposive sampling, simple random sampling and stratified sampling.

Purposive sampling was used to select secondary schools which offer Computer Studies as one of the examinable subjects at KCSE level in the County. This is because the computer laboratory was a key resource required for the implementation of CBCML lessons. The Experimental Group also required learners with basic computer skills. Therefore, four county co-educational schools that offer computer studies in the county were selected for the study. This ensured that the students have the pre-requisite skills on the use of computers for learning. Form Three classes were purposively selected for the study. This is because the topic to be covered is usually done in Form Three. In addition, the learners at this level have fully adapted to the environment and have selected the subjects that they will be examined on for the KCSE Examination.

The Form Three classes in the four Co-educational County secondary schools were randomly assigned to experimental and control groups. In this case simple random sampling was used. Preliminary information collected from the county education office indicated that all schools in the County selected chemistry as an examinable subject. Therefore, all form three students in their respective streams take chemistry. Out of the four selected schools, two had three streams of both boys and girls studying in the same class while the rest two schools had four streams. For ethical reasons all the streams were taught the same chemistry content using similar approach for control and experimental groups respectively. After the six-week intervention period one stream was randomly picked from each of the schools for use.

Bomet County has four sub-counties. These sub-counties include: Bomet, Chepalungu, Sotik and Konoin. This structure enabled the use of stratified sampling. To ensure that the four schools selected guided by the research design used are located far apart from each other and to eliminate diffusion of information regarding treatment from the Experimental Groups to the Control Groups, one school was picked from each of the four sub-counties of the County. Table 6 shows the total number of respondents per group used in the study.

Table 6

Number of Respondents per Group and Distribution among the four Sub-counties

Group	**Type of Group**	**Respondents (N)**			**Sub-County**
		Gender		**Total**	
		Male	**Female**		
Group 1	Experimental 1 (E1)	29	30	**59**	Bomet
Group 2	Control 1 (C1)	38	32	**60**	Chepalungu
Group 3	Experimental 2 (E2)	30	22	**52**	Konoin
Group 4	Control 2 (C2)	32	35	**67**	Sotik
Total		**129**	**109**	**238**	

Source: Research Data, 2017

Table 6 shows that the total number of respondents selected from the four sub-counties for the study was 238. According to the Solomon's Four Non-equivalent Control Group Design, the four schools selected for use in the study represents the county as a whole.

3.5 Instrumentation

Data was collected using three instruments namely; Chemistry Practical Skills Acquisition Test (CPSAT), Student Motivation Questionnaire (SMQ) and Chemistry Achievement Test (CAT). These instruments were used to measure the learners' level of Skills Acquisition, Motivation and Achievement in Chemistry respectively.

3.5.1 Chemistry Practical Skills Acquisition Test (CPSAT)

Science process skills are cognitive and psychomotor skills employed in problem solving. They can be acquired and developed through training such as are involved in science practical activities. Science process skills are the aspect of science learning which is retained after cognitive knowledge has been forgotten.

Chemistry as a practical subject, provides students with an opportunity to interact with science process skills that can be used to solve problems in everyday life and contribute to national development (Abungu, Okere, & Wachanga, 2014). Using science process skills is an important indicator of transfer of knowledge which is necessary for problem-solving and functional living. Competency in science process skills in chemistry is important for proper understanding of concepts in the subject. According to Akinbobola and Afolabi (2010), the mode of assessment of practical work directly influences the teachers' teaching methods, students' learning styles and motivation towards practical activities.

Science process skills are classified as basic (observing, measuring, classifying, collecting data and using number relationships), causal (predicting, identifying variables and drawing a conclusion) and experimental (formulating hypotheses, making models, experimenting, controlling variables and making a decision) (Ayas, Cepni, Ozmen, Yigit, & Ayvaci, 2007). All of these science process skills are complementary to each other, providing students opportunities to reach meaningful learning goals in science.

In this study skills acquisition in chemistry practical work was measured using a Chemistry Practical Skills Acquisition Test (Appendix A). The instrument was constructed by the researcher on the basis of objective (i) and (iv) of the study for measurement of the level of students' skills acquisition before and after treatment. This tool comprised of two parts; Section A which required personal information from the respondent (bio data) and Section B which consisted of questions including basic or lower skills such as observing, classifying, measuring, communicating, recording, using number relationships and integrated skills such as hypothesizing, predicting, inferring, identifying/controlling variables, interpreting data, defining operationally, experimenting, manipulating, and building mental models.

This instrument comprised a practical test on titration with a procedure to be followed involving manipulation of apparatus, measurement of required volumes of solutions, performance of the titration process, making observations and recording the volumes of solutions used to reach the end-point of the neutralization reaction involved. This was then followed by questions requiring students to carry out calculations based on the values obtained during the titration process. The maximum score in this instrument was 10 marks.

Dichotomous scoring technique was adopted during marking of the students' responses in section B of the instrument. Each correct answer was assigned 1 mark while the incorrect answer was assigned 0 mark. The same trend of scoring was adopted in questions with more than 1 mark but in this case stepwise as explained in Appendix A. The CPSAT provided data on the level of skills acquisition before and after treatment among students in chemistry practical activities when students are taught chemistry through CTM or CBCML.

3.5.2 Student Motivation Questionnaire (SMQ)

The development of this instrument for data collection was informed by objective (ii) and (v) of the study. The SMQ (Appendix B) contained items on the students' socio-background factors and psychological concept of motivation which is related to various outcomes such as curiosity, persistence, learning, and performance (Deci & Ryan, 1985; Tuan, Chin, & Shieh, 2005). Aspects of motivation included in this instrument includes perceived confidence, perceived choice, perceived interest/enjoyment and perceived pressure/tension. This instrument provided data on the motivation level of the learners before and after treatment when either CTM or CBCML is used in teaching chemistry.

The instrument contained items based on the Keller's ARCS Motivation Theory and other motivational theories such as Instinct, Drive-Reduction, Arousal, Incentive and Cognitive theories. This instrument was used to assess students' motivation to learn chemistry and was constructed based on motivation theories; Keller's ARCS Motivation Theory (Hohn, 1995; Kiboss, 1997) and Self-Determination Theory (SDT). Motivation to Learn Chemistry (MTLC) was measured along four dimensions:

(i) Perceived Interest: -items on the extent to which the students found the lesson interesting and applies the information learned to solve related problems

(ii) Perceived Competence: -items on the extent to which students found the information easy or difficult or unclear to enable them perform competently in chemistry

(iii) Perceived Choice: - items on the extent to which student found themselves doing chemistry against their will or having made a choice

(iv) Perceived Tension: - items on the extent to which the student felt tense or confident to carry out chemistry tasks successfully

These are the four domains under which motivation was measured in the study to determine the level of motivation of the learners before and after intervention.

The instrument contained closed-ended items on favourable and unfavourable statements regarding students' Motivation to learn Chemistry. Items in the instrument were written in relation to the topic; Volumetric Analysis. The researcher adapted the SMQ developed and used by Barchok (2006) and modified the items accordingly to suit the study. The instrument was divided into two parts. The first part required the participants' demographic data such as sex, age, KCPE mark and name of school while the second part contained items from the four dimensions of Motivation. The students' level of Motivation to Learn Chemistry (MTLC) was assessed through 23 close-ended question items. All the items were on a 5-point Likert scale ranging from Strongly Agree (SA) to Strongly Disagree (SD). Scoring of each positive item in the SMQ was done using the key SD=1, D=2, U=3, A=4 and SA=5 while negative items were scored using the key SD=5, D=4, U=3, A=2 and SA=1.

3.5.3 Chemistry Achievement Test (CAT)

The Chemistry Achievement Test (CAT) (Appendix C) was adapted from the Kenya National Examinations chemistry past papers and modified to make them suitable for use in the study. This instrument measured the cognitive aspect of the practical work learnt in Volumetric Analysis. It was used to obtain students' achievement scores in Chemistry. The students' scores from the test were recorded and used for data analysis. The test contained six comprehensive objective items to assess the students' achievement in chemistry practical activities before the treatment and also the conceptual understanding of the topic; Volumetric

Analysis after the intervention. The test required the learners to carry out calculations related to titration experiments from the topic, Volumetric Analysis.

The items in this instrument were structured in such a way as to start with those of low order thinking and progressively move to more complex ones. The maximum score in this instrument was 25 marks. Dichotomous scoring technique was adopted during marking of the students' responses in the instrument. Each correct answer was assigned 1 mark while the incorrect or wrong answer was assigned 0 mark. The same trend of scoring was adopted in questions with more than 1 mark but in this case stepwise like in the case of CPSAT.

3.5.4 Intervention

The instrument was pilot-tested in two selected county co-educational secondary schools in the neighbouring Narok West Sub-County in which respondents were assumed to have similar characteristics with those used in the actual study.

The two groups received CBCML treatment conducted by the Chemistry teachers for a period of six weeks guided by the Scheme of Work (Appendix E) specifically prepared for the intervention. Six sessions of practical work were organized, each session lasting eighty minutes (double lessons). The students carried out experiments on Volumetric analysis (Titration of a base with an acid). During the practical sessions, the students were divided into groups of five students each. Before the beginning of each session, the teacher informed and instructed the students on the objectives and procedures of working.

The materials, apparatus and instructions for the experiment for each practical session were provided. The students did all the activities and the teacher visited the groups and posed guiding questions intended to lead them to an appropriate direction. The pre-tests were administered to the students in the two groups (Experimental Group 1 and Control Group 1) to measure the initial chemistry knowledge of both boys and girls in both groups. The post-test was administered to all the four groups at the end of intervention period. CAT was used to obtain students' achievement in Chemistry. The students' scores from the test were recorded, coded and used for data analysis based on the six objectives of the study.

3.6 Validity and Reliability of Research Instruments

Reliability of an instrument in research means that the scores of an instrument are stable and consistent (Creswell, 2005). The scores should remain the same when the instrument is administered repeatedly at different times, and it should remain consistent. Validity, on the other hand, means that the individual scores of an instrument are meaningful and allow the researcher to draw good conclusions from the sample population being studied (Crewell, 2005). Reliability can be more easily understood by identifying the testing methods for stability and consistency.

To ensure that both validity and reliability were satisfied, all the instruments were pilot-tested. The tools were administered to 50 form three students from two schools whose respondents were not involved in the actual research. Piloting was done in neighbouring Narok West Sub-County which had similar characteristics with the study area. The results obtained from piloting and suggestions from experts helped in modifying and improving the items in the research instruments.

Content validity is the extent to which the questions on the instrument and the scores from these questions represent all possible questions that could be asked about the content or skill (Creswell, 2005). The present research used content validity to examine the information, content areas, and difficulty of the items. According to Fraenkel and Wallen (2000) an alpha value of 0.7 or greater is considered suitable to make possible group inferences that are accurate enough.

3.6.1 Validity

According to Ghauri and Gronhaug (2005), validity explains how well the collected data covers the actual area of investigation in a study. It basically means the ability of the instrument to measure what is intended to measure (Field, 2005; Glynn, Taasoobshirazi, & Brickman, 2009). In this study, main types of validity namely; face validity, content validity, construct validity, criterion validity and reliability were addressed.

The CPSAT, SMQ and CAT were checked by the two supervisors in the Department of Curriculum, Instruction and Educational Management (CIEM) of Egerton University and chemistry teachers from selected secondary schools. It was then moderated by education specialists from the Department of CIEM of Egerton University and Kenya National

Examinations Council (KNEC) Chemistry Examiners. The experts involved in validation checked for face, construct and content validity of the items in the instruments. Comments from these specialists were used to improve the instruments and make them suitable for use in the study. Items which were found inadequate for measuring the variables were either discarded or modified.

The experts were requested to scrutinize:

(i) The relevance of the items of the instrument to the study.

(ii) Whether the activities under each skill properly represent the skill in question;

(iii) The clarity of the items of the instrument to the study.

(iv) Whether the statements are observable and rateable.

Based on the observations of these experts, the items of the instrument were modified accordingly and used for data collection.

3.6.2 Reliability

The instruments were administered to 50 respondents who were students selected from another secondary school which was not part of the study sample to estimate the reliability after modification. This pilot testing of the instruments to estimate reliability was conducted in the neighbouring Narok West Sub-County in selected secondary schools whose subjects had similar characteristics with that of the sampled schools. According to Bichi (2002), the purpose of the pilot test was to:

- determine the reliability of the instrument before administration,
- assess the feasibility of the study before trial,
- identify possible problems or difficulties that respondents may encounter with a view of eliminating them,
- determine the approximate time duration required for the respondents to answer the test questions correctly.

The outcome of pilot testing was used to estimate the reliability of the instrument. Kuder-Richardson 21 (K-R21) formula was used to estimate the reliability coefficient of the CPSAT and CAT. The K-R21 formula was appropriate because the test items were scored dichotomously (Wiersma & Jurs, 2005). The Cronbach's alpha coefficient was used to estimate the reliability of SMQ because the items were not scored dichotomously and therefore the scores take a range of values.

The internal consistency reliability coefficients for the instruments were found to be 0.76, 0.88 and 0.85 for CPSAT, SMQ and CAT respectively. According to Fraekel and Wallen (2000), an alpha value of 0.7 and above is considered suitable to make possible inferences that are accurate. Any reliability of 0.7 and above is taken to depict an agreeable level of reliability for the instruments (Kothari, 2004). The items in the questionnaires were therefore reliable for use in the study.

3.7 Development of Instructional Materials

The researcher developed an instructional manual for teachers involved in the implementation of CBCML (see Appendix D) referred to as the Chemistry Practical Teachers' Manual (CPTM). This manual focused on the objectives, content covered and the teaching and learning activities as prescribed in the KICD Chemistry Syllabus (KIE, 2002). The teachers who taught the experimental groups were trained for two days by the researcher on the implementation of CBCML and their teaching monitored throughout the intervention period. The teachers were also issued with a Secondary Chemistry Form 3 Data DVD produced and distributed by Kenya Institute of Curriculum Development (KICD). This DVD contains computer simulations for use during the instruction process by the learners in their cooperative learning groups as prescribed in the Teachers' Manual.

3.8 Data Collection Procedures

The researcher sought permit to conduct research in the sampled schools in Bomet County from the National Commission for Science, Technology and Innovation (NACOSTI), through the Board of Postgraduate Studies of Egerton University. The researcher then reported to the office of County Director of Education and the office of County Commissioner as indicated in the NACOSTI research authorization letter. The sampled schools were then visited to seek permission to carry out the research from the school Principals. A meeting with the Chemistry teachers of the experimental groups was then organized, in which basic issues about the study and its benefits were discussed. The training for the chemistry teachers of the Experimental Groups took two days. This enabled them to master the skills of using CBCML as a teaching strategy. A Chemistry Practical Teachers' Manual (CPTM), (Appendix D) was issued to each of the teachers in these two groups.

The teachers involved in the study adopted similar common Schemes of Work (SOW) developed for the topic; Volumetric Analysis (Appendix E); this ensured that the intended content was covered uniformly for all the groups in the study. The students in the experimental groups were put into groups of mixed ability and then trained by the respective teacher on cooperative learning skills, mastery learning and how to use computer technology in learning chemistry for a period of two weeks prior to the treatment period.

Data was collected in two stages during the main study. At the beginning of the study, the CPSAT, SMQ and CAT were administered to the Experimental Group (E1) and Control Group (C1) as a pre-test. This was followed by exposure of the Experimental Groups 1 and 3 to treatment which lasted six weeks. Students in the Control Groups 2 and 4 were taught through the Conventional Teaching Methods (CTM). At the end of the six-week period, the items in the instruments were re-organised and administered by the researcher as a post-test with the assistance of the chemistry teachers in the respective schools involved in the study. The researcher then scored the tests to get quantitative data to use for data analysis.

3.9 Data Analysis

The administration and scoring of the three instruments; CPSAT, SMQ and CAT gave rise to data in two levels; the pre-test data and the post-test data. The results obtained were used to determine students' level of competence in science process skills, motivation to learn chemistry and level of achievement in Chemistry before and after the intervention.

The data obtained from the instruments during the pre-test and post-test assessment tests were coded and analysed using means and followed by a t-test to compare means of the two groups subjected to pre-test. This enabled the researcher to find out whether there was any statistically significant difference between the performance of the Experimental and the Control Groups, before. After the treatment, ANOVA was used check on whether there was any statistically significant difference among the four groups post-tested in each of the three domains of learning (psychomotor, affective and cognitive). To take care of initial differences that could have been existing among the four groups in regard to skills acquisition and achievement, ANCOVA test was used. This way, it was possible to determine the impact of CBCML on skills acquisition in chemistry, motivation to learn Chemistry and achievement in chemistry.

A post-hoc analysis was also carried out to determine where the difference occurred. Statistical Package for Social Sciences (SPSS) version 20.0 was used to facilitate the analysis of the data. The sequence of the presentation of the results is in accordance with that of the hypotheses of the study. To make reliable inferences from the data, all statistical tests were tested for significance at alpha (α) level at 0.05. Table 7 shows the summary of the hypotheses, variables and the statistical tests that were used in the study.

3.10 Ethical Considerations for the Study

According to Israel and Hay (2006), researchers need to protect their research participants, develop trust in them, promote integrity of research, and guard against misconduct that might reflect on the researcher and institution posing challenging problems that may arise during the study. For this reason, the researcher provided for ethical considerations in the study as advised by the Board of Graduate Studies of Egerton University in their introductory letter to National Commission for Science Technology and Innovation (NACOSTI) (Appendix H). In response, research authorization letter to conduct research was received from the commission (Appendix I & J). Upon receiving the authorization letter from NACOSTI, the researcher reported to the County Commissioner's Office and County Director of Education's office as directed by the Commission. These county authorities issued the researcher authorization letters allowing research to be done within their area of jurisdiction (Appendix K and L).

In addition, permission was sought from the school administration to allow research to be conducted in their schools and to allow for training of teachers to be involved in the intervention. This was done with the help of research authorization and introduction letter from the researcher (Appendix G).

Participation of respondents in this study was voluntary and therefore there were no rewards for participation. The respondents were also assured of their privacy and confidentiality with regard to their personal opinion about the learning of Chemistry. The identity of the respondents was not disclosed during the study as well as in the final report. Finally, the calendar of activities on conducting the study was adhered to as planned to avoid disrupting the school routine.

Table 7

Summary of the Variables and Statistical Tests of the study

HYPOTHESIS	INDEPENDENT VARIABLE	DEPENDENT VARIABLE	TYPE OF TEST
H_01 There is no statistically significant difference in students' Skills Acquisition in Chemistry between those exposed to CBCML and those taught using CTM.	CBCML CTM	Post-test scores on CPSAT	ANOVA ANCOVA
H_02: There is no statistically significant difference in students' Motivation to learn Chemistry between those exposed to CBCML and those taught through CTM	CBCML CTM	Post-test scores on SMQ	ANOVA
H_03: There is no statistically significant difference in Achievement in Chemistry between students exposed to CBCML and those taught through CTM	CBCML CTM	Post-test scores on CAT	ANOVA ANCOVA
H_04 There is no statistically significant Gender difference in Skills Acquisition in Chemistry among students exposed to CBCML.	Gender	Post-test scores on CPSAT	t-Test
H_05: There is no statistically significant Gender difference in Motivation to learn Chemistry among students exposed to CBCML	Gender	Post-test scores on SMQ	t-Test
H_06: There is no statistically significant Gender difference in Achievement in Chemistry among students exposed to CBCML	Gender	Post-test scores on CAT	t-Test

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter covers presentations on data analyses as well as the findings on the effect of CBCML on secondary school students' skills acquisition, motivation and achievement in Chemistry Practical. Descriptive as well as inferential statistics were used in data analyses. The statistics used include the means, t-test, ANOVA and ANCOVA. Inferential statistics were used to test the six hypotheses of the study. Results of the analyses are presented in a tabular form and a conclusion made indicating whether the hypothesis was rejected or accepted at a stated significance of 0.05 alpha level.

The presentation of the results was done based on the six objectives of the study**.** The study was designed to determine the effect of using CBCML on students' Skills Acquisition, Motivation to learn and achievement in Chemistry and to examine whether gender affects students Skills Acquisition, Motivation and Achievement in Chemistry when CBCML is used in teaching.

4.2 Presentation of Results and Discussion

Data were obtained by administration of CPSAT, SMQ and CAT to the Control and Experimental Groups. Analyses of data were done using inferential statistics. Specifically, t-test, ANOVA and ANCOVA were used. To establish whether the Experimental (E) and the Control Groups(C) were similar at the beginning of the study, the pre-test scores of CPSAT, SMQ and CAT were analysed using independent sample t-test. The post-test results were then analysed to determine the effects of CBCML on students' Skills Acquisition, Motivation and Achievement in Chemistry using ANOVA and ANCOVA. In particular, ANOVA was used to identify the differences in post-test mean scores between Experimental Groups (E) and Control Groups (C) while ANCOVA was used to cater for initial differences in the Experimental (E) and Control Groups (C). To find out where the differences existed, *Bonferroni post-hoc* analysis was carried out. The effect of gender on Skills Acquisition, Motivation and Achievement in Chemistry when CBCML was used in teaching was examined using t-test.

4.2.1 Effects of CBCML on Students' Skills Acquisition in Chemistry

The first objective of the study was to determine to determine the effects of CBCML on students' Skills Acquisition in Chemistry practical. Data analysis was based on research hypothesis one:

$H_0 1$: There is no statistically significant difference in students' Skills Acquisition in Chemistry between those exposed to CBCML and those taught using CTM.

CPSAT was administered as a pre-test to Group 1 and 2. After the intervention period, CPSAT was administered as a post-test to all the four groups. An analysis of the CPSAT scores on the pre-test for Groups 1 and 2 as well as the post-test for all the four groups was carried out using SPSS.

4.2.1.1 Pre-test Scores on CPSAT

Skills acquisition in chemistry was perceived as the ability of the students to follow a given procedure to conduct a practical competently through manipulation of the apparatus, accurately record results, analyze and present the results as required. The results obtained from the experiment were then used to answer subsequent questions with regard to standardizing a solution whose concentration in not known.

In this study learners' level of competence in Science Process Skills were measured in two levels. The first level was superficial and required the learners to carry out a given practical before any guidance from the instructor was given. However, the second level came after intervention. This required the learners to display a high level of competence in following the procedure, accurate measurements, correct manipulation of apparatus to get accurate results and be able to record, analyse and represent the results appropriately. The two levels of skills acquisition were measured by of use of Chemistry Practical Skills Acquisition Test (CPSAT). The first level of competence was coded as CPSAT Pre-test while the second level was coded as CPSAT Post-test. In the pre-test, only one level of competence in practical work was measured; that is students scoring or not scoring the correct answer(s) as expected.

The CPSAT had an outline of the procedure to be followed by the respondents while carrying out the practical work. This was followed by a table to be completed while carrying out the practical followed by questions based on the practical having maximum score of 10. The Sum, Means and Standard Deviations (SD) on students' competence in pre-test CPSAT are presented in Table 8.

Table 8

Summary of Students' Pre-test Scores on CPSAT

Group	Type of group	Mean	N	Std. Deviation
1	E1	1.750	59	.939
2	C1	1.730	60	1.071

Maximum Score: 10 Marks

The results in table 8 shows that the mean score for group 1 was (M=1.75, SD=0.939) while that of group 2 was (M=1.73, SD=1.071) out of a maximum score of 10. These results show that the mean scores in the experimental and control groups were similar.

To assess the homogeneity of the groups before treatment, a t-test was conducted on the CPSAT pre-test mean scores. Table 9 shows the independent sample t-test analysis on pre-test results for CPSAT.

Table 9

Independent Sample t-test of Pre-test Scores on CPSAT

Scale	Group	N	Mean	SD	Df	t-value	p-value
CPSAT	1	59	1.750	0.940	117	0.349	0.947(ns)
	2	60	1.730	1.070			

ns = not significant at 0.05 level; CPSAT Maximum Score = 10 Marks

The t-test analysis results in Table 9 shows that the pre-test CPSAT mean scores of both groups 1 and 2 were not significantly different at 0.05 alpha level ($t(117) = 0.349$, $p>0.05$). Therefore, the two groups had comparable characteristics. Therefore, the groups suitable for use in the study.

4.2.1.2 Post-test Scores on CPSAT

All the four groups took the CPSAT post-test. The students' post-test mean scores and standard deviation (SD) for the four groups based on competence in Chemistry practical skills are summarized in Table 10.

Table 10

Students' Post-test Mean Scores on CPSAT

Group	**1**	**2**	**3**	**4**
Type of Group	**E1**	**C1**	**E2**	**C2**
N	59	60	52	67
Mean Scores	8.17	5.02	8.15	4.93
Std. Deviation	1.37	2.05	1.41	2.03

Maximum Score: 10 Marks

The means scores of the level of competence in Chemistry practical skills were (M=8.17, SD=1.37), (M=5.02, SD2.05), (M=8.15, SD=1.41), and (M=4.93, SD=2.03) for groups 1, 2, 3 and 4 respectively. The findings in this study show that CPSAT pre-test scores did not interact significantly with the treatment conditions. This is because the groups which were exposed to the pre-test did not score higher than those not exposed to it. The level of competence in skills acquisition among the Experimental Groups, 1 and 3 was higher relative to that of the Control Groups, 2 and 4. This shows that the experimental groups performed better than the control groups in CPSAT. If the results of Experimental Groups are similar to each other in post-test as opposed to the Control Groups, the researcher is in a position to attribute the difference to the treatment. Thus, the higher scores by the Experimental Groups 1 and 3 are as a result of CBCML treatment and not the pre-testing effects. Figure 8 shows the graphical representation of the post-test scores on CPSAT.

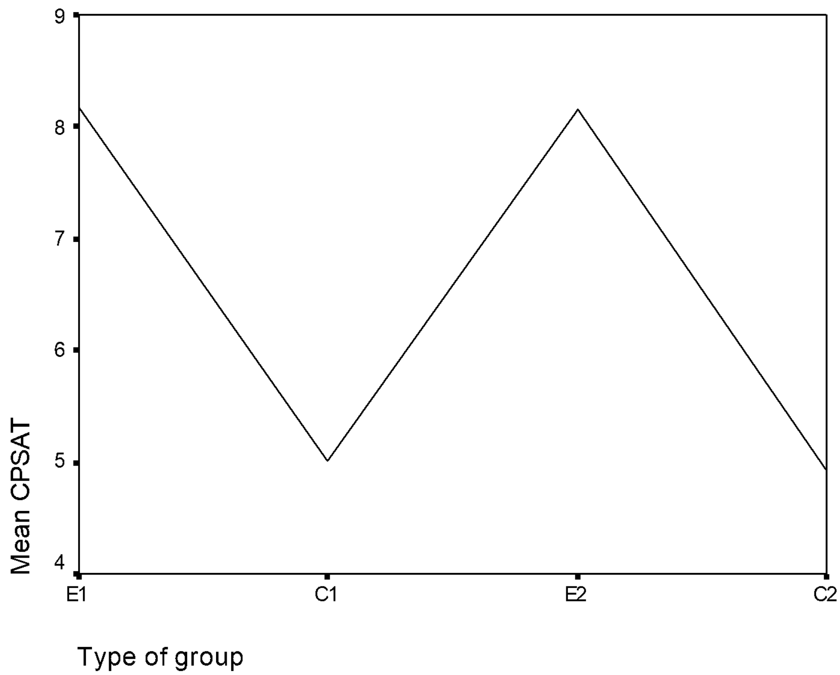

Figure 8. Graph of Mean of Post-test CPSAT against Type of Group

One-way ANOVA was run on students' post-test CPSAT scores to find out whether the means differed significantly. The results of this analysis were used estimate the effect of CBCML on student's Chemistry Practical Skills Acquisition. Table 11 shows the ANOVA of post-test scores on CPSAT.

Table 11

ANOVA of Post-test Scores on CPSAT

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	604.395	3	201.465	64.696	.000(s)
Within Groups	728.685	234	3.114		
Total	1333.080	237			

s = significant mean difference at 0.05 alpha level; CPSAT Maximum Score = 10

The ANOVA results in Table 11 shows that the computed p-value (0.000) was less than the set alpha value of 0.05. Therefore, the differences in CPSAT post-test mean scores among the four groups were statistically significant (F (3, 234) = 64.696, $p<0.05$). This implies that the intervention had a positive effect on students' Skills Acquisition in Chemistry.

ANOVA does not have features that make initial difference adjustments during post-test analysis. Hence it was not proper to conclusively reject the hypothesis on the basis of ANOVA. Further analysis was therefore conducted using ANCOVA which has features that takes care of initial differences by making compensating adjustments to the post-test means of the groups involved. ANCOVA was carried out on the post-test mean scores of the groups using the students' Kenya Certificate of Primary Education (KCPE) mark as covariates. This was done in an attempt to reduce the effect of the initial group differences that may have been existing. Table 12 shows the adjusted CPSAT post-test mean scores for ANCOVA using KCPE mark as covariate.

Table 12

Adjusted CPSAT Post-test Mean Scores for ANCOVA

Group	Type of group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	E1	8.169(a)	.230	7.716	8.623
2	C1	5.017(a)	.228	4.567	5.467
3	E2	8.154(a)	.245	7.671	8.637
4	C2	4.925(a)	.216	4.500	5.351

a. Covariates appearing in the model are evaluated at the following values: Mean of KCPE Mark = 293.118.

The adjusted CPSAT post-test mean scores with KCPE as covariate for the four groups are shown in Table 12. When the adjusted CPSAT post-test mean scores of the Experimental Groups were compared to those of the Control Groups, the results showed that the Experimental Groups which received treatment had better mean scores over the control groups despite the fact that the Control Group, C1 received pre-test which would otherwise have influenced the post-test results. This suggested that the pre-test did not influence the skills acquisition of the students who were pre-tested. This therefore implies that the high level of competence in Chemistry practical skills was as a result of the treatment and not the prior exposure to CPSAT. Table 13 shows Analysis of Covariance (ANCOVA) of the post-test CPSAT mean scores with KCPE scores as covariate.

Table 13

ANCOVA of the Post-test Scores on CPSAT

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	604.396(b)	4	151.099	48.315	.000
Intercept	83.998	1	83.998	26.859	.000
KCPE	.000	1	.000	.000	.992
GROUP	603.713	3	201.238	64.347	.000(s)
Error	728.684	233	3.127		
Total	11259.000	238			
Corrected Total	1333.080	237			

a. Computed using alpha = .05
b. R Squared = .453 (Adjusted R Squared = .444)

ANCOVA test confirmed that the differences in mean scores of the groups was statistically significant at 0.05 alpha level, ($F (3, 233) = 64.347$), $p<0.05$). The results show that there was a statistically significant difference between the means of Experimental Groups and Control Groups with regard to the level of skills acquisition among the learners. It can then be concluded that CBCML had an effect on students' competence in Chemistry practical skills.

After establishing that there was a significant difference in competence to perform Chemistry practical activities by students taught through CBCML and those taught through CTM, it was important to conduct further tests to show where the difference occurred. To find out where the difference occurred, a *Bonferroni post-hoc* analysis was carried out. Table 14 shows post-hoc pair-wise comparisons based on ANCOVA for CPSAT mean scores for the four groups. *Bonferroni post-hoc* analysis was preferred for this study because it controls for the overall error rate hence the observed significance level is adjusted for the fact that multiple comparisons were being made. Whenever there is a difference between the means of different groups, this test in particular shows where the difference occurred.

Table 14

Bonferroni post-hoc Pair-wise Comparisons of Post-test CPSAT Mean Scores

(I) Type of group	(J) Type of group	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	3.153*	.324	.000
	E2	.016	.336	1.000
	C2	3.244*	.315	.000
C1	E1	-3.153*	.324	.000
	E2	-3.137*	.334	.000
	C2	.091	.314	1.000
E2	E1	-.016	.336	1.000
	C1	3.137*	.334	.000
	C2	3.229*	.326	.000
C2	E1	-3.244*	.315	.000
	C1	-.091	.314	1.000
	E2	-3.229*	.326	.000

* The mean difference is significant at .05 alpha level

Table 14 shows the results of *Bonferroni post-hoc* pair-wise comparisons of significance for a difference between any two means. These results show that there was a statistically significant difference between the pairs of CPSAT post-test means for groups E1 and C1, groups E1 and C2, groups C1 and E2 and groups E2 and C2 at 0.05 α-level. However, there was no statistically significant difference in the means between Groups E1 and E2 and Groups C1 and C2. It is also evident from Table 10 that CPSAT post-test mean scores of control groups were significantly lower than those of experimental groups. Consequently, $H_0 1$ was rejected.

The students mean gain in Skills Acquisition was determined for Group 1 and 2 which received both the pre-test and the post test. Table 15 shows the mean gain between students' CPSAT pre-test scores and post-test scores for Group 1 and 2.

Table 15

Comparison of Students' Mean Scores with their Mean Gain in CPSAT

	Group 1 (N=59)	Group 2 (N=60)	Overall (N=118)
Pre-test mean scores	1.75	1.73	1.74
Post-test mean scores	8.17	5.02	6.60
Mean Gain	**6.42**	**3.29**	**4.86**

CPSAT Maximum Score = 10 Marks

Table 15 shows that the mean gain for the Experimental Group was higher than that of the Control Group. The results indicate that both Group 1 and 2 acquired skills significantly from the teaching. However, group 1 which received the treatment had a higher mean gain of 6.42 in skills acquisition compared to the control group with a mean gain of 3.29. Therefore, CBCML improved the skills acquisition among students who were in the experimental groups more than those in control groups taught through CTM. This implies that CBCML has a positive effect on skills acquisition in chemistry.

4.2.1.3 Discussion

In this study, students' skills acquisition in chemistry was assessed using a CPSAT. The items in this instrument included a procedure outlining the steps learners were to follow in carrying out the practical, a blank table for recording the results and questions to be attempted based on the results obtained from the practical. The information sought through these CPSAT items wanted the respondents to demonstrate their level of competence in handling chemistry practical before and after treatment. The skills and competencies assessed in practical examination are in line with some of the general objectives of teaching and learning of chemistry as prescribed in the chemistry syllabus. Examples of such objectives includes to select and handle appropriate apparatus for use in experimental work and to make accurate measurements, observations and draw logical conclusions from experiments (KIE, 2002).

The post-test data obtained from the CPSAT was analyzed using the KCPE mark as covariates. Consequently, the ANCOVA test results show that the differences in mean scores of the groups were statistically significant, (F (3, 233) = 64.347), $p<0.05$). The results show that there was statistically significant difference between the means of Experimental Groups and Control

Groups with regard to the level of skills acquisition among the learners. It can then be concluded that CBCML had an effect on students' competence in Chemistry practical.

Bonferroni post-hoc pair-wise comparisons of significance for difference between any two means results conducted show that there was a statistically significant difference between the pairs of CPSAT post-test means for groups E1 and C1, groups E1 and C2, groups C1 and E2 and groups E2 and C2 at 0.05 alpha level. However, there was no statistically significant difference in the means between Groups E1 and E2 and Groups C1 and C2. Consequently, H_01 was rejected. Analysis of the Mean gain between students upon considering the pre-test and post-test scores shows that those in the experimental group outshined their counterparts in the control group. This implies that CBCML improved the skills acquisition of students who were in the experimental groups compared to those in control groups. These results therefore show that the use of CBCML in the teaching and learning of chemistry is beneficial to learners as far as skills acquisition is concerned.

The results of this study show significant difference in the means between the experimental and control groups in skills acquisition scores between Chemistry students who were taught through CBCML and CTM respectively. This finding may be hinged on the quality of instructional modes used by the teachers. The finding of this study is somewhat in consonant with the view of Galleto and Refugio (2011) who deduced that there is a significant variation in the students' skills in mathematical computation between the control group with the traditional method of teaching and the experimental group with the use of graphing calculator in teaching and learning mathematics. This means that students performed skilfully better during the post-test than during the pre-test. They concluded that the treatment given to the science students by their teachers had significant effect on their computation skills.

Computation skills remain an integral part of students' science education because they lay the foundation for success in future mathematical learning such as algebra, geometry, trigonometry, calculus, in particular, and science, generally. Hence, efforts at improving the skills by both the teachers and the science students should be encouraged.

This findings of the study supports the work of Akpokorie (2000) and Omajuwa (2011) whose study showed that students find most process skills difficult. According to earlier work Ajaja (2010), the reason why students may find all process skills difficult could be due to the persistent use of lecture methods for teaching Chemistry as against the recommended use of laboratory and discovery/inquiry approaches which are student-activity centred.

Chebii, Wachanga and Kiboss, (2012) investigated the effectiveness of science process skills mastery learning approach on students' acquisition of practical skills among form two students from co-educational schools in Koibatek district in Kenya. Results revealed that students in the experimental group outperformed students in the control group in the acquisition of some selected chemistry practical skills.

Okinuga, Ojo and Yande (2013) conducted a study to assess science process skills acquisition of Basic science students in Junior Secondary Schools 3. The results of their study showed that students have a low acquisition of science process skills. However, classification is the most acquired skill and the only proficient skill in the domain of science process skills measuring/using number relations is the least acquired of all the science process skills. The study also revealed that students are not successful at acquiring process skills such as observation, interpreting, inferring, communicating, predicting and experimenting.

Science Process skills are the aspect of science learning which is retained after cognitive knowledge has been forgotten. Using science process skills is an important indicator of transfer of knowledge which is necessary for problem-solving for functional living. The knowledge of process skills in science is very important for proper understanding of concepts in science. Ajaja (2010) stated that process skills are fundamental to science, which allows everyone to conduct investigation and reach conclusions.

4.2.2 Effects of CBCML on Students' Motivation in Chemistry

Objective two of the study sought to compare the students' motivation to learn Chemistry between those taught through CBCML and those taught through Conventional Teaching Methods (CTM). Data analysis was guided by the corresponding null hypothesis of the study:

$H_0 2$: There is no statistically significant difference in students' Motivation to learn Chemistry between those exposed to CBCML and those taught through CTM.

In this study, motivation was perceived to mean the students effort put in as a result of their desire to learn chemistry. A Student Motivation Questionnaire (SMQ) was used to measure students' motivation to learn chemistry. The students' level of motivation was measured before intervention as a pre-test and after intervention as a post-test.

To determine the effects of CBCML on students' motivation in Chemistry practical, an analysis of the SMQ scores on the pre-test for groups 1 and 2 as well as the post-test for all the four groups was carried out using SPSS.

4.2.2.1 Pre-test Scores on SMQ

The aim of the pre-test was to ascertain whether the students selected to participate in this study had comparable characteristics. Table 16 shows the pre-test SMQ mean scores and standard deviation (SD), based on the students' motivation in Chemistry.

Table 16

Students' Pre-test Mean Scores on SMQ

Group	Type of group	N	Mean	Max. Score	Std. Deviation
1	E1	59	3.735	5	.689
2	C1	60	3.938	5	.424

The results in Table 16 shows that the pre-test SMQ mean scores of experimental group (E1) (M=3.735, SD=0.689) and control group (C1) (M=3.938. SD=0.424) were similar. To investigate homogeneity of the groups before treatment, a t-test was conducted on the SMQ pre-test mean scores. Table 17 shows independent sample t-test on SMQ pre-test t-test mean scores.

Table 17

Independent Sample t-test of SMQ Pre-test Scores for Groups 1 and 2

Scale	Group	Group Type	N	Mean	SD	df	t-value	p-value
SMQ	1	E1	59	3.74	0.69	117	0.003	0.055(ns)
	2	C1	60	3.94	0.42			
	Total		119	3.87	0.58			

ns = not significant at 0.05 alpha level; SMQ Maximum Score = 5

The t-test analysis results in Table 17 reveals that pre-test SMQ mean scores of both Groups 1 and 2 were not significantly different at 0.05 alpha level ($t (117) = 0.003, p > 0.05$). The SMQ pre-test mean scores for the Experimental Group (E1) was ($M = 3.74, SD = 0.69$) while for Control Group (C1) was ($M = 3.73, SD = 0.42$). Therefore, the two groups had comparable characteristics as far as motivation was concerned, hence homogenous. Thus, they were suitable for use in the study.

4.2.2.2 Post-test Scores on SMQ

After intervention, the SMQ was administered to all the four groups as a post-test. The post-test Sum, Mean and Standard Deviation (SD) of the four groups on motivation in Chemistry are summarized in Table 18.

Table 18

Students' Post-test Mean Scores on SMQ

Type of Group	**E1**	**C1**	**E2**	**C2**
Group	**1**	**2**	**3**	**4**
N	59	60	52	67
Mean Scores	4.48	3.93	4.51	3.94
Std. Deviation	0.32	0.35	0.32	0.34

SMQ Maximum Score = 5

The results in Table 18 indicate that the SMQ post-test mean scores of experimental groups 1 and 3 (4.48 and 4.51) were higher than that of the control groups 2 and 4 (3.93 and 3.94). This shows that the MTLC among the experimental groups was more enhanced compared to that of the control groups. The findings in this study show that the SMQ pre-test scores did not interact significantly with treatment conditions. This is because the groups which were exposed to the pre-test did not score higher than those not exposed to it. Greater scores by group 1 and 2 than group 3 and 4 could have been the results, if the pre-test had a practice effect. Thus, the higher scores by experimental group 1 and 3 could be as a result of the intervention and not the pre-testing effects. Figure 9 shows the graphical representation of the SMQ mean scores for the four groups.

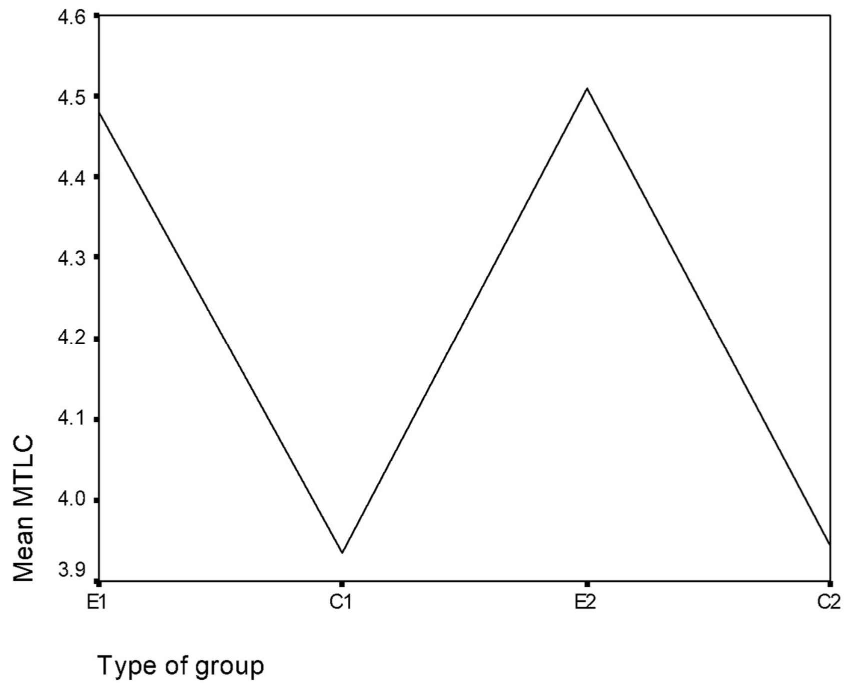

Figure 9. Graph of Mean of Post-test MTLC against Type of Group

One-way ANOVA was carried out on students' SMQ post-test scores to estimate the effect of CBCML on student's Motivation to Learn Chemistry. The results of this test are shown in Table 19.

Table 19

One-way ANOVA of SMQ Post-test Mean Scores

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.217	3	6.072	53.582	.000(s)
Within Groups	26.518	234	.113		
Total	44.735	237			

s = significant mean difference at 0.05 alpha level; SMQ Maximum Score = 5

The results in Table 19 show that the computed p-value (0.000) was less than the set alpha value of 0.05. Therefore, the differences in the level of motivation among the four groups were statistically significant at 0.05 alpha level ($F(3, 234) = 53.582$, $p<0.05$).

To find out where the differences in motivation existed, a *Bonferroni post-hoc* pair-wise comparisons analysis for differences between any two means was carried out. Table 20 shows the results of this test.

Table 20

Bonferroni post-hoc Pair-wise Comparisons of the Post-test SMQ

(I) Type of group	(J) Type of group	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	.546*	.062	.000
	E2	-.029	.064	1.000
	C2	.536*	.060	.000
C1	E1	-.546*	.061	.000
	E2	-.574*	.064	.000
	C2	.009	.060	1.000
E2	E1	.029	.064	1.000
	C1	0.574*	.064	.000
	C2	0.565*	.062	.000
C2	E1	-.536*	.060	.000
	C1	-.009	.059	1.000
	E2	-.565*	.062	.000

* The mean difference is significant at 0.05 alpha level.

The results in Table 20 show that there was a statistically significant difference between the pairs of SMQ post-test means for groups E1 and C1, groups E1 and C2, groups C1 and E2 and groups E2 and C2 at 0.05 alpha level. However, there was no statistically significant difference in the means between Groups E1 and E2 and Groups C1 and C2. Consequently, $H_0 2$ was rejected.

It was possible to determine the mean gain in students' motivation to learn chemistry for Group 1 and 2 only because they received both the pre-test and post-test SMQ treatment. Table 21 shows the mean gain between students' SMQ pre-test scores and post-test scores, which was higher for the experimental than the control group.

Table 21

Comparison of Students' Mean Scores with their Mean Gain in SMQ

Score	Group 1 (N=59)	Group 2 (N=60)	Overall (N=118)
Pre-test mean scores	3.74	3.94	3.84
Post-test mean scores	4.48	3.98	4.23
Mean Gain	**0.74**	**0.04**	**0.39**

SMQ Maximum Score = 5

The results in Table 21 indicate that both Group 1 and 2 became more motivated from the teaching. However, the Experimental Group (E1) has a higher mean gain in motivation than the Control Group (C1) implying that the use of CBCML in teaching resulted in higher Motivation to Learn Chemistry (MTLC) than the CTM.

Therefore, these results show that CBCML improved the motivation of students who were in the experimental groups compared to those in control groups. This implies that CBCML has a positive effect on Motivation to Learn Chemistry among the students.

4.2.2.3 Discussion

In this study students' motivation to learn chemistry was assessed using Students Motivation Questionnaire (SMQ). The items constructed on a five point Likert-Scale were 23. The information sought through these SMQ items wanted the respondents to give their personal feeling or opinion about chemistry learning.

The results of the pre-test showed that the mean score for Experimental Group 1 (E1) was ($M = 3.74$, $SD = 0.69$) while for Group 2 (C1) was ($M = 3.73$, $SD = 0.42$), $t(117) = 0.003$, $p > 0.05$. This shows there was no significant difference in the students' level of motivation to learn chemistry between the Experimental group (E1) and Control group (C1). These results implied that the level of students' MTLC in the two groups were similar before the intervention and therefore suitable for use in the study.

The results of the post-test show the MTLC mean scores for the four groups were 4.48, 3.93, 4.51 and 3.94 for group 1, 2, 3 and 4 respectively. The results show that the students in all the four groups have moderately favourable MTLC with the highest mean being that of the two experimental groups, 1 and 3.

One-way ANOVA was carried out on students' post-test SMQ scores to find out whether these means were significantly different and to estimate the effect of CBCML on student's Motivation to Learn Chemistry. The results in Table 19 shows that the differences in the level motivation among the four groups after treatment was significant ($F (3, 234) = 53.582, p<0.05$).

Bonferroni post-hoc pair-wise comparisons of significance for differences between any two means indicates that there was a statistically significant difference between the pairs of SMQ post-test means for groups E1 and C1, groups E1 and C2, groups C1 and E2 and groups E2 and C2 at 0.05 α-level. However, there was no statistically significant difference in the means between Groups E1 and E2 and Groups C1 and C2. An analysis on the mean gain in the SMQ scores shows that the use of CBCML teaching approach motivated the learners. These results show that CBCML improved the motivation of students who were in the experimental groups compared to those in control groups. This implies that CBCML has a positive effect on motivation to learn chemistry. Consequently, the second hypothesis, H_02 which stated that there is no statistically significant difference in students' motivation to learn chemistry between those exposed to CBCML and those taught through CTM was rejected.

From these results there is evidence that students respond positively to the use of computers in the learning of chemistry. The computer simulations and tutorials in the DVD led to increased intrinsic motivation to learn among the students. Students concentrate more on a task and express more positive feelings when they use computers than when they are given other tasks to do, Becker (2000). This positive response is linked to the stimulus variation which ensured active participation of the learners during the teaching/learning process in class. If the learner is passive, the technology has less effect in increasing student interest and motivation to learn. Teacher directed technology that is limited to a reproduction of old material using technology or for example using power point to display written notes is not considered a beneficial use of technology (Lowerison, Sclater, Schmid & Abrami, 2006).

The findings of this study is in accordance with earlier studies by Keraro, Wachanga and Orora (2007) conducted to investigate the effects of Cooperative Concept Mapping (CCM) teaching approach on secondary school students' motivation to learn Biology. Their findings indicate that the CCM teaching approach significantly enhanced students' motivation to learn because the students were actively engaged during the instructional process. Another study by Ronoh and Ndonga (2013) showed that the use of Computer Based Mastery Learning (CBML) on Secondary School Students' to Learn Biology motivated the learners to a great extent. A study by Wachanga (2002) that compared the effects of traditional and Cooperative Class Experiment (CCE) learning strategies on achievement and motivation in secondary school chemistry also found significant difference in motivation. Those taught through CCE were found to have a higher level of motivation to learn chemistry than their counterparts taught through traditional methods.

It is known that the cooperative learning method benefits students in their learning process, Basili and Sanford (1991). The use of CBCML provides students room to work together at their own pace. They can communicate and discuss with each other and get clarified of their doubts thereby enhancing their level of understanding towards chemistry concepts. This gives students the chance to exchange information and build a body of common knowledge. In turn they are motivated by the successful learning they have engaged in.

Motivating students to learn is a topic of great concern for educationists today. Moreover, motivating students so that they can succeed in school is one of the greatest challenges of this century. Lack of motivation is a big hurdle in learning and a pertinent cause of deterioration in education standards. According to Deci and Ryan (2000) motivation is greatly appreciated because of the consequences it produces. The attitude that is often used in conjunction with motivation to achieve is self-concept, or the way one thinks about oneself to perform a task successfully. There is considerable evidence to support the contention that positive academic self-concept contributes to academic achievement by enhancing the motivation to achieve. This study's purpose was to explore effects of CBCML on students' skills acquisition, motivation to learn chemistry and consequently how these factors impacts on the learners' achievement in the subject.

There is a strong relationship between learning and motivation. According to Abraham Maslow when the need for love and belongingness are met, individuals can then focus on higher level needs of intellectual achievement. At this stage, the urge to learn increases (Woolfolk, 2004). All students are influenced by a need to achieve to a certain degree. Those students, who hold a high desire for success, work hard to achieve (Pullmann & Allik, 2008).

The findings of the present study have shown that CBCML enhances students' motivation to learn. The use of CBCML therefore, enabled learners to be active cognitively while learning using computers in groups, performing practical work together and hence intrinsically motivated to learn chemistry. A study by Solomon (1986) on motivation shows that active involvement of learners enhances their understanding of new situations. Another study by Tella, (2007) on motivation and achievement in Mathematics showed that motivating students to learn enhances their academic achievement. In this study, learners worked together in groups, therefore, active involvement and stimulus variation captured their interest hence their MTLC was enhanced.

4.2.3 Effects of CBCML on Students' Achievement in Chemistry

The third objective of this study was to compare achievement in Chemistry between students taught through CBCML and those taught through CTM. According to Osborn and Wittrock, (2003) achievement is the ability to perform tasks in the areas of lower and higher order skills as an outcome of an instruction process. In this study achievement meant the competence of a student that enables him/her to perform well in all chemistry tasks from all the three domains of learning as proposed by Blooms.

In this study, achievement was measured using a Chemistry Achievement Test (CAT) (see Appendix C). In line with this objective, data obtained was analysed based on the third hypothesis of the study:

$H_0$3 There is no statistically significant difference in Achievement in Chemistry between students exposed to CBCML and those taught through CTM.

To determine the effects of CBCML on students' Achievement in Chemistry practical, an analysis of the CAT mean scores on the pre-test for groups 1 and 2 as well as the post-test for all the four groups (1, 2, 3 and 4) was carried out using SPSS.

4.2.3.1 Pre-test Scores on CAT

To assess the homogeneity of the groups before treatment, a pre-test was administered to Experimental Group 1 (E1) and Control Group 2 (C1). The pre-test mean scores and standard deviation (SD) for the two groups that received the pre-test based on the students' achievement in chemistry are summarized in Table 22.

Table 22

Summary on Students' Pre-Test Scores in CAT

Group	Type of group	Mean	N	Std. Deviation
1	E1	3.017	59	1.635
2	C1	3.033	60	1.605

CAT Maximum Score=25

Results in Table 22 shows that the mean scores obtained from CAT pre-test was (M=3.017, SD=1.635) and (M=3.033, SD=1.605) for group 1 and 2 respectively out of a maximum score of 25 marks. This performance in the CAT pre-test is equivalent to 4.1%. To test whether there was any significant difference in the two means, an independent t-test was performed and the results are presented in Table 23.

Table 23

Independent Sample t-test of Pre-test Scores on CAT for Groups 1 and 2

Scale	Group	N	Mean	SD	df	t-value	p-value
CAT	1	59	1.020	1.630	117	0.768	0.956(ns)
	2	60	1.030	1.600			

ns = not significant at 0.05 alpha level; CAT Maximum Score = 25

The results in Table 23 shows that the CAT pre-test mean scores for Groups 1 and 2 and for the students were not significantly different ($t(117)=0.768$ $p>0.05$). This implies that the groups had comparable characteristics at the beginning of the treatment. Therefore, the groups were suitable for use in the study.

4.2.3.2 Post-test Scores on CAT

The post-test Sum, Mean and Standard Deviation (SD) of the four groups on the overall CAT mean scores are summarized in Table 24.

Table 24

Students' Post-test CAT Mean Scores

Type of Group	E1	C1	E2	C2
Group	**1**	**2**	**3**	**4**
N	59	60	52	67
Mean Scores	16.76	8.88	16.40	9.94
Std. Deviation	5.13	6.44	5.43	6.47

CAT Maximum Score = 25

The CAT mean scores were 16.76, 8.88, 16.40 and 12.64 for groups 1, 2, 3 and 4 respectively out of a maximum score of 25. The results in Table 24 indicate that the CAT post-test mean scores of Experimental Groups 1 and 3 (16.76 and 16.4) were much higher than those of the Control Groups 2 and 4 (8.88 and 9.94). This shows that the experimental groups performed better than the control groups in the CAT. Figure 10 shows the graphical representation of the CAT mean scores for the four groups.

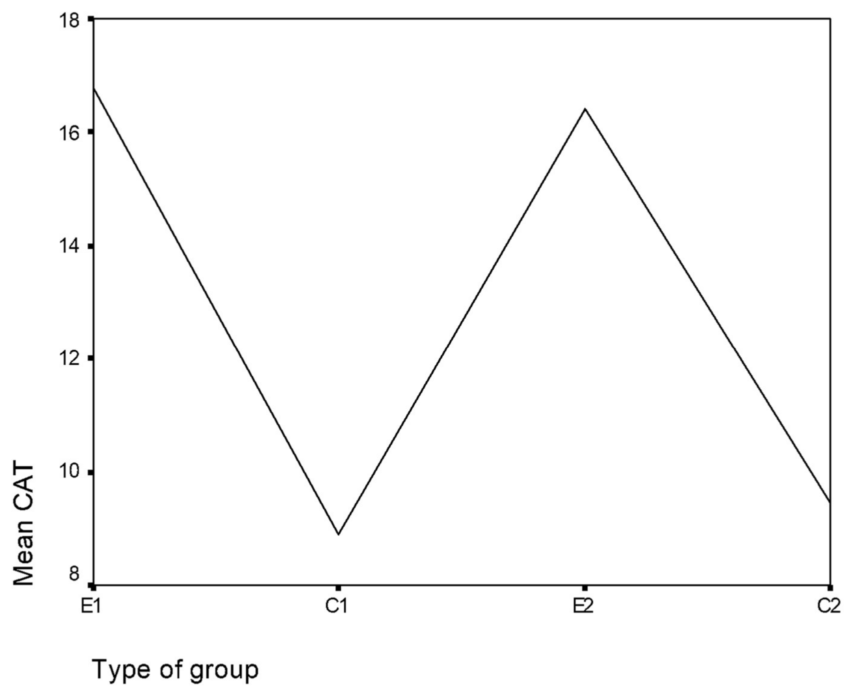

Figure 10. Graph of Mean of Post-test CAT against type of Group

One-way ANOVA was used to estimate the effect of CBCML on student's achievement in chemistry. Table 25 shows the results of one-way ANOVA of post-test scores on CAT.

Table 25

One-way ANOVA of Post-test Mean Scores on the CAT

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	3262.606	3	1087.535	30.876	.000(s)
Within Groups	8242.037	234	35.222		
Total	11504.643	237			

s = significant at 0.05 alpha level; CAT maximum score = 25

The results in Table 25 show that the computed p-value (0.000) was less than the set alpha value of 0.05. Therefore, the differences in CAT mean scores among the four groups were statistically significant at 0.05 alpha level ($F (3, 234) = 30.876$, $p<0.05$).

ANCOVA test was carried out using the students' Kenya Certificate of Primary Education (KCPE) mark as covariate, in an attempt to reduce the effect of the initial group differences. Table 26 shows the adjusted CAT post-test mean scores for ANCOVA using KCPE as covariate.

Table 26

Adjusted CAT Post-test Mean Scores for ANCOVA

Group	Type of group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	E1	16.764(a)	.774	15.238	18.289
2	C1	8.883(a)	.768	7.369	10.396
3	E2	16.404(a)	.825	14.779	18.030
4	C2	9.462(a)	.727	8.031	10.894

a. Covariates appearing in the model are evaluated at the following values: KCPE Mean Mark = 293.118.

The adjusted CAT post-test mean scores with KCPE as covariate for the four groups are shown in Table 26. When the adjusted CAT post-test mean scores of the experimental groups were compared to those of the control groups, the results showed that the Experimental groups had better mean scores as compared to the Control groups despite Control Group, C1 receiving pre-test. This suggested that the pre-test did not influence the achievement of the students who were pre-tested. This therefore implies that the high level of achievement in Chemistry practical was as a result of exposure to CBCML. Table 27 shows the ANCOVA results for the CAT post-test scores using KCPE mark as covariate.

Table 27

Analysis of Covariance (ANCOVA) of the Post-test Scores on CAT

Source	Type III Sum of Squares	df	Mean Square	F	p-value
Corrected Model	3262.702(b)	4	815.676	23.059	.000
Intercept	310.791	1	310.791	8.786	.003
KCPE	.097	1	.097	.003	.958
GROUP	3260.167	3	1086.722	30.722	.000(s)
Error	8241.941	233	35.373		
Total	49547.000	238			
Corrected Total	11504.643	237			

a. Computed using alpha = .05
b. R Squared = .284 (Adjusted R Squared = .271)

ANCOVA test results in Table 27 confirmed that the differences between the group means were statistically significant at 0.05 alpha level ($F (3, 233) = 30.722$), $p<0.05$). Consequently, $H_0 3$ was rejected.

To find out where the difference in achievement occurred, a *Bonferroni post-hoc* analysis was carried out. The results of this analysis are presented in Table 28.

Table 28

Bonferroni post-hoc Pair-wise Comparisons of Post-test CAT Mean Scores

(I) Type of group	(J) Type of group	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	7.879*	1.088	.000
	E2	.359	1.128	1.000
	C2	7.300*	1.000	.000
C1	E1	-7.879*	1.088	.000
	E2	-7.521*	1.124	.000
	C2	-.579	1.054	1.000
E2	E1	-.359	1.129	1.000
	C1	7.521	1.124	.000
	C2	7.941*	1.096	.000
C2	E1	-7.300*	1.060	.000
	C1	.579	1.056	1.000
	E2	6.941*	1.096	.000

* The mean difference is significant at 0.05 alpha level.

Bonferroni post-hoc pair-wise comparisons of significance for a difference between any two means results in Table 28 show that there was a statistically significant difference between the pairs of CAT post-test means for groups E1 and C1, groups E1 and C2, groups C1 and E2 and groups E2 and C2 at 0.05 alpha level. However, there was no statistically significant difference in the means between Groups E1 and E2 (Experimental Groups alone) and Groups C1 and C2 (Control Groups alone).

The results in Table 29 shows the mean gain between students' CAT pre-test scores and post-test scores, which was significantly higher for the Experimental Group than the Control Group.

Table 29

Comparison of Students' Mean Scores with their Mean Gain in the CAT

	Group 1 (N=59)	Group 2 (N=60)	Overall (N=119)
Pre-test mean scores	1.02	1.03	1.03
Post-test mean scores	16.76	8.88	12.82
Mean Gain	**15.74**	**7.85**	**11.79**

CAT Maximum Score = 25

The results in Table 29 indicate that both Groups 1 and 2 gained from the teaching. However, the CBCML group had a higher mean gain than the control group implying that the CBCML method resulted in higher achievement than the CTM. Therefore, CBCML improved the achievement of students who were in the experimental groups more than those in control groups which were taught through CTM. This implies that CBCML enhanced students' achievement in chemistry more than the CTM.

4.2.3.3 Discussion

In this study, achievement was perceived at two levels; the first level was a superficial one, where students' presentation in CAT pre-test was scored in terms of whether the answer given was correct or wrong with an aim of establishing homogeneity in the level of achievement of the participants from the two groups before treatment. The second level of achievement was deeper in that the student's work was assessed for understanding. Here the students' responses were scored in terms of their ability to demonstrate understanding of concepts and principles tested irrespective of whether the final answer was correct or wrong. Assessment in the second level was achieved by scoring students' detailed responses as well as all the steps involved to obtain the final answer.

An analysis of CAT Pre-test results showed that the pre-test mean scores between the experimental and control group were not significantly different. The group therefore had comparable characteristics, hence were suitable for use in the study.

To determine the relative effects of CBCML teaching strategy on students' achievement in Chemistry practical, an analysis of students' CAT post-test scores was carried out. The results indicate that the performance of the Experimental Groups was higher. The performance mean scores were 16.76 and 16.40 for E1 and E2 respectively compared to that of the control groups whose mean scores were 8.88 and 9.94 for group C1 and C2 respectively. This shows that CBCML had a significant effect that led to improvement of performance in the subject as compared to CTM. These findings were subjected to further tests to determine whether to reject or accept the hypothesis.

The ANOVA results show that the difference between the groups is statistically significant at 0.05 alpha level ($F (3,234) = 30.876, p<0.05$). This therefore, suggests that CBCML improved the achievement of students in the Experimental Groups compared to those in Control Groups. ANCOVA test results shown in Table 27 with the KCPE mark as covariate indicates that the difference in the mean scores of the groups were statistically significant at 0.05 alpha level ($F(3, 233) = 30.722$), $p<0.05$). These results show that there is statistically significant difference between Experimental Groups and Control Groups. Consequently, $H_0 3$ was rejected at 0.05 alpha level in favour of the alternative hypothesis.

Moreover, the results of *Bonferroni post-hoc* pair-wise test for significance difference between any two means in Table 27 show that there was a statistically significant difference between the pairs of CAT post-test means for groups E1 and C1, groups E1 and C2, groups C1 and E2 and groups E2 and C2 at 0.05 alpha level. However, there was no statistically significant difference in the means between Groups E1 and E2 and Groups C1 and C2. Therefore, these results show that CBCML improved the achievement of students who were in the experimental groups compared to those in control groups. This implies that CBCML has a positive effect on achievement in chemistry.

From these findings it is evident that weak students benefit from interaction with brighter students. This is because of the fact that when bright students explain their ideas to others, they learn the material they are explaining in more depth and remember it longer (Johnson & Johnson, 1992; 1998). In a cooperative learning group, bright students are also seen as resources and are valued by team-mates (Wachanga, 2002). The CBCML teaching strategy exhibited these qualities, hence the higher achievement reported.

The findings of this study is in accordance with earlier studies by Wachanga, (2002) that compared the effects of traditional and Cooperative Class Experiment (CCE) learning strategies on achievement and motivation in secondary school chemistry also found significant difference in achievement. Moreover, a research done in the teaching of physics by Wambugu (2006) using Mastery Learning Approach (MLA) revealed that students taught using the approach outshined their counterparts taught using CTM. This result is similar to the findings of Wachanga and Gamba (2004) that investigated the effects of using MLA on secondary school students' achievement in Chemistry and found that MLA facilitates students learning of Chemistry better than the regular teaching method. It also agrees with the findings of Ngesa (2002) who reported that Mastery Learning Approach resulted in higher student achievement in Agriculture than the regular teaching method.

Bloom (1984) cited in Wambugu and Changeiywo (2007) in his research on group instruction showed scores of students taught through Mastery Learning Approach were around the ninety-eighth percentile, or approximately two standard deviations above the mean. He argued that students taught through Mastery Learning needed more time to master more advanced materials. Also, Adepeju (2003) asserted that the purpose of mastery learning method is that all students achieve high levels of learning. Therefore, one should concentrate on high level mental skills and processes while learning and implementing this learning method. His results showed that there was a difference between students exposed to Mastery Learning Method and the Conventional Teaching Methods.

This agrees with Ngesa (2002) who reported that MLA resulted in higher student achievement in Agriculture than the Regular Teaching Method (RTM). He argued that the results were significant with regard to classroom Instruction and Teacher Education in Agriculture. The Cooperative Concept Mapping (CCM) approach teaching method enhanced the teaching of secondary school biology in Gucha district (Orora, Wachanga & Keraro, 2005). Moreover, a research done in the teaching of Agriculture by Kibett and Kathuri (2005) revealed that students who were taught using Project Based Learning (PBL) outperformed their counterparts in regular teaching approach. Wambugu (2006), in her study on the effects of MLA on secondary school physics achievement found that MLA facilitates students learning in physics better as compared to regular teaching methods.

This result is further in line with the findings and recommendation of Awotunde and Bot (2003), Yildrin and Adyin (2005), Aderemi (2006) and Kazu, Kazu and Ozedemi (2008) who found that mastery learning is effective and if effectively employed by classroom teaching would improve students' achievement in a given task. This means that

Mastery Learning approach increases the performance of students exposed to it than students exposed to the regular teaching strategies. This means that Mastery Learning Approach teaching method is better in increasing the performance of students. However, an earlier study by Akinbobola (2006) studied the effects of using Group Investigation Cooperative Learning and found no significant difference in achievement between cooperative and competitive groups.

Abonyi (2013) conducted study on the effect of practical activities on students' achievement in senior secondary school chemistry concepts in Nsukka Local Government Area. The study found that the impact of practical activities on achievement of chemistry concepts is high; students taught with practical activities had a higher mean score than those taught with lecture method; male gender had a higher achievement, there was significant difference in favour of practical activities than lecture method and significant difference in favour of male students than the female.

Ugwuanyi (2014) studied the extent of use of practical activities in teaching and learning chemistry in Senior Secondary Schools in Nsukka Local Government Area. Ugwuanyi (2014) studied the extent of use of practical activities in teaching and learning chemistry in Senior Secondary Schools in Nsukka Local Government Area. The study found that teachers do not use practical activities in teaching chemistry effectively. The students are not fully involved in practical activities, chemistry scheme of work is not adequately covered and chemistry practical start late with low rate.

Muhammad (2014) conducted study on evaluation of the efficacy of conceptual instructional method of teaching practical chemistry. The findings from the study include the following: Academic Achievement of subjects exposed to conceptual instructional method was significantly higher than their counterparts exposed to lecture method of instruction.

In Uganda the trend in academic excellence in the secondary schools' final examination has shown that boys perform better than girls in Chemistry (Ssempala, 2005). In Kenya similar results are evident as shown by a study carried out by the Institute of Policy Analysis and Research (IPAR) (2003) reported in Amunga et al., that boys performed better than girls in Chemistry, Physics and Biology in KCSE. A study carried out by Amunga et al. (2011) in secondary schools in Western Province, Kenya, indicated that boys performed better than girls in Chemistry. The outcome of a study carried out by Nyakan (2008) in Kenya revealed that there was significant difference between the performance of boys and girls in physics. Other studies carried out by Wambugu and Changeiywo (2008) in Kenya, Prokop, Tuncer, and Chuda, (2007) in Slovakia in with secondary school students showed similar results in Physics and Biology subjects respectively.

4.2.4 Effect of Gender on Students' Skills Acquisition, Motivation and Achievement in Chemistry when CBCML is used

To establish whether the male and female student were similar at the beginning of the study the pre-test of CPSAT, SMQ and CAT were analysed using independent sample t-test. Thereafter, the post-test scores were analysed based on gender using t-test to check whether there is any significant gender difference in skills acquisition, motivation and achievement when CBCML is used in teaching Chemistry.

4.2.4 Effects of Gender on Students' Skills Acquisition when CBCML is used

The fourth objective of the study sought to determine the effect of gender on students' skills acquisition in Chemistry when CBCML is used. Data analysis was guided by the fourth hypothesis of the study:

$H_0$4 There is no statistically significant gender difference in Skills Acquisition in Chemistry between students exposed to CBCML.

An analysis of the CPSAT pre-test and post-test data was carried out for boys and girls who attempted the items in the questionnaire. T-test was used to determine the homogeneity of the two groups; that of male students and that of the female students before treatment. The same test was also administered as a post-test to check whether there was any significant gender difference in skills acquisition between the two groups after intervention.

4.2.4.1 CPSAT Pre-test Results based on Gender

To establish whether there were any significant gender differences in the CPSAT mean scores of the two groups before treatment, an independent t-test of pre-test scores based on gender was necessary. The results are shown in Table 30.

Table 30

Independent Sample t-test of Pre-test Scores on CPSAT based on Gender

Scale	Group	N	Mean	SD	df	t-value	p-value
CPSAT	Male	57	1.610	0.990	117	0.895	0.192(ns)
	Female	62	1.850	1.000			
	Total	119	1.730	1.000			

ns = not significant at 0.05 alpha level; CPSAT maximum score = 10

The results in Table 30 show that the male (M=1.61, SD=0.990) and female (M=1.85, SD=1.000) CPSAT mean scores were similar. The t-test results reveals that pre-test CPSAT mean scores of both male and female were not significantly different at 0.05 alpha level ($t(117)=0.895$, $p>0.05$). Thus, there was no gender difference in skills acquisition at the beginning of the treatment. This made them suitable for use in the study.

4.2.4.2 Post-test Scores on CPSAT based on Gender

To establish the effect of CBCML on gender Skills acquisition in chemistry, the post-test mean scores of the CPSAT were analyzed. Table 31 shows the sum, mean and Standard deviation.

Table 31

Students' Post-test CPSAT mean scores based on gender

Gender of respondents	Mean	N	Std. Deviation
Male	6.532	57	2.276
Female	6.394	61	2.460
Total	**6.458**	**118**	**2.371**

CPSAT Maximum Score = 10

The results in Table 31 shows that the CPSAT mean scores for both male and female students is almost equal with that of male student being a mean of 6.53 while that of the female students was 6.39 out of a total mark of 10. This therefore shows CBCML improved the skills acquisition in chemistry practicals equally for both boys and girls. Table 32 shows the results of t-test on CPSAT mean scores for both male and female students exposed to CBCML.

Table 32

Independent Sample t-test on Post-test Scores based on Gender on CPSAT

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	p-value
CPSAT	Equal variances assumed	1.108	.294	.447	111	.656(ns)
	Equal variances not assumed			.449	235.223	.654

ns = not significant at 0.05 alpha level; CPSAT Maximum Score = 10 marks

The results in Table 32 show that there was no significant gender difference in skills acquisition in chemistry at the end of CBCML intervention ($t(111)= 0.447$, $p>0.05$). Therefore, $H_0 4$ was accepted. Table 33 shows the mean gain for boys and girls on skills acquisition.

Table 33

Students' Mean Gain in CPSAT based on Gender

Gender	N	Pre-test	Post-test	Mean Gain
Male	57	1.61	6.53	4.92
Female	62	1.85	6.39	4.54
Total	**119**	**1.73**	**6.45**	**4.72**

CPSAT Maximum Score = 10

The results in table 33 show that the mean gain male and female students were 4.92 and 4.54 respectively. Thus, both boys and girls equally benefited from the CBCML approach in terms of skills acquisition in chemistry.

4.2.4.3 Discussion

The determination of the effect of gender on students' skills acquisition when CBCML Teaching Strategy is used to teach the topic Volumetric Analysis was guided by hypothesis four ($H_0 4$). Post-test mean scores on CPSAT were analysed based on gender. The CPSAT mean scores for both male and female students was found to be almost equal with that of male students being a mean of 6.53 while that of the female students was 6.39 out of a total mark of

10. A comparison of this CPSAT post-test scores with the pre-test scores shows that the mean gain for boys was 4.92 while that of girls was 4.54. This therefore shows CBCML improved the skills acquisition in Chemistry practical equally for both boys and girls.

The post-test CPSAT t-test results show that there was no significant gender difference in skills acquisition among boys and girls exposed to CBCML. This therefore implies that both boys and girls improved in skill competence in chemistry equally at the end of CBCML intervention. Hypothesis four ($H_0 4$) was therefore accepted.

This result is in agreement with the findings of Ibe (2004) who found out that gender did not affect the performance of students' in science process skills acquisition. Ibe therefore suggested that activity based instruction should be used in teaching. The findings of this study also indicated that there was no interaction between teaching strategy and gender of the subjects to influence students' acquisition of science process skills in biology. This result is in agreement with the findings of Chukelu (2008) who found no interaction effect between teaching strategy and gender in acquisition of science process skills as measured by science process skill acquisition test (SPSAT).

Abungu, Okere and Wachanga (2014) investigated on the effects of science process skills teaching strategy (SPSTS) on boys' and girls' achievement in chemistry. The result on achievement is in favour of boys. Moreover, Ibe, Adah and Ihejamaizu (2013) assessed secondary school chemistry teachers' quality with respect to identification and use of seventy-one (71) laboratory pieces of apparatus. Gender of teachers exerted significant influence on their level of identification and uses of laboratory apparatus.

Akpokorie (2000) researched on the effects of sex on difficulties experienced by students in 15 process skills using 600 JSS3 integrated science students from schools in Delta State and the study revealed that; gender has no significant effect on the magnitude of difficulties experience by integrated science students on each of the 15 process skills. This finding also supports the that of Omajuwa (2011) who found that gender have no influence on students experienced difficulty in science process skills acquisition.

The findings of this study is in agreement with those of Akpokorie (2000) and Omajuwa (2011) who found that gender have no influence on students experienced difficulty in science process skills acquisition; contradicts the works by Afif and Majdi (2015) whose results of the study indicated that there were significant differences in science process skills due to gender in favour of the females. The contradicts the works by Afif and Majdi (2015) whose results of the study indicated that there were significant differences in science process skills due to gender in favour of the females.

There have been contrasting opinions on gender related issues in science process skills acquisition. Ibe (2004), found out that gender has no influence on students' science process skill acquisition. Nnachi as cited in Olike (2006), reported that female students achieved significantly higher than their male counterpart in science process skills. These differences shows that a consensus has not been arrived at on the use of gender as a factor in science process skill acquisition in science and more work needed to be done in order to ascertain whether gender is a factor on students' science process skill acquisition.

Literatures reviewed above are contradicting in their findings. For example, Abungu, Okere and Wachanga (2014) and Adonu (2006) are in favour of males whereas the result of Ibe, Adah and Ihejamaizu (2013) was in favour of females. The work by Akinbobola and Afolabi (2012) has no significant effect. Hence since the findings are inconclusive, there is the need to carry out study on identification of science process skills in practical chemistry to fill in the gaps.

This finding is in agreement with the views of Njoku and Jacks (2011), Ugwu (2009), Adonu (2006), Akinbobola and Afolabi (2012) and Ibe, Adah and Ihejiamaizu (2013) who found that gender had no significant influences on science process skills acquisition. However, it contradicts those of Abungu, Okere and Wachanga (2014) and Ugwuanyi (2014) who found out that gender has significant effect on process skills acquisition in favour of male students. Despite the controversy, it is obvious from this study that some differences might have occurred due to some factors like nature of learners, teachers, environment and subject matters as pointed out in the background.

4.2.5 Effects of Gender on Students' Motivation in Chemistry when CBCML is used

The fifth objective of the study sought to determine the effect of gender on students' motivation to learn chemistry when CBCML is used, an analysis of the SMQ pre-test and post-test data was carried out for the boys and girls who filled the questionnaire. Data analysis in this case was guided by the corresponding fifth hypothesis:

H_05 There is no statistically significant gender difference in Motivation to learn Chemistry between students exposed to CBCML.

T-test was used to determine the homogeneity of the two groups; that of male students and that of the female students before treatment. The same test was administered as a post-test to check whether there was any significant gender difference in students' level of motivation between the two groups after intervention.

4.2.5.1 SMQ Pre-test Results based on Gender

To find out whether there were any significant gender differences in the SMQ means of the two groups before treatment, an independent t-test based on gender was necessary. The results of this pre-test t-test are shown in Table 34.

Table 34

Independent Sample t-test of Pre-test Scores on SMQ based on Gender

Scale	Group	N	Mean	SD	df	t-value	p-value
SMQ	Male	57	3.860	0.590	117	0.410	0.694(ns)
	Female	62	3.820	0.570			

ns = not significant at 0.05 alpha level; SMQ Maximum Score = 5

Results in Table 34 shows that the pre-test mean scores on SMQ for male students was (M =3.86, SD = 0.59) while for females was (M = 3.82, SD = 0.57). T-test analysis shows that there was no significant gender difference in motivation to learn chemistry between male and female students before intervention ($t(117) = 0.410$, $p>0.05$). The two groups were not significantly different at 0.05 alpha level and therefore were suitable for use in the study.

4.2.5.2 SMQ Post-test Results based on gender

Post-test analysis on the SMQ results on the mean, sum and standard deviation are as shown in Table 35.

Table 35

Students' Post-test SMQ Mean Scores based on Gender

Gender of respondents	Mean Score	N	Std. Deviation
Male	4.237	57	.427
Female	4.164	62	.441

SMQ Maximum Score = 5

The results in Table 35 show that the male (4.2374) and female (4.1640) SMQ mean scores out of a maximum score of 5 were similar. A t-test was conducted to investigate whether the two groups were statistically different on SMQ pre-test mean scores based on gender. Table 36 shows the independent sample t-test analysis results for the post-test scores on SMQ.

Table 36

Independent Sample t-test on Post-test Scores based on Gender on SMQ

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	Df	p-value
MTLC	Equal variances assumed	.002	.964	1.302	111	.194(ns)
	Equal variances not assumed			1.305	233.606	.193

ns = not significant at p>0.05 level; SMQ Maximum Score = 5

The t-test results in Table 36 show that there was no statistically significant gender difference in Motivation to learn chemistry at the end of CBCML intervention ($t(111)= 1.302$, $p>0.05$). Thus, $H_0 5$ was accepted.

It was possible to determine the mean gain in motivation for boys and girls in group 1 and 2 because they received both the SMQ pre-test and post-test. Table 37 shows the mean gain for boys and girls on their level of motivation to learn chemistry.

Table 37

Students' Mean Gain in SMQ based on Gender

Gender	N	Pre-test	Post-test	Mean Gain
Male	57	3.86	4.24	**0.38**
Female	62	3.82	4.16	**0.34**
Total	**119**	**3.85**	**4.20**	**0.38**

SMQ Maximum Score = 5

The results in Table 37 shows that the male (0.38) and female (0.34) SMQ mean gain were similar. This implies that both boys and girls benefited from the CBCML approach in terms of motivation to learn chemistry.

4.2.5.3 Discussion

The determination of the effect of gender on motivation when CBCML Teaching Strategy is used to teach chemistry was guided by hypothesis five (H_05). To establish the effect of CBCML on motivation by gender in chemistry, the post-test mean scores of the SMQ were analysed. Data analysis indicates that the difference in SMQ mean scores between the male and the female students were not statistically significant ($t(117) = 0.410$, $p>0.05$). The pre-test mean scores on SMQ for male students was ($M = 3.86$, $SD = 0.59$) while for female students was ($M = 3.82$, $SD = 0.57$). This shows that there was no significant difference in motivation to learn chemistry between boys and girls before intervention.

Post-test results show that the SMQ mean score for male students was 4.24 while that of the female students was 4.16 out of 5. A slight mean gain in the students' level of motivation of 0.38 for boys and 0.34 for girls was recorded. This implies that CBCML boosted the level of motivation to learn chemistry for both boys and girls.

A comparison of the two scores using t-test yielded the statistic, $t(111)= 1.302$, $p>0.05$. Therefore, that there was no gender difference in Motivation to learn chemistry at the end of CBCML intervention. Hypothesis five, (H_05) was therefore accepted.

The findings of this study indicates that there was no significant gender difference in motivation to learn chemistry. Wachanga (2002) argued that teachers treat boys and girls differently and in ways that often are not beneficial to girls' motivation and achievement. Puhan & Hu (2006) in their study also found that motivation is an important predictor of science achievement than gender. Proko, Tuncer and Chuda (2007) also posit that teacher characteristics have a significant role on students' motivation to learn chemistry. This suggests that more research needs to be carried out on the role of teacher characteristics on students' motivation to learn science.

4.2.6 Effects of Gender on Students' Achievement in Chemistry when CBCML is used

The sixth objective of this study sought to determine the effect of gender on students' achievement in Chemistry when CBCML was used during instruction. an analysis of the CAT pre-test and post-test data was carried out for the boys and girls that attempted the items in the questionnaire. This analysis was guided by the sixth hypothesis of the study:

H_06 There is no statistically significant gender difference in Achievement in Chemistry between students exposed to CBCML.

T-test was used to determine the homogeneity of the two groups; that of male students and that of the female students before treatment. The same test was also used to check whether there was any significant difference in students' level of achievement between the two groups after intervention.

4.2.6.1 CAT Pre-test Results based on Gender

To find out whether there were any significant gender differences in the CAT means of the male and female students before treatment, an independent t-test based on gender was necessary. Table 38 shows the t-test results of pre-test mean scores on CAT.

Table 38

Independent Sample t-test of Pre-test Scores on CAT based on Gender

Scale	Group	N	Mean	SD	df	t-value	p-value
CAT	Male	57	0.980	1.570	117	0.471	0.783(ns)
	Female	62	1.060	1.660			

ns = Non-significant Mean Difference at 0.05 alpha level; CAT Maximum Score = 25

Table 38 shows that the pre-test mean scores on CAT for male students was (M =0.98, SD = 1.57) while for females was (M = 1.060, SD = 1.660). The t-test results reveal that the two groups were not significantly different in achievement in chemistry (t (117) = 0.471, p>0.05). The two groups were therefore suitable for use in the study.

4.2.6.2 CAT Post-test Results based on Gender

To determine whether there was any gender difference in achievement between boys and girls exposed to CBCML, the analysis of post-test scores on CAT was done. Table 39 shows the t-test results.

Table 39

Students' Post-test CAT Mean Scores based on Gender

Gender of respondent	Mean	N	Std. Deviation
Male	12.882	56	6.835
Female	12.433	61	7.101

CAT Maximum Score = 25

The results in Table 39 shows that after intervention, the mean for male students went up from 0.98 to 12.88 while that of their female counterparts went up from 1.06 to 12.43. A t-test was conducted to investigate whether the two groups were statistically different on SMQ post-test mean scores based on gender.

A t-test was conducted to investigate whether the CAT means scores for the two groups were different. Table 40 shows the Independent Samples t-test results of Post-test scores based on Gender on CAT.

Table 40

Independent Samples t-test on Post-test Scores based on Gender on CAT

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	p-value
CAT	Equal variances assumed	.358	.550	.496	111	.620(ns)
	Equal variances not assumed			.497	233.789	.619

ns = Non-significant Mean Difference at 0.05 alpha level; CAT Maximum Score = 25

The results in Table 40 show that the computed p-value (0.620) was greater than the set alpha value of 0.05. Therefore, there was no statistically significant difference in the means of the two groups ($t_{(111)} = 0.496$, $P>0.05$). Therefore, H_06 was accepted.

It was possible to determine the mean gain in achievement for boys and girls that received both the pre-test and post-test. These were the respondents from group 1 and 2 of the study. Table 41 shows the mean gain for boys and girls on their achievement in chemistry.

Table 41

Students' Mean Gain in CAT based on Gender

Gender	N	Pre-test	Post-test	Mean Gain
Male	57	0.98	12.88	**11.90**
Female	62	1.06	12.43	**11.37**
Total	**119**	**1.02**	**12.64**	**11.62**

CAT Maximum Score = 25

The results in Table 41 shows that both boys (11.90) and girls (11.37) equally benefited from the CBCML approach with regard to achievement in chemistry. This therefore, means that there was no significant difference in achievement between boys and girls taught through CBCML.

4.2.6.3 Discussion

The determination of the effects gender on achievement when CBCML teaching strategy is used in teaching chemistry was guided by hypothesis six ($H_0 6$) of the study. To find out whether there were any significant gender differences in the CAT means of the male and female students before treatment, an independent t-test based on gender was necessary. The results of this analysis shows that the pre-test mean scores on CAT for male students was (M =0.98, SD = 1.57) while for females was (M = 1.06, SD = 1.66). T-test results show $t(117) = 0.471$, $p>0.05$. This shows that there was no significant difference in achievement in chemistry between male and female students before intervention. The groups were therefore suitable for use in the study.

To determine whether there was any gender difference in achievement between boys and girls exposed to CBCML, the analysis of CAT post-test scores was done. The results show that after intervention, the mean for male students went up from 0.98 to 12.88 while that of their female counterparts went up from 1.06 to 12.43. This implies that CBCML teaching strategy had a positive effect on the chemistry achievement for both boys and girls.

T-test analysis results on the CAT mean scores indicates that there was no significant difference in the means of the two groups ($t_{(111)} = 0.496$, $p>0.05$). This therefore, means that both boys and girls achieved equally in chemistry when taught through CBCML. Therefore, $H_0 6$ was accepted.

The non-significant difference between the male and female students' academic achievement in Chemistry could be due to the free interaction between male and female students in the county co-educational secondary schools used in the study. It may also be because both male and female students have equal perception of what success is all about. In other words, the female students did not feel inferior to their male counterparts and thus they were able to compete favourably with them. It appeared that the male students did not also feel superior to their female counterparts. This implies that both had a level playing ground hence, no gender differences occurred in their achievement.

The CBCML teaching strategy used in this study stressed on achievement through stepwise mastery of content, corrective feedback, remediation as well as cooperative skills. The results showed that CBCML is superior to CTM in terms of motivating the learners towards achieving higher scores in the subject. The cooperative activities and computer technology supplement, but do not replace, direct instruction. However, they involve individual accountability because group success depends on members' contribution to a team task. This study was done with these issues in mind and the results show that use of CBCML leads to better students' achievement than the CTM.

Positive interdependence is critical to successful application of the CBCML teaching strategy. It benefits both the weak and bright students because group memberships and interpersonal interaction are not, in themselves, sufficient to produce higher achievement and productivity. Weak students benefit from interaction with brighter students and when bright students explain their ideas to others, they learn the material they are explaining in more depth and remember it longer (Wachanga, 2002). In a cooperative group, bright students are also seen as resources and are valued by group members. The CBCML approach exhibited these qualities hence higher achievement was reported in the study.

Studies carried out by International Evaluation of Educational Achievement (IEA) from a cross cultural survey revealed that sex differences have been found in every subject area in the written test, and that boys outperformed girls in Biology, Chemistry and Physics at all levels (Amunga et al., 2011). The outcome of Wachanga (2002) investigation on the effect of cooperative class experiment (CCE) on the achievement of boys and girls in chemistry agrees with the findings of this study. It showed that there was no significant difference between the achievement of boys and girls who were taught chemistry through CCE methods.

Oludipe (2012) carried out a study to investigate the influence of gender on junior secondary school students' academic achievement in basic sciences using cooperative learning-teaching strategy. His findings revealed that there was no significant difference in academic achievement of male and female students. A study carried out by Olatoye, Aderogba and Aanu (2011) in Ogun State, Nigeria, on the effect of cooperative and individualized teaching methods on senior secondary school students' achievement in organic chemistry showed no significant difference between the achievement of boys and girls. Nonetheless the findings of this study have indicated that boys and girls exposed to science process skills teaching approach show significant difference in chemistry achievement.

Muhammad (2014) conducted study on evaluation of the efficacy of conceptual instructional method of teaching practical chemistry. The findings from the study include the following:

Academic Achievement of subjects exposed to conceptual instructional method was significantly higher than their counterparts exposed to lecture method of instruction. With reference to gender, there was no significant difference between male and female students' academic achievement in the experimental group. Muhammad's work is related to the present study because both of them are aimed at using practical chemistry activities to find out the effect of gender.

Ezeudu and Obi (2013) investigated the effects of gender and school location on students' achievement in chemistry in Nsukka Local Government Area of Enugu State, Nigeria. The findings showed that male students achieved significant difference.

Adonu (2006) researched on the development and preliminary validation of an instrument for assessment of psychomotor skills in physics in senior secondary schools in old Nsukka and Obollo Afor education zones. The instrument for data collection was Instrument for Assessment of Psychomotor skills in Physics (IAPSP). However, significant difference existed in the gender performance of the students in favour of the males

The results also show that CBCML is beneficial to both boys and girls. If secondary school Chemistry teachers appreciate and incorporate the use of this method, they might be able to overcome the challenge of general decline in performance, dismal performance and gender disparity in achievement in KCSE examinations which has triggered a lot of concerns among educationists and other stakeholders. CBCML assumes that virtually all students can learn what is taught in school if their instruction is approached systematically and students are helped when and where they have learning difficulties (Bloom, 1984). The most important feature of CBCML is that, it accommodates the natural diversity of ability with any group of students. Moreover, individualized learning also helps learners to learn at their own pace. With careful preparation and greater flexibility all students can be appropriately accommodated according to their respective levels of understanding and they can progress at their own rate (Kibler, Cegala, Watson, Barkel & David 1981).

Several researchers like Nagarathanamma and Rao (2007) and Kaushik and Rani (2005) found no significant difference between boys and girls with regard to achievement level. In summary, research on gender differences in achievement for males and females has resulted in inconsistent findings. Some researchers such as Ligon (2006) found no significant difference, whereas others such as Vermeer, Boekaerts, & Seegers (2000) found significant differences.

In the present study the results indicate that there was no significant difference in achievement between boys and girls exposed to CBCML but both performed significantly better than those taught through CTM. The Forum for African Women Educationists (FAWE) (1998) indicates that science achievement for girls in Kenya was lower than for boys partly due to their poor attitudes towards science and discouragement by their teachers. Some teachers assumed, for instance, that girls could not answer certain questions or perform certain tasks in science and mathematics. They made remarks that indicated their biased beliefs or feelings that girls were unintelligent and lazy while using positive reinforcement more on boys than on girls (FAWE, 1997).

The CBCML Teaching Strategy helped chemistry teachers to balance classroom interaction between boys and girls enabling them to give similar attention to both sexes, which led to improved achievement by both. This teaching approach could therefore be used to reduce gender disparity in achievement in KCSE chemistry examination.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The purpose of this study was to investigate the effect of using CBCML approach on students' Skills Acquisition, Motivation and Achievement in Chemistry. This chapter presents a summary of the major findings of the study based on the results of the analysis guided by the six hypotheses of the study. Conclusions are highlighted based on the findings and generalized to Form Three Chemistry students in County Co-educational Secondary Schools in Bomet County, Kenya. Implications of the findings of the study are also discussed. The last part of this chapter gives the recommendations to chemistry educators and all the stakeholders on how chemistry teaching can be structured to ensure effective and efficient meaningful learning by all students irrespective of their gender through active interaction and construction of new knowledge structures as opined by proponents of constructivism. Suggestions for further research have also been outlined.

5.2 Summary of the Major Findings of the Study

The following are the major findings of the study:

(i) The results of the study show that there was a statistically significant difference in Skills Acquisition in Chemistry between students exposed to CBCML and those not exposed to it. CBCML had a positive significant effect on students' Skills Acquisition. The findings of this study contradicts the current situation of students' performance in Chemistry practical where boys have continued to outshine their female counterparts in KCSE Examinations.

(ii) The results of the study show that CBCML as a teaching strategy had a positive significant effect on students' level of Motivation to Learn Chemistry (MTLC). Students taught through CBCML felt more motivated than those not exposed to it.

(iii) The results of the study show that the use of CBCML teaching strategy had a greater positive significant effect on students' level of achievement compared to those not exposed to it. The mean achievement of students in the Experimental Groups was higher than those in the Control Groups.

(iv) Results of the study show that gender does not affect Skills Acquisition when students are taught through CBCML. The use of CBCML enhanced Skills Acquisition equally for both boys and girls in the Experimental Groups.

(v) The results of the study show that there was no significant gender difference in Motivation to Learn Chemistry (MTLC) when students are taught through CBCML. Both boys and girls felt more motivated after learning Chemistry through CBCML.

(vi) The results of the study show that there was no significant gender difference in Achievement in Chemistry between boys and girls taught through CBCML. The use of CBCML enhanced the academic achievement equally for both boys and girls.

5.3 Conclusions

Based on the findings of the study, the following conclusions were reached:

(i) The use of CBCML approach in teaching Chemistry enhances students' Skills Acquisition more than the CTM.

(ii) Teaching Chemistry through CBCML approach boosts students' level of Motivation better than when CTM.

(iii) Teaching Chemistry through CBCML approach enhances students' Achievement in the subject more than the CTM is used.

(iv) Gender does not affect students' Skills Acquisition in Chemistry when they are taught through CBCML approach.

(v) Gender does not affect students' Motivation to learn Chemistry when they are taught through CBCML approach.

(vi) Gender does not affect students' Achievement in Chemistry when they are taught through CBCML approach.

Students taught through CBCML obtained higher scores than those taught through CTM in all the three domains of leaning investigated. This implies that the use of CBCML approach in teaching would be suitable for enhancing students' Skills Acquisition, Motivation and Achievement in Chemistry. Moreover, the performance of girls in the Experimental Groups in the subject was similar to that of boys. This implies that CBCML would be appropriate for minimizing the perennial gender disparities in performance in Chemistry and other science subjects.

5.4 Implications of the Study

The findings of this study indicate that the use of CBCML approach in the teaching and learning of Chemistry in secondary schools results in higher students' Skills Acquisition, Motivation to learn and Achievement in the subject. When this approach is used, the students' gender does not affect their Skills Acquisition, Motivation and Achievement in Chemistry. This would, therefore, imply that its incorporation in teaching would enhance the teaching and learning of Chemistry in secondary schools for all the students irrespective of their gender. This in turn would improve achievement in Chemistry for both boys and girls in KCSE examinations which has been low over the years. Moreover, CBCML approach could also help is closing the gender gap in Chemistry achievement.

The findings of this study have some practical implications to Chemistry education as well as Science education in general. First, chemistry teachers should be sensitized not only to focus on the cognitive aspects of the subject, but they should also be equally concerned with the psychomotor domain as well as the affective domain. CBCML as a teaching strategy has the potential to meet the psychomotor, cognitive as well as affective characteristics of learners. The approach engages students in constructing and altering their knowledge structures together with others and with the help of computer technology leading to better understanding of chemistry concepts and principles. In this study CBCML was found to be beneficial to all students in chemistry irrespective of their gender.

Educationists and designers of technology-based learning programmes should emphasize the use of CBCML in Chemistry lessons and possibly other science subjects in their effort to boost students' Skills Acquisition and Motivation. Consequently, achievement in Chemistry will improve. Teacher training institutions such as universities and colleges should also incorporate the CBML concepts in their training curriculum in order to empower teachers to use the new approach.

There is considerable evidence that CBCML promotes meaningful learning in science. To promote meaningful learning, instructional activities must enhance learners' abilities to actively construct meaning out of what is being taught. This observation underlies the constructivist perspective on learning, that is, learning is an active process in which the learner is constantly creating and revising his or her internal representation of knowledge (Duffy & Jonassen, 1992). Thus chemistry teachers need to give more attention to the use of CBCML approach to promote active and meaningful learning in Chemistry lessons. The strategy is expected to help all students make psychomotor, cognitive and affective improvements in Chemistry learning.

5.5 Recommendations

The findings of this study show that the use of CBCML in the teaching of chemistry improved the students' competence in handling practical work, motivation and achievement in chemistry. Based on these findings recommendations were made on the improvement of Skills Acquisition, Achievement and Motivation in Chemistry as well as suggestions for further research.

5.5.1 Recommendations for Improvement of Chemistry Education

Based on the findings and conclusions made in this study, it is recommended that:

(i) Chemistry teachers could use CBCML in their teaching to enhance students' Skills Acquisition, Motivation and Achievement in the subject.

(ii) The use of CBCML enhanced Skills Acquisition, Motivation and Achievement in Chemistry equally for both boys and girls. As such it could be useful closing the persistent gender gap that has for a long time denied girls the opportunity to pursue science based courses in institutions of higher learning.

(iii) Teacher Training Colleges and Universities could make CBCML part of their training curriculum in the teacher education programmes they offer.

(iv) The Kenya Institute of Curriculum Development (KICD) could include CBCML as one of the innovative teaching methods in the Chemistry curriculum.

(v) Regular in-service training in workshops, seminars and SMASSE Programme could include CBCML in the training of Mathematics and Science teachers.

(vi) Teachers should also ensure that they create opportunities for students to share ideas through interaction with others in group tasks using computer technology or manipulation of apparatus. Such activities will engage them effectively in the lesson.

5.5.2 Suggestions for Further Research

The researcher identified some areas, which requires further investigation in order to gain more insight into the effect CBCML as a teaching approach on Skills Acquisition, Motivation and Achievement.

(i) A study on the effects of CBCML on Skills Acquisition, Motivation and Achievement in other science subjects; Biology and Physics should be carried out.
(ii) This study focused on the effects of CBCML on Skills Acquisition, Motivation and Achievement in Volumetric Analysis among form three students. Similar studies could be conducted in the rest of the form three topics prescribed in the syllabus. Similarly, it can be done in other grades.
(iii) This study was limited to County Co-educational Secondary Schools and Bomet County. Further research could be done in other categories of schools such as sub-county schools and national schools. In addition, similar studies could be done in other counties that were not part of the study.
(iv) There is need to determine the amount of time needed to reap maximum benefits from the use of CBCML as a teaching approach in Chemistry learning.
(v) There is need for a comparative study on students' attitude and self-concept on teaching Chemistry and other science subjects through CBCML approach versus those taught through CTM.
(vi) A study on the teachers' attitude towards the use of CBCML in teaching Chemistry could be carried out.
(vii) Further research should be directed to the determination of the students' perception of the classroom environment when they are taught Chemistry through CBCML.

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APPENDICES

APPENDIX A: Chemistry Practical Skills Acquisition Test (CPSAT)

SCHOOL: ....GENDER: M F **AGE:** **KCPE MARK:**

You are provided with:

- Solution E, dilute sulphuric (VI) acid
- Solution G, a 0.5M solution of sodium hydroxide.
- Phenolpthalein indicator.

You are required to: standardize solution E

Procedure

- Fill the burette with solution E.
- Pipette $25cm^3$ of solution G into a conical flask.
- Titrate E against G using Phenolpthalein indicator.
- Repeat procedure two more times and tabulate the results in table (I) below.

Table 1

	I	II	III
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of E used (cm^3)			

(3 mks)

a) Calculate the average volume of E used. (1 mk)

b) Calculate: -

i) the number of moles of solution G used. (1 mk)

ii) the number of moles of solution E used. (2 mks)

iii) the concentration of solution E in moles per litre. (2 mks)

iii) the concentration of solution E in grams per litre. (1mk)

Chemistry Practical Skills Acquisition Test (CPSAT)

MARKING GUIDE

Table 1

	I	II	III
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of E used (cm^3)			

(3 mks)

Complete Table = 1 or 0, or Uniform Decimal= 1 or 0 Correct Arithmetic = 1 or 0

a) Calculate the average volume of E used. (1 mk)

Principal of Averaging = 1 or 0

b) Calculate: -

i) the number of moles of solution G used. (1 mk)

Final answer= 1or 0

ii) the number of moles of solution E used. (2 mks)

Step 1 = 1 or 0

Step 2 = 1 or 0

iii) the concentration of solution E in moles per litre. (2 mks)

Step 1 = 1 or 0

Step 2 = 1 or 0

iv) the concentration of solution E in grams per litre. (1mk)

1 or 0

APPENDIX B: Student Motivation Questionnaire (SMQ)

Instructions

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

SECTION I

Demographic Data

1. Sex. Male ☐ Female ☐

2. Age (years) ☐

3. K.C.P.E Mark ☐

SECTION II

Personal Opinion on the Learning of Chemistry

For the following section, please indicate the extent to which you agree with the statement in each of the following questions. Indicate whether you Strongly Agree, Agree, Uncertain, Disagree or Strongly Disagree by CIRCLING the letters that best describe your level of agreement.

For example: Learning chemistry is:

Fun SD D U (A) SA

KEY

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

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

19.	I feel pretty skilled in chemistry activities	SD	D	U	A	SA
20.	I find learning chemistry to be very interesting	SD	D	U	A	SA
21.	I feel pressured while learning chemistry	SD	D	U	A	SA
22.	I always look forward to chemistry lessons	SD	D	U	A	SA
23.	I feel like I have to learn chemistry	SD	D	U	A	SA
24.	I can describe chemistry lessons as very enjoyable	SD	D	U	A	SA
25.	I believe I have a choice in learning chemistry	SD	D	U	A	SA
26.	Having learnt chemistry for a while, I feel pretty competent	SD	D	U	A	SA

APPENDIX C: Chemistry Achievement Test (CAT)

SCHOOL: .... GENDER: M F **AGE:** **KCPE MARK:**

Instructions

Attempt all the questions in the spaces provided.

1. Calculate the number of moles of sodium carbonate present in $100cm^3$ of 2M Na_2CO_3 solution. (Na=23, C=12, O=16) (2mks)

2. Calculate the mass of sulphuric (VI) acid in $250cm^3$ of a solution whose concentration is 0.25mole dm^{-3} (S=32, H=1, O=16) (3mks)

3. When 34.8 grams of potassium sulphate (K_2SO_4) is dissolved in $400cm^3$ distilled water and the solution made to $500cm^3$. Calculate:

a) The concentration of potassium sulphate in g/litre. (2mks)

b) The concentration of the solution in moles per litre (2mks)

4. In a class of 25 students, each student requires $120cm^3$ of 0.2M potassium hydroxide solution for a titration experiment. Calculate:

a) the total volume of potassium hydroxide required for the class. (K=39, O=16, H=1) (2mks)

b) the total mass of potassium hydroxide required to prepare the total volume of solution for the class (2mks)

5. $250cm^3$ of a 2M sodium hydroxide solution is diluted to $2000cm^3$. Calculate the new concentration. (2mks)

6. Calculate the volume of water that is to be added to $20cm^3$ of 12.4M hydrochloric acid, HCl solution to make 2M solution. (2mks)

7. If $25cm^3$ of 0.1M Na_2CO_3 solution neutralised a solution containing 2.5g sulphuric (VI) acid, H_2SO_4, in $250cm^3$ of solution:

a) Calculate the molarity of sulphuric (VI) acid (3mks)

b) Write the equation for the reaction from this information (1mk)

8. $25.0cm^3$ of 0.2M solution of hydrochloric acid required $12.5cm^3$ of sodium hydroxide solution for complete neutralisation. Calculate the concentration of sodium hydroxide in:

a) moles per litre (2mks)

b) grams per litre (2mks)

Chemistry Achievement Test (CAT) -

DICHOTOMOUS SCORING GUIDE

Instructions
Attempt all the questions in the spaces provided.

1. Calculate the number of moles of sodium carbonate present in $100cm^3$ of 2M Na_2CO_3 solution. (Na=23, C=12, O=16) (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

2. Calculate the mass of sulphuric (VI) acid in $250cm^3$ of a solution whose concentration is 0.25mole dm^{-3} (S=32, H=1, O=16) (3mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**
- **Step 3 = 1 or 0 mark**

3. When 34.8 grams of potassium sulphate (K_2SO_4) is dissolved in $400cm^3$ distilled water and the solution made to $500cm^3$. Calculate:

c) The concentration of potassium sulphate in g/litre. (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

d) The concentration of the solution in moles per litre (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

4. In a class of 25 students, each student requires $120cm^3$ of 0.2M potassium hydroxide solution for a titration experiment. Calculate:

c) the total volume of potassium hydroxide required for the class. (K=39, O=16, H=1) (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

d) the total mass of potassium hydroxide required to prepare the total volume of solution for the class (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

5. 250cm^3 of a 2M sodium hydroxide solution is diluted to 2000cm^3. Calculate the new concentration. (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

6. Calculate the volume of water that is to be added to 20cm^3 of 12.4M hydrochloric acid, HCl solution to make 2M solution. (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

7. If 25cm^3 of 0.1M Na_2CO_3 solution neutralised a solution containing 2.5g sulphuric (VI) acid, H_2SO_4, in 250cm^3 of solution:

c) Calculate the molarity of sulphuric (VI) acid (3mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**
- **Step 3 = 1 or 0 mark**

d) Write the equation for the reaction from this information (1mk)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

8. 25.0cm^3 of 0.2M solution of hydrochloric acid required 12.5cm^3 of sodium hydroxide solution for complete neutralisation. Calculate the concentration of sodium hydroxide in:

c) moles per litre (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

d) grams per litre (2mks)

- **Step 1 = 1 or 0 mark**
- **Step 2 = 1 or 0 mark**

APPENDIX D: Chemistry Practical Teachers' Manual (CPTM)

Teachers guide to planning and implementing Computer Based Cooperative Mastery Learning (CBCML).

Introduction

This guide is intended to assist the chemistry teachers to plan and implement a teaching-learning program based CBCML Model in which the students will be taught in small groups of mixed ability. The instructional materials to be used in the study will be based on the K.I.E approved syllabus (KNEC, 2002). This manual will be used throughout the treatment period together with the Form three e-learning DVD developed by Kenya Institute of Curriculum Development (KICD) formerly KIE.

The subject matter to be learned will be divided into small units. Instructional objectives will be developed for each unit and at the end of the unit the learners will be tested to determine if they have acquired a pre-determined mastery level with the help of the e-learning DVD. However, those who will not have acquired the desired competence will be provided with extra tuition until they perform at or above the desired level.

The guide will be organised into the following sections:

1.0 Guide on Volumetric Analysis

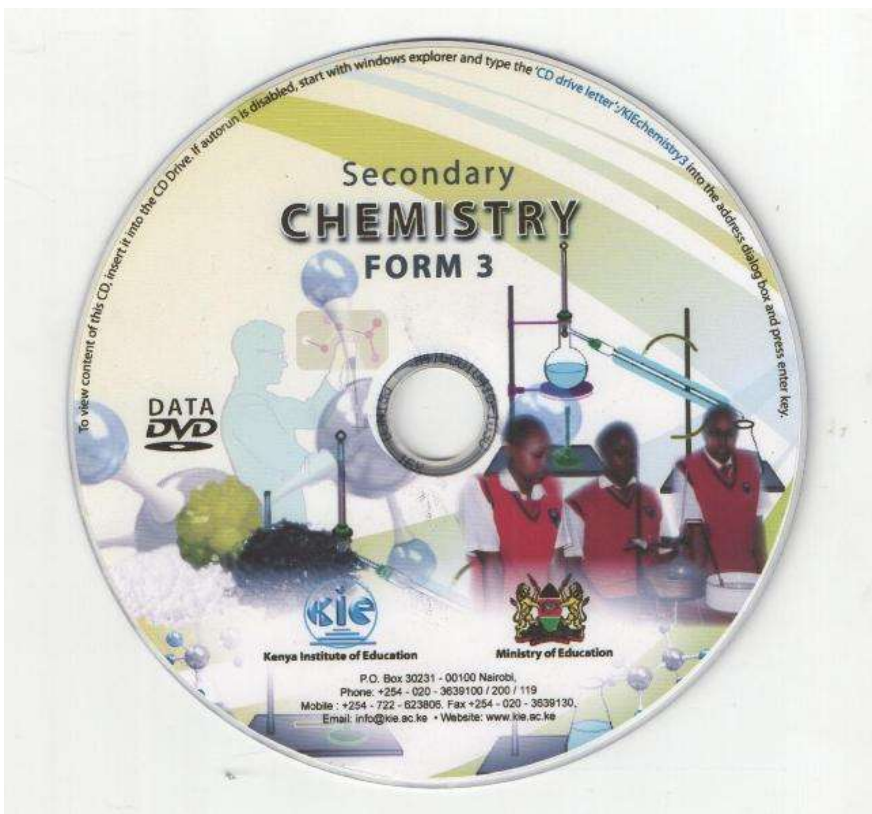
In this study, the sub-topic: Molar solutions (volumetric analysis) with reference to the CBCML which recommends that the content should be divided into small units of study, the topic will be subdivided basing on the objectives as follows:

- Preparing molar solutions
- Dilution
- Acid-base Titration 1 mole ratio 1:1
- Acid-base Titration 2 mole ratio 1:2
- Redox titration
- Back titration
- Titration involving formation of precipitates
- Thermo-titration

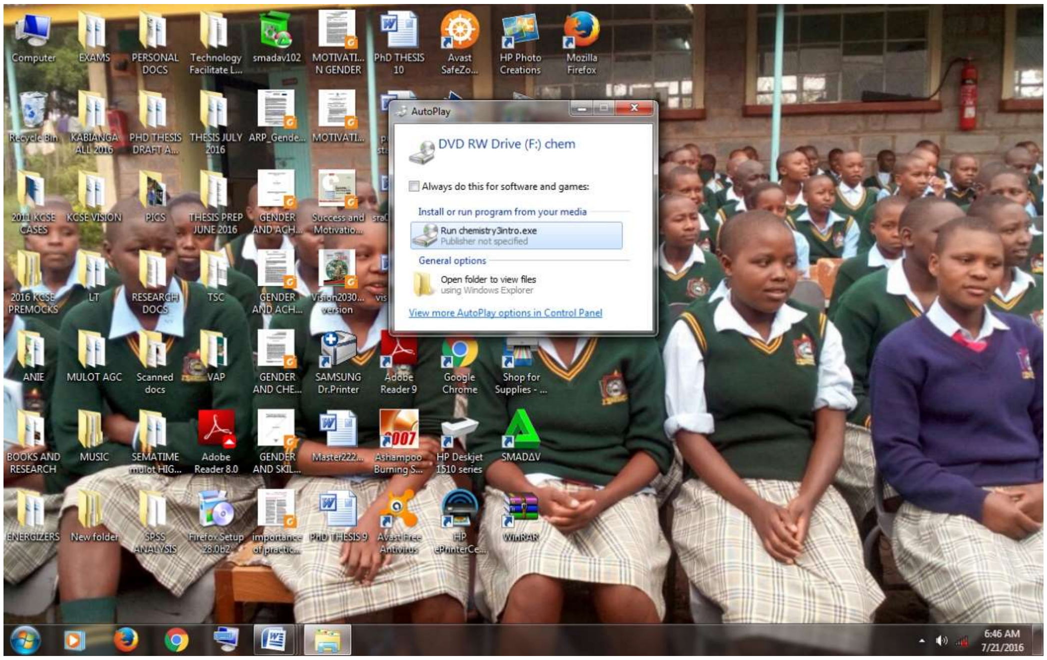
Each of these units will have its own objective and will be clearly stated in the scheme of work (Appendix E). Sample questions will be given to the learners after every unit in the form of assignments. This will assist learners in carrying out a self-check assessment on whether they have understood the concepts covered in the topic or sub-topic. The e-learning material will be provided to the learner for them to interact with it and learn in groups. Moreover, it will give learners an overview of the test items they are likely to find in the formative tests to be given as well as the summative test to be administered at the end of the topic. Four formative tests will be administered on a weekly basis namely; Mastery Quiz 1, 2, 3, 4 and 5 covering each of the small units covered per week. The results of the scores by the chemistry students in these formative tests will guide the teacher in planning for remedial lessons for those who do not attain the required pass mark.

CBCML TUTORIAL

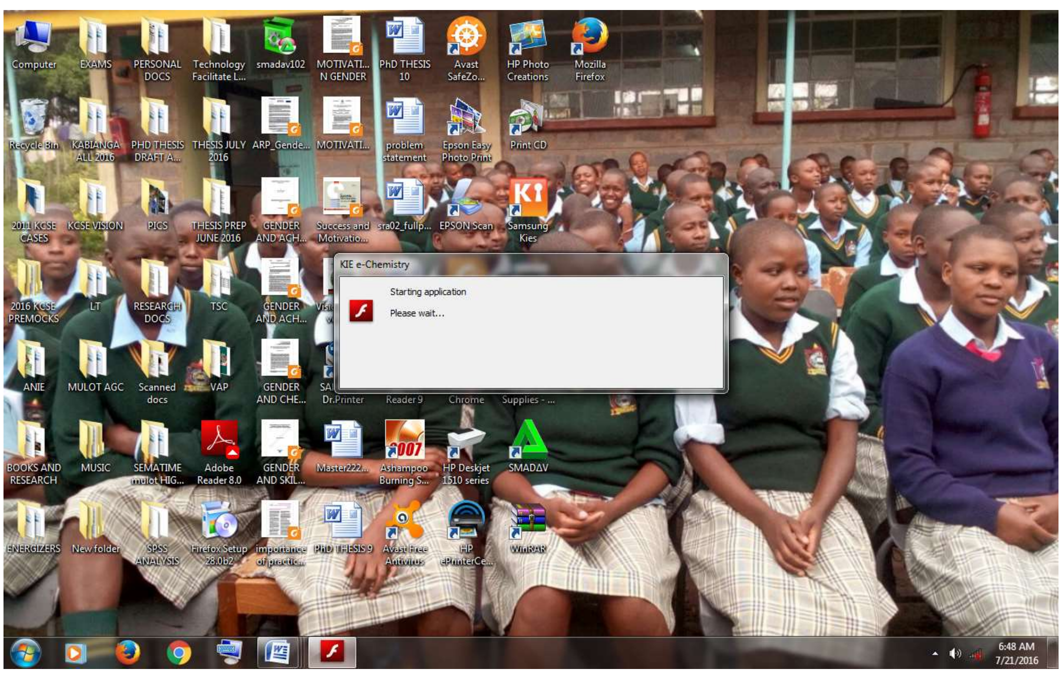
- Power on your computer
- Insert the data DVD in the DVD drive and allow it to run



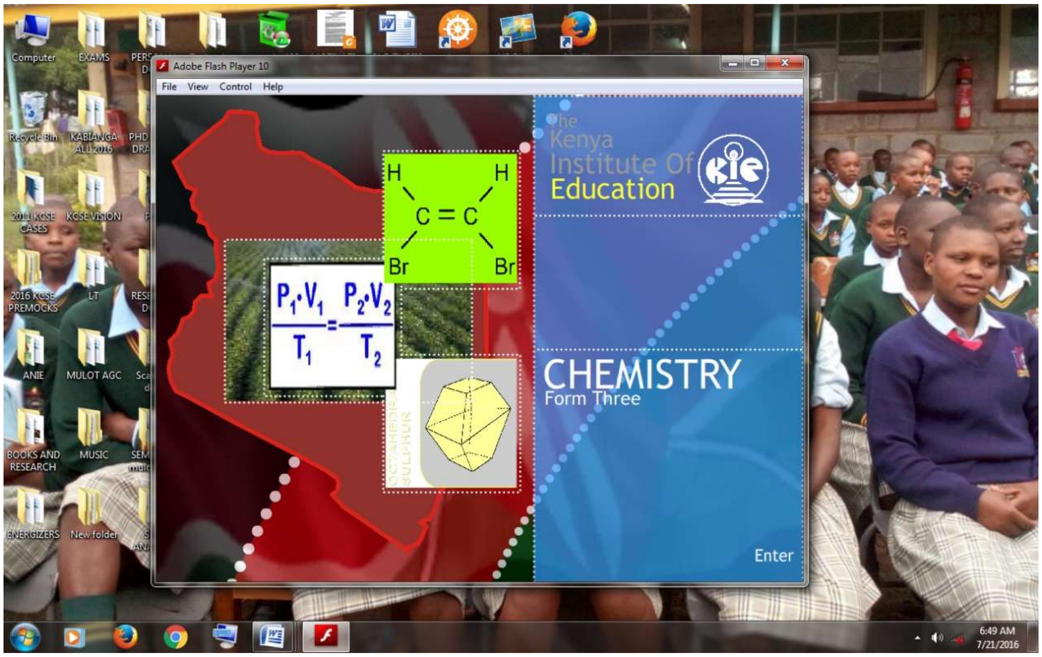
- An “**auto play”** dialog box will appear on the screen



- Click the “Run chemistry3intro.exe” icon on the dialog box that appears. The command “starting application”, “please wait” will appear on the screen.

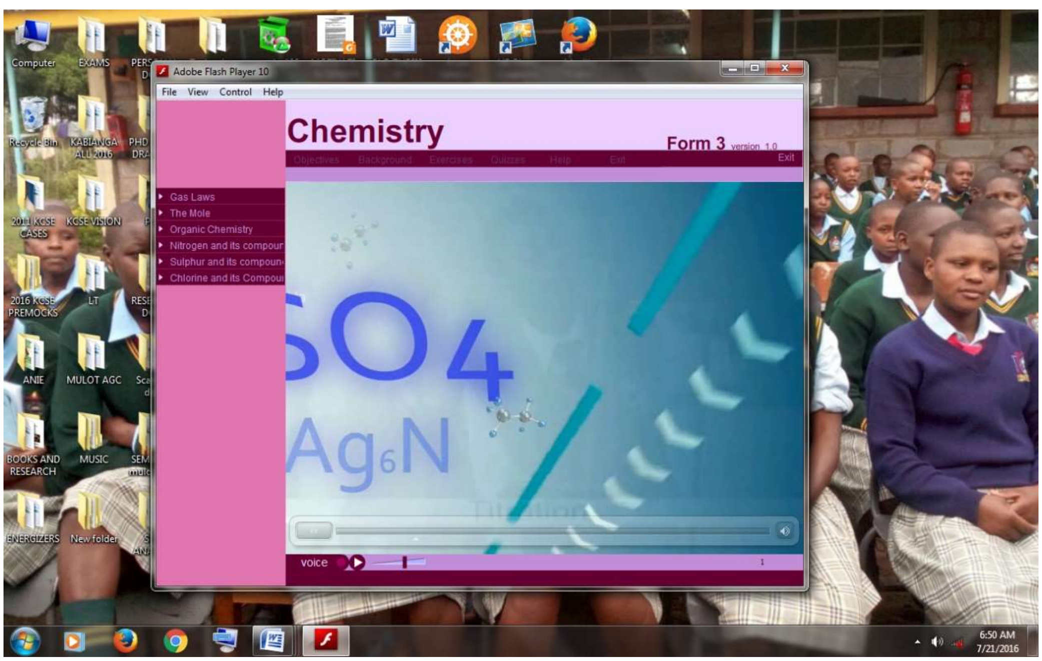


- In a few seconds an automated auto play of the introduction will run

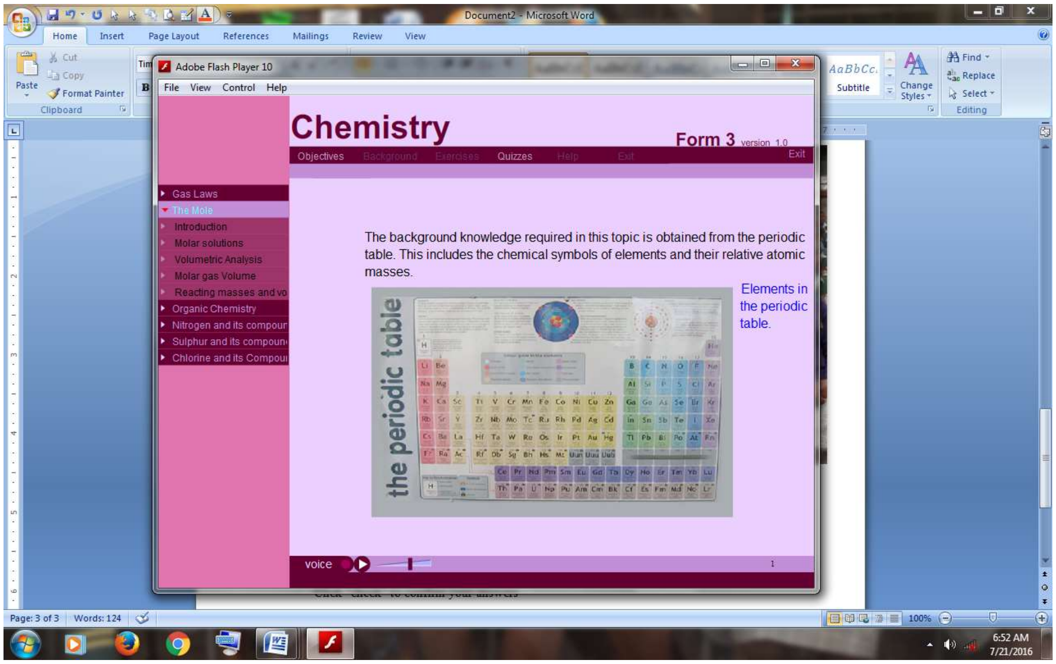


- Skip the introduction and click “**Enter**” to display the form 3 topics in the DVD

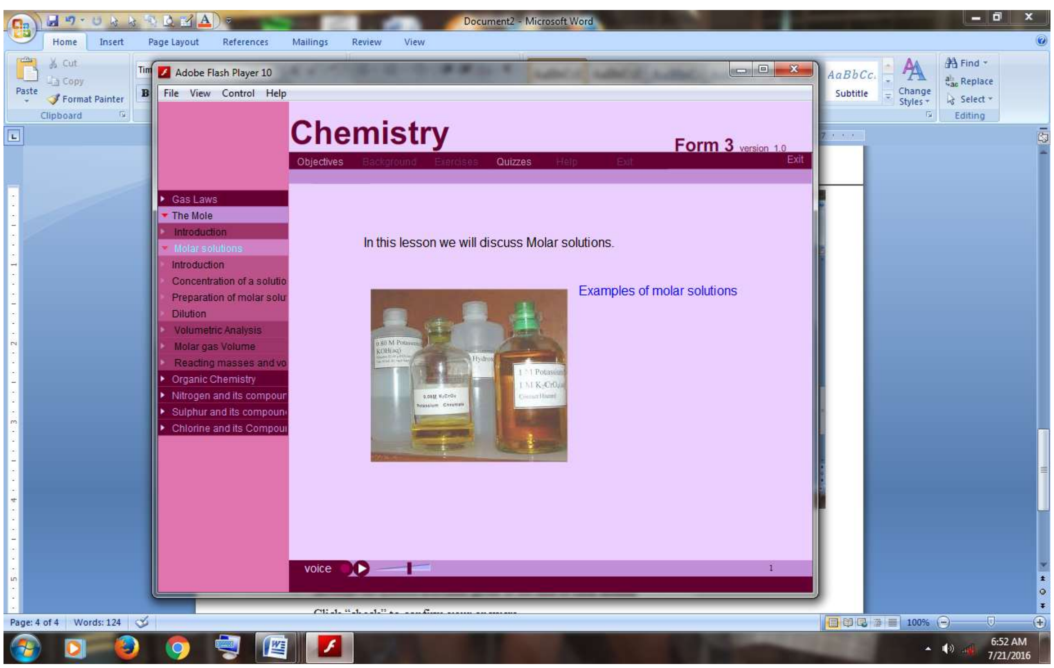
All the Form 3 Topics as per the Syllabus will appear as follows:



- Select the topic of study “**The Mole**” which is second in the list
- Lesson topics will appear on the screen



- Select “**Molar Solutions**”



- Preview the objectives of each unit and the background information. The units in this sub-topic includes:

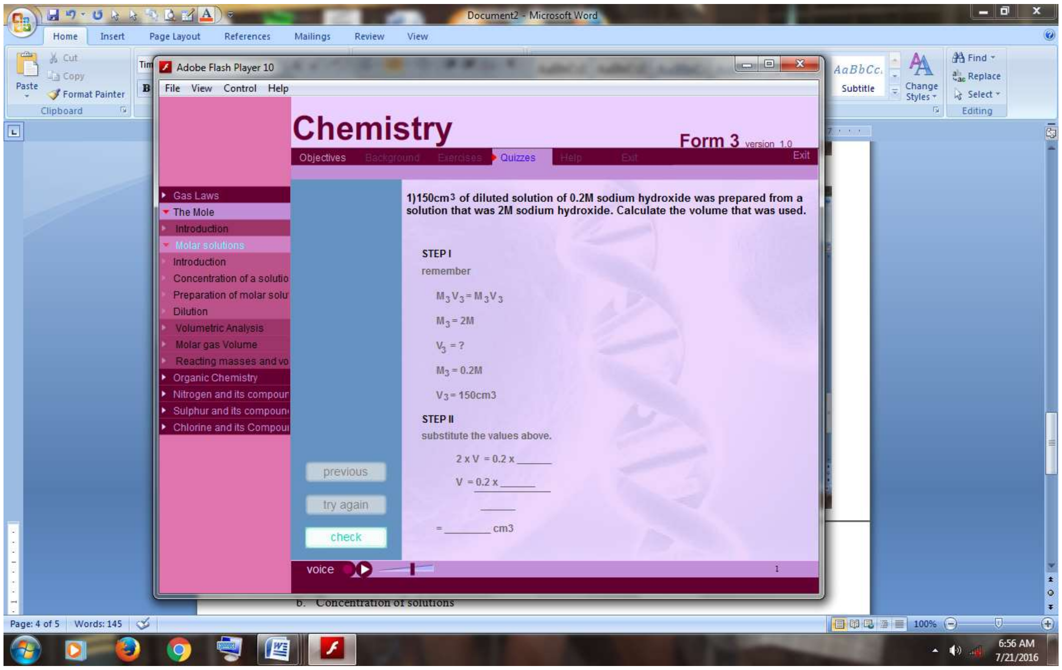
a. Introduction

b. Concentration of solutions

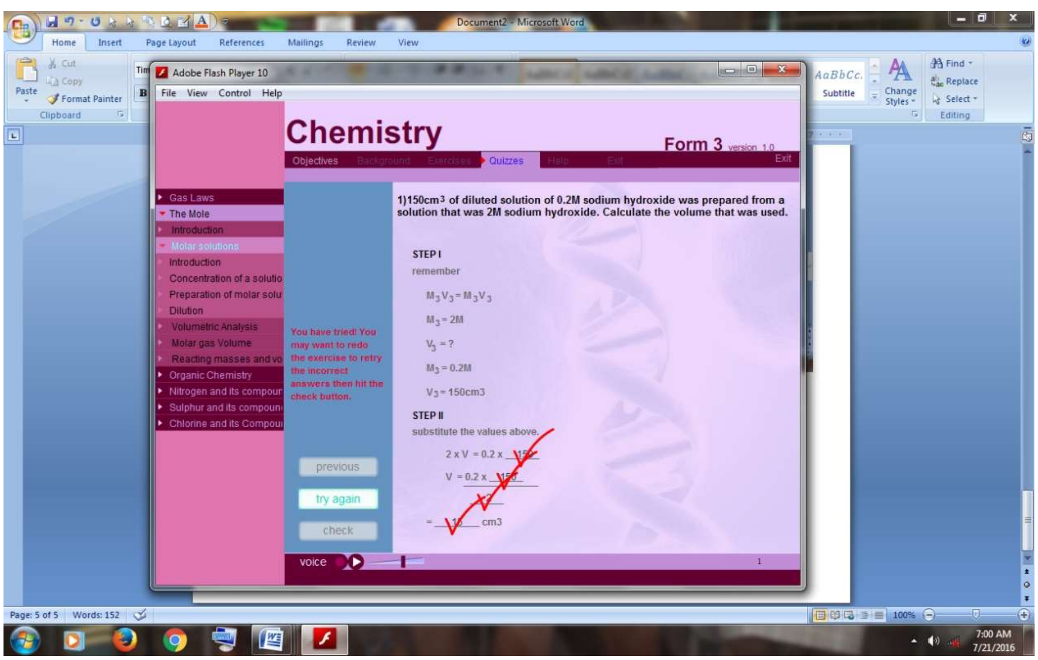
c. Preparation of molar solutions and

d. Dilution

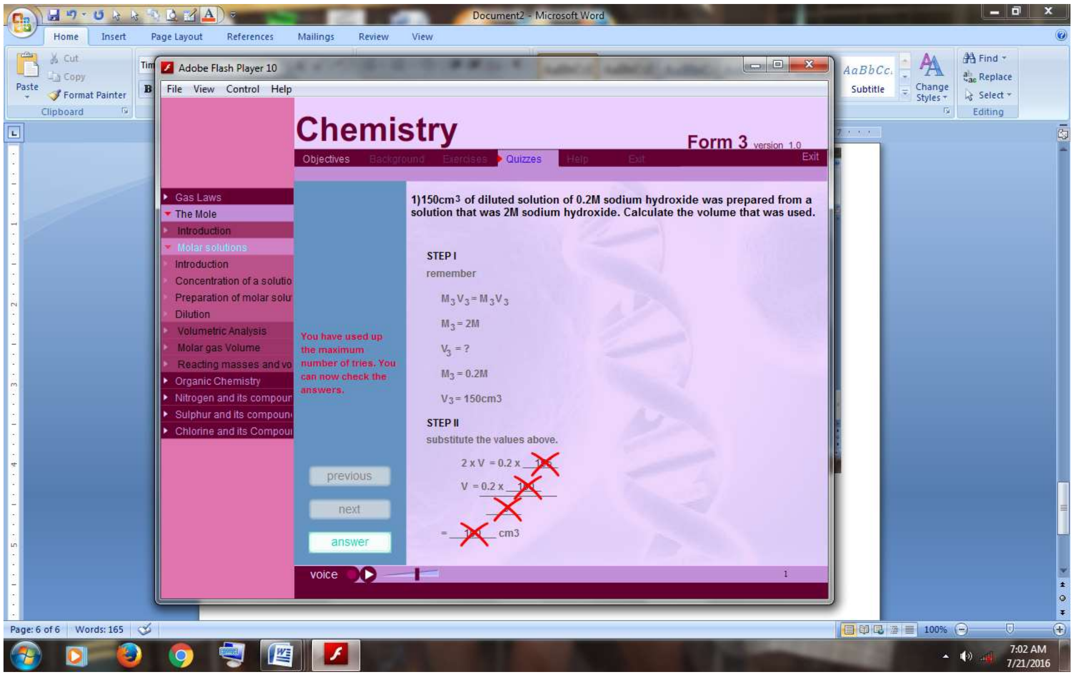
- Attempt the quizzes or activities given at the end of each section, for example:



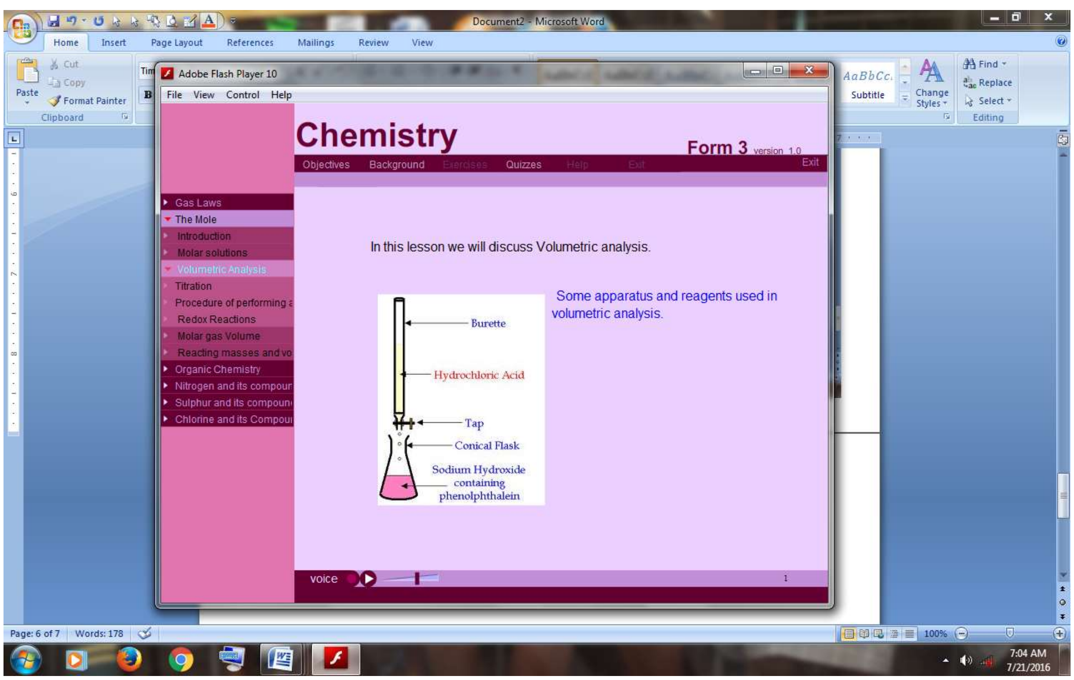
- Click "check" to confirm your answers
- If your answer is correct the automated response will appear as follows



If your answer is **wrong** then the automated response will be as follows:



- Select molar "**Volumetric Analysis**"

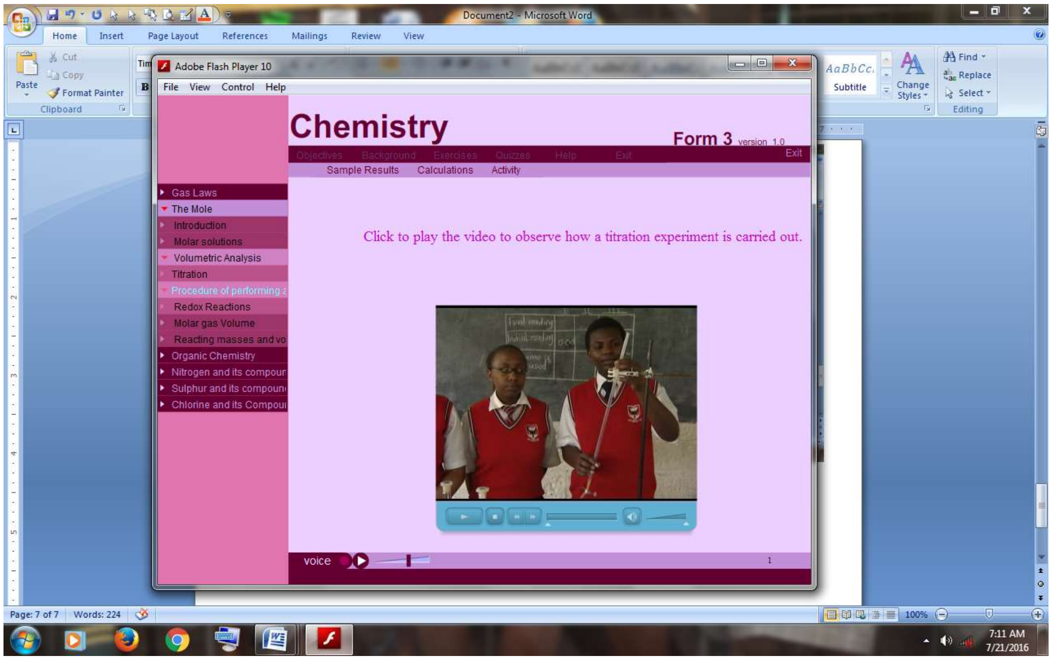


- In this section the following sub-units will be covered:

a. Introduction to titration; apparatus used, indicators and colour changes

b. Procedure for performing acid-base titrations

This is in a form of a video demonstrating the titration procedure; manipulation of apparatus and recording of results, calculations and activities.

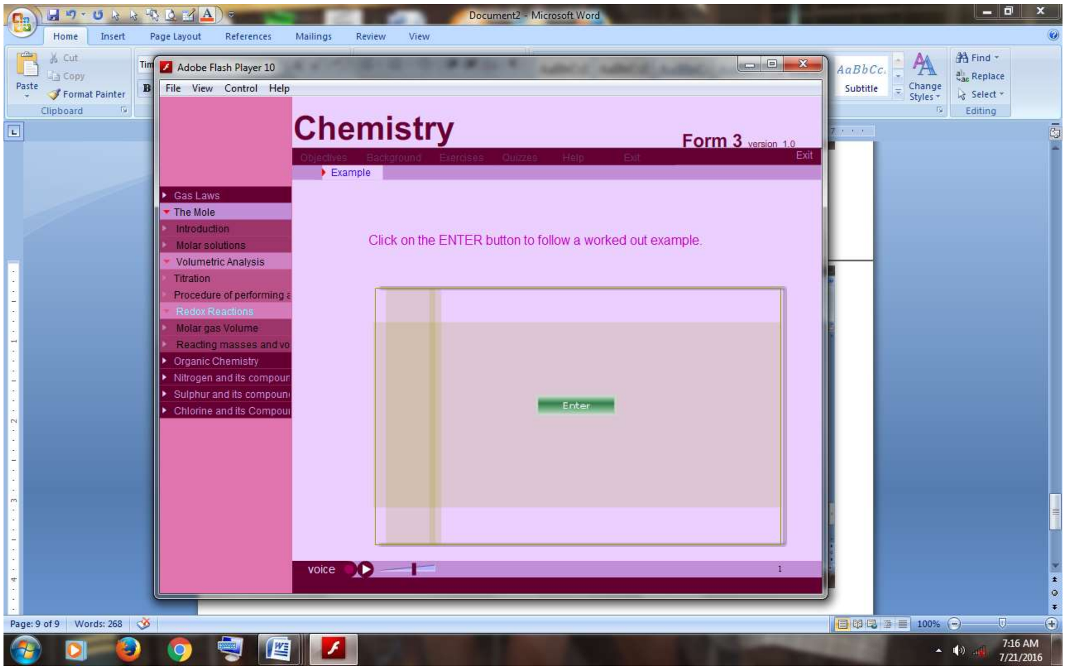


c. Back titration

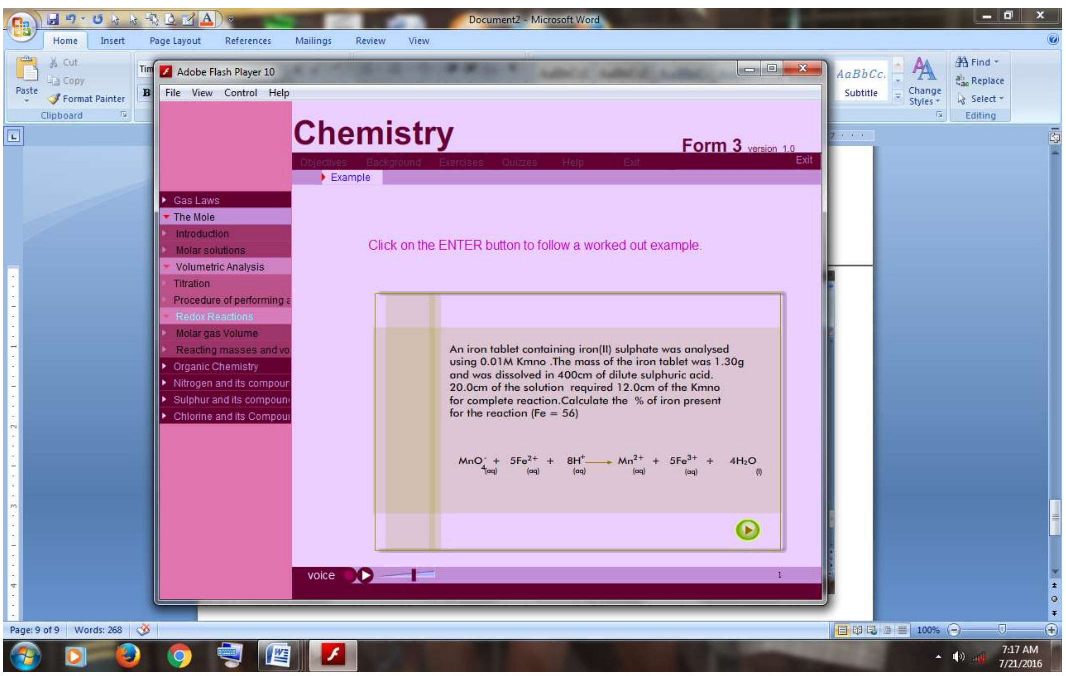
d. Redox titration

- In each of these sub-unit lesson objectives, background information and self-check Quizzes will be covered.

- Worked examples are also available to help learners in understanding how to solve mathematical problems based on the results obtained. For example:

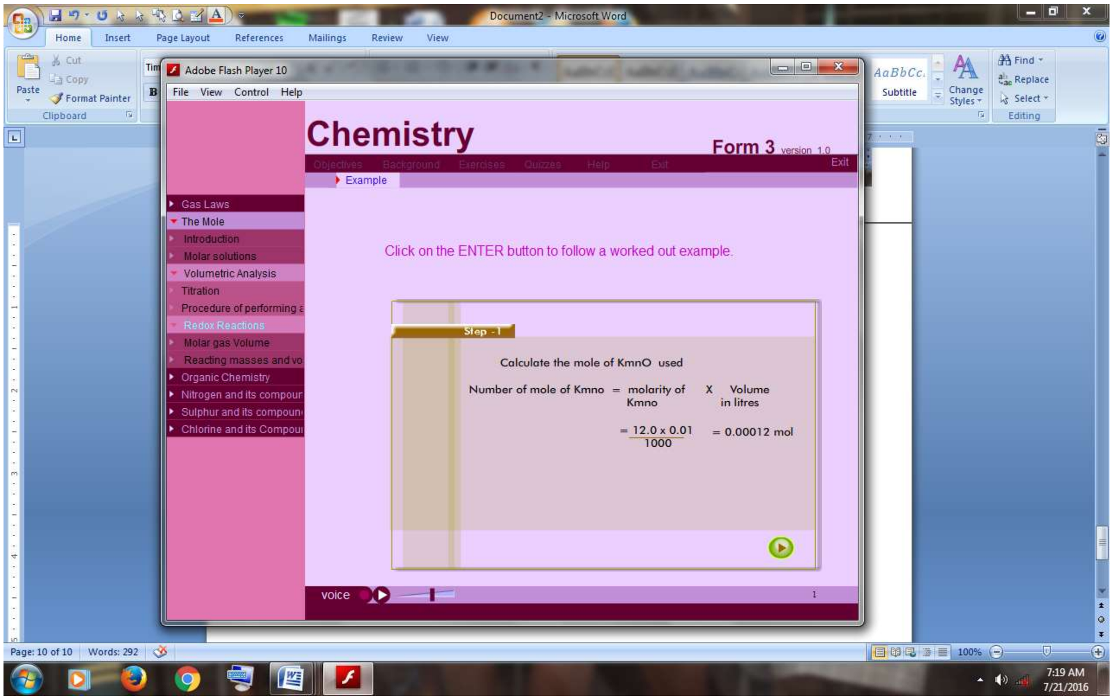


- On clicking "**Enter**" the question will appear as follows:

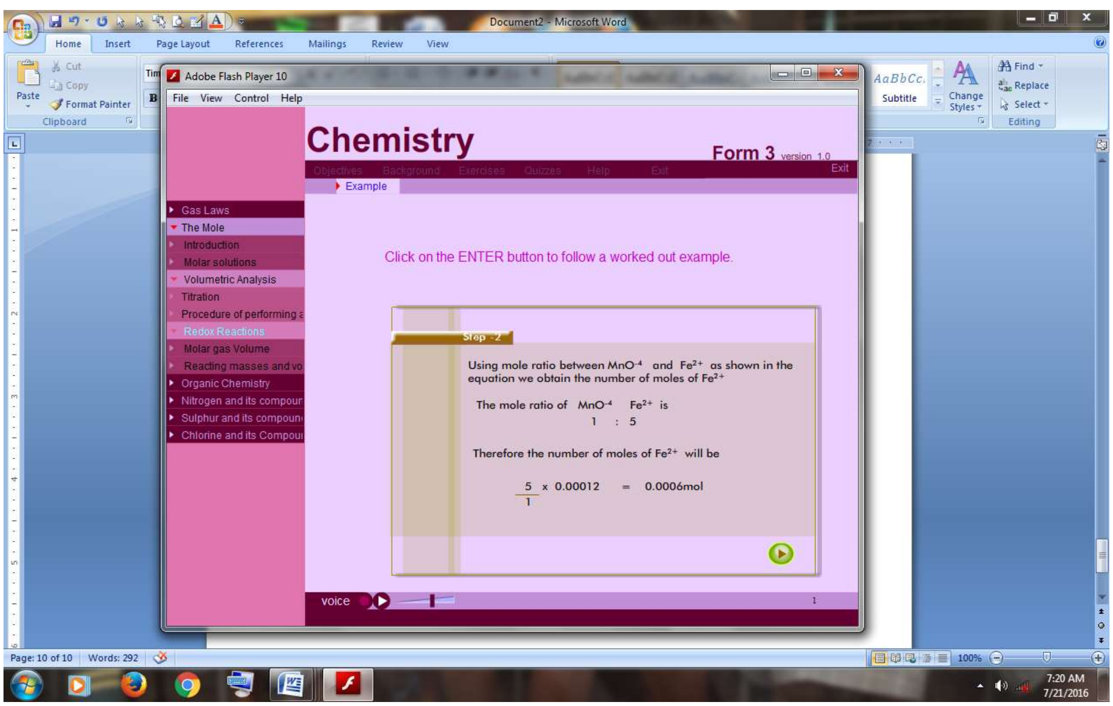


- Steps involved in solving the problem are the outlined as follows:

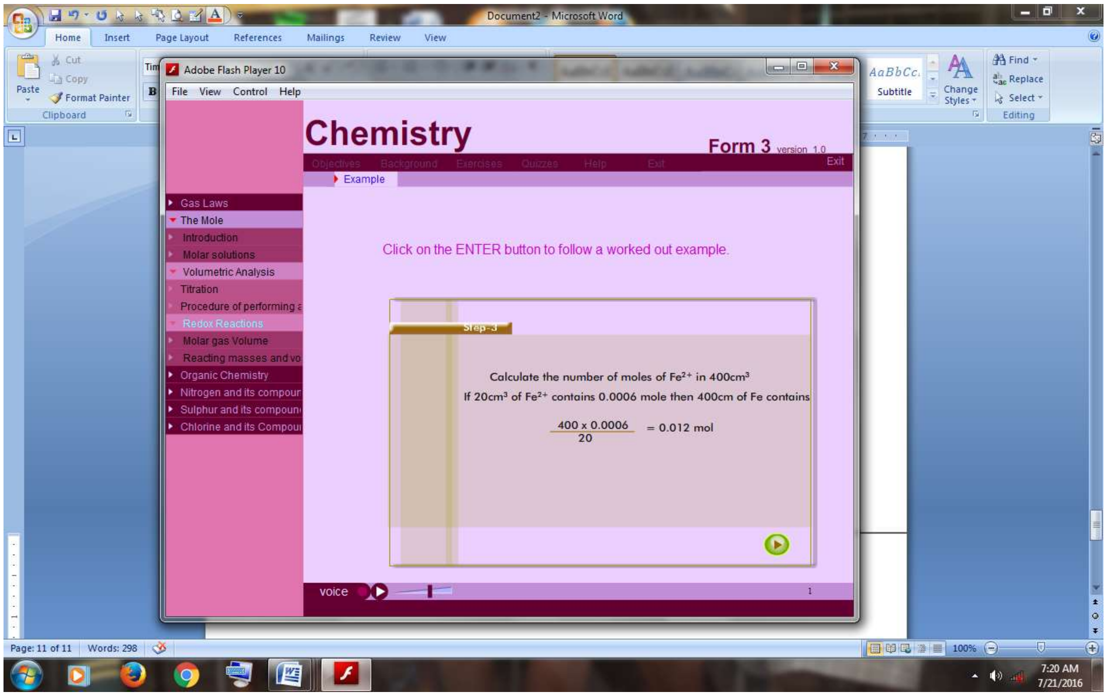
Step 1


Document2 - Microsoft Word
Adobe Flash Player 10
File View Control Help
Chemistry
Form 3 version 1.0
Exit
Example
Gas Laws
The Mole
Introduction
Molar solutions
Volumetric Analysis
Titration
Redox Reactions
Molar gas Volume
Organic Chemistry
Click on the ENTER button to follow a worked out example.
Step - 1
Calculate the mole of KmnO used
Number of mole of Kmno = molarity of Kmno X Volume in litres
= 12.0 x 0.01 / 1000 = 0.00012 mol
voice
7:19 AM
7/21/2016

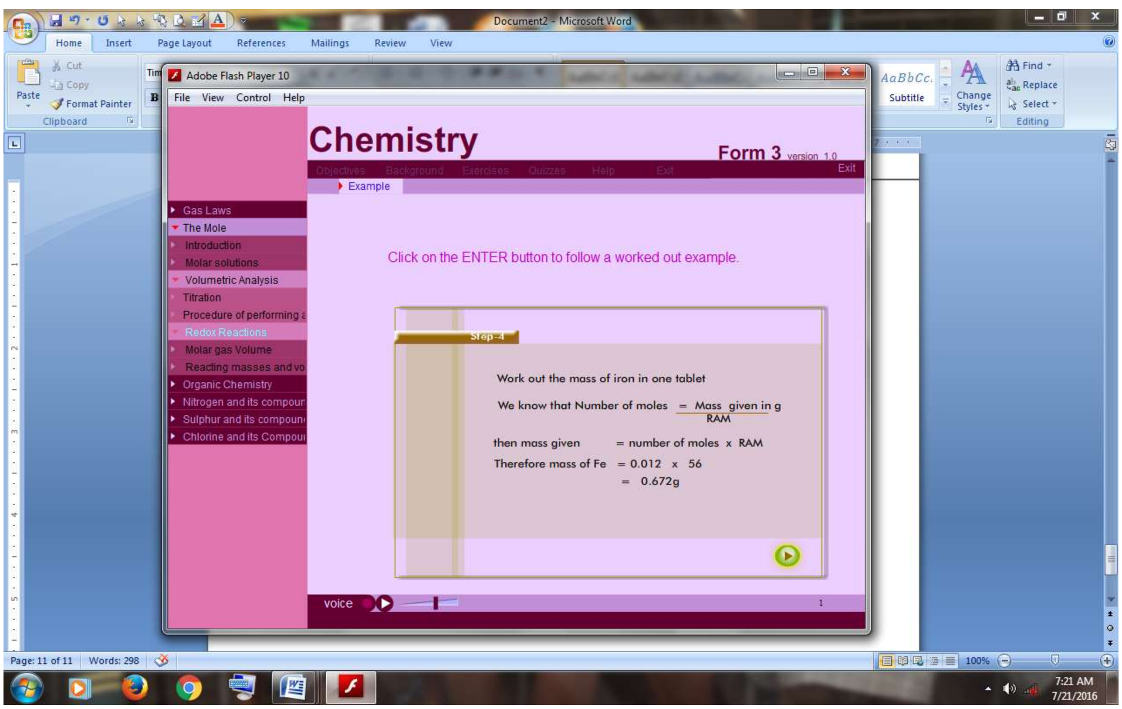
Step 2


Document2 - Microsoft Word
Adobe Flash Player 10
File View Control Help
Chemistry
Form 3 version 1.0
Exit
Example
Gas Laws
The Mole
Introduction
Molar solutions
Volumetric Analysis
Titration
Redox Reactions
Molar gas Volume
Organic Chemistry
Click on the ENTER button to follow a worked out example.
Step - 2
Using mole ratio between MnO-4 and Fe2+ as shown in the equation we obtain the number of moles of Fe2+
The mole ratio of MnO-4 Fe2+ is
1 : 5
Therefore the number of moles of Fe2+ will be
5/1 x 0.00012 = 0.0006mol
voice
7:20 AM
7/21/2016

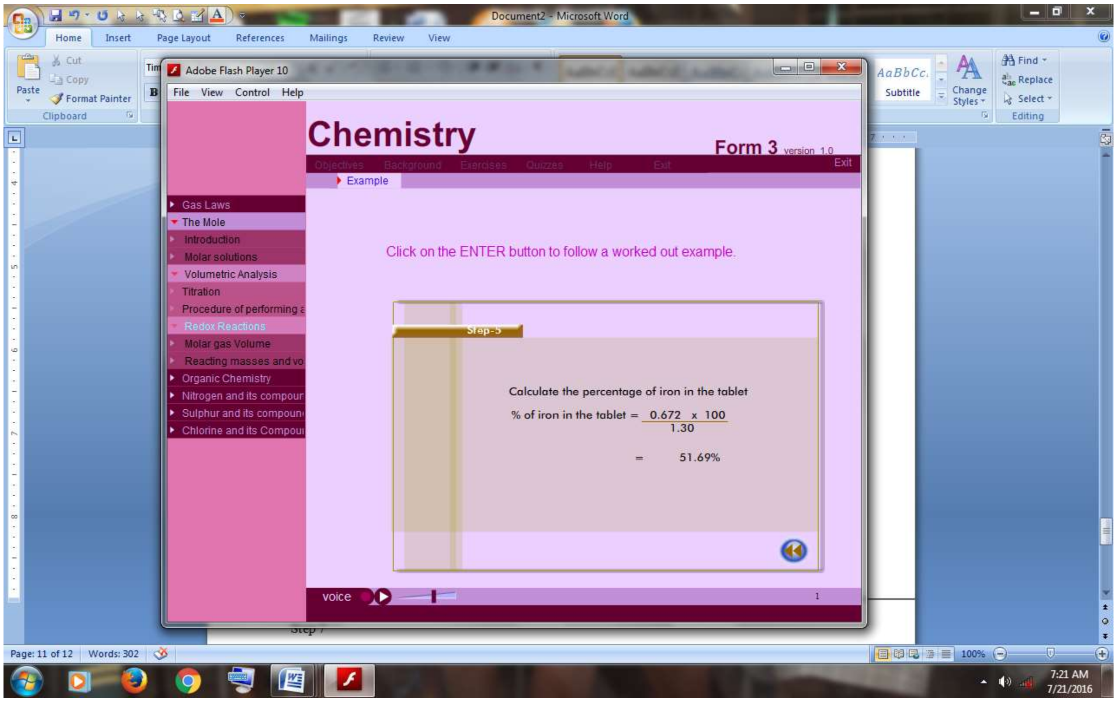
Step 3


Document2 - Microsoft Word
Adobe Flash Player 10
File View Control Help
Chemistry
Form 3 version 1.0
Exit
Example
Gas Laws
The Mole
Introduction
Molar solutions
Volumetric Analysis
Titration
Procedure of performing a
Redox Reactions
Molar gas Volume
Reacting masses and vo
Organic Chemistry
Nitrogen and its compour
Sulphur and its compoun
Chlorine and its Compoun
Click on the ENTER button to follow a worked out example.
Step-3
Calculate the number of moles of Fe²⁺ in 400cm³
If 20cm³ of Fe²⁺ contains 0.0006 mole then 400cm of Fe contains
400 x 0.0006 / 20 = 0.012 mol
voice
Page: 11 of 11 Words: 298
7:20 AM
7/21/2016

Step 4


Document2 - Microsoft Word
Adobe Flash Player 10
File View Control Help
Chemistry
Form 3 version 1.0
Exit
Example
Gas Laws
The Mole
Introduction
Molar solutions
Volumetric Analysis
Titration
Procedure of performing a
Redox Reactions
Molar gas Volume
Reacting masses and vo
Organic Chemistry
Nitrogen and its compour
Sulphur and its compoun
Chlorine and its Compoun
Click on the ENTER button to follow a worked out example.
Step-4
Work out the mass of iron in one tablet
We know that Number of moles = Mass given in g / RAM
then mass given = number of moles x RAM
Therefore mass of Fe = 0.012 x 56
= 0.672g
voice
Page: 11 of 11 Words: 298
7:21 AM
7/21/2016

Step 5



Step 5 gives the final answer of the worked example.

This Computer Tutorial DVD can be replayed by the learners as many times as they wish.

This CBCML Tutorial will be helpful when introducing lesson topics, revision and checking whether the lesson objectives have been met after instruction. This will enable the researcher in ascertaining the level of mastery of content by the learners after instruction.

CHEMISTRY PRACTICALS WORKSHEETS

EXPERIMENT 1: VOLUMETRIC ANALYSIS INVOLVING FORMATION OF A PRECIPITATE

You are provided with:

- 1.0M potassium iodide solution P
- 1.0M lead (II) nitrate solution Q
- Ethanol

You are required to write:

- Balanced chemical equation for the reaction
- Ionic equation for the reaction

Procedure

Take 6 test-tubes and label them, 1 to 6. Run 5cm^3, of 1.0M potassium iodide solution from a burette into each one of them. Add 1.0cm^3 of 1.0M lead (II) nitrate solution to the test-tube labeled 1, and stir the mixture well with a glass rod. Add about 5 drops of ethanol to the mixture, stir, and place it in a test- tube rack.

Add 1.5cm^3, 2.0cm^3, 2.5cm^3, 3.0cm^3 and 3.5cm^3 of the 1.0M lead (II) nitrate to the test tubes labeled 2, 3, 4, 5 and 6 respectively. Add about 5 drops of ethanol to each test-tube, stir and allow the mixture to settle. Measure the height of the precipitate in each tube in (mm) and record the measurements in table I below.

Table I

Test tube number	**1**	**2**	**3**	**4**	**5**	**6**
Volume of 1.0M lead (II) nitrate (cm^3)	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**
Height of precipitate (mm)						

a) Plot a graph of the heights of the precipitates against the volume of lead (II) nitrate solution added (3mks)

b) What was observed on mixing the two solutions? (1mk)

c) What was the purpose of adding ethanol to the mixture (1mk)

d) Calculate:

  i. Number of moles of KI in 5cm^3 of 1.0M KI solution (2mks)

  ii. Number of moles of $Pb(NO_3)_2$ which reacted completely with 5.0cm^3 of 1.0M KI. (2mks)

e) The heights of the precipitate remained constant in the test-tubes labeled 4, 5 and 6. Explain. (2mks)

f) How many moles of KI would react with one mole of lead (II) nitrate? (2mks)

g) Write:

i. Balanced chemical equation (1mk)

ii. Ionic equation for the reaction between lead (II) nitrate and potassium iodide (1mk)

h) Comment on the shape of the graph of height of precipitate against the volume of lead (II) nitrate (1mk)

EXPERIMENT 2: THERMO-TITRATION

You are provided with:

- 2M sodium hydroxide, solution N
- Sulphuric (VI) acid, solution W

You are expected to: standardize sulphuric (VI) acid with 2M sodium hydroxide.

Procedure

Measure 20cm^3 of sulphuric (VI) acid, solution W and transfer into 100ml beaker provided. Measure its temperature and record in the table below under 1st column. Take 5cm^3 of solution N and add to this solution, stir with the thermometer and record the final steady temperature. Continue to add 5cm^3 of **N** to the same solution and record the final steady temperatures until 40cm^3 of N has been added.

Table

Volume of H_2SO_4, W used (cm^3)	20	20	20	20	20	20	20	20	20
Volume of 2M NaOH $_{(aq)}$ N, added (cm^3)	0	5	10	15	20	25	30	35	40
Highest temperature reached (°C)									

(i) Plot a graph of highest temperature reached (vertical axis) against volume of 2M NaOH $_{(ag)}$ added. (4mks)

(ii) From your graph determine the following: -

I. Highest Change in temperature (ΔT) (1mk)

II. Volume of 2M NaOH $_{(aq)}$ needed to neutralize completely 20cm^3 of sulphuric (VI) acid (1mk)

(iii) Determine the number of moles of sulphuric (VI) acid used given that the solution contains 1 mole per litre of the acid. (2mks)

EXPERIMENT 3: ACID-BASE TITRATION INVOLVING MOLE RATIO OF 1:1

You are provided with:

- Solution X, dilute hydrochloric acid
- Solution Y, a 0.5M solution of sodium hydroxide.
- Phenolphthalein indicator.

You are required to: standardize solution X

Procedure

Fill the burette with solution X. Pipette 25cm^3 of solution Y into a conical flask. Titrate X against Y using phenolphthalein indicator. Repeat procedure two more times and tabulate the results in table (I) below.

Table 1

	I	II	III
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of X used (cm^3)			

(4 mks)

a) Calculate the average volume of X used. (1 mk)

b) Calculate: -

i) the number of moles of solution Y used. (2 mks)

ii) the number of moles of solution X used. (2 mks)

iii) the concentration of solution X in moles per litre. (2 mks)

EXPERIMENT 4: ACID-BASE TITRATION INVOLVING MOLE RATIO OF 1:2

You are provided with:

- Solution E, dilute hydrochloric acid
- Solution G, a 0.5M solution of anhydrous sodium carbonate.
- Screened methyl orange indicator.

You are required to: standardize solution E

Procedure

- Measure exactly $40.0cm^3$ of solution E using the measuring cylinder provided. Transfer it into a 100ml measuring cylinder and top it up to $100cm^3$ mark with distilled water. Label this resulting solution F.
- Fill the burette with solution F. Pipette $25cm^3$ of solution G into a conical flask.
- Titrate F against G using screened methyl orange indicator. Repeat procedure two more times and tabulate the results in table (I) below.

Table 1

	I	II	III
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of F used (cm^3)			

(4 mks)

a) Calculate the average volume of F used. (1 mk)

b) Calculate: -

i) the number of moles of solution G used. (2 mks)

ii) the number of moles of solution F used. (2 mks)

iii) the concentration of solution F in moles per litre. (2 mks)

i) the molarity of solution E (1 mk)

EXPERIMENT 5: REDOX TITRATION

You are provided with:

- 4.0g of potassium Manganate (VII) – ($KMnO_4$), solution P
- 49grams ammonium ferrous sulphate $(NH_4)_2SO_4.FeSO_4.6H_2O$ per litre of solution – Solution Q

You are required to: determine the reacting mole ratio between Manganate (VII) ions and Iron (II) Ions

Procedure

Using a pipette transfer 25.0cm^3 of solution Q into a conical flask. Titrate with solution P in the burette; until pink colour just appears. Record your results in the table below.

Table I

	I	II	III
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of P used			

(3 Marks)

a) Calculate the average volume of solution P used. (1 Mark)

b) Calculate;

i) Molarity of solution P (K=39, Mn=55, O=16). (2 Marks)

ii) The number of moles of solution P used. (1 Mark)

iii) Concentration of solution Q in moles per litre. (1 Mark)

iv) The number of moles of Q that reacted with solution P in this experiment.

(1 Mark)

v) Calculate the reaction mole ratio between $MnO^-_{4(aq)}$ and $Fe^{2+}_{(aq)}$. (2 Marks)

EXPERIMENT 6: BACK TITRATION

You are provided with:

- 2M hydrochloric acid solution A
- 2M sodium hydroxide solution B
- 2g of dustless chalk (impure calcium carbonate) solid P

You are required to:

Determine how the rate of the reaction of calcium carbonate (marble chips) with hydrochloric acid varies with the concentration of hydrochloric acid.

Procedure I

(a) Measure 10cm³ of solution B into a 100cm³ measuring cylinder. To this solution add distilled water to make to the 100cm³ mark. Transfer into a conical flask and label this solution C. Fill the burette with sodium hydroxide solution C.

(b) Label 5 test tubes as A, B, C, D and E.

(c) Using a dropper and the 10cm³ measuring cylinder measure 1cm³ of solution A and place it in test tube A.

(d) Measure 100cm³ of solution A using the 100ml measuring cylinder and place in the conical flask. Place all solid P in the same conical flask. **Immediately start the stop watch**.

(e) Swirl the mixture for 1 minute. Using the dropper and 10cm³ measuring cylinder draw 1cm³ of the reacting mixture and place in test tube B.

(f) Swirl the mixture for a further 1 minute and repeat procedure (e) to fill test tubes C.

(g) Repeat procedure (f) to fill test tubes D and E.

(h) To each of the test tube A – E add 10cm³ of water. Transfer the content of test tube A into a clean conical flask. Add 2-3 drop phenolphthalein indicator to the solution in conical flask. Titrate this solution against the solution B in burette by adding solution B from the burette drop by drop until the solution Just turns permanently PINK. Record the volume required in table.

(i) Pour the contents in the conical flask and rinse it with distilled water. Repeat procedure (h) with contents in test tubes B, C, D and E to complete table 1.

Retain the reacting mixture for use in procedure II – label it as solution P.

Table 1

Test tube	A	B	C	D	E
Time (minutes)	0	1	2	3	4
Final burette reading					
Initial burette reading					
Volume of solution B used (cm³)					

(6 mks)

(a) Plot a graph of volume of sodium hydroxide solution B used (vertical axis) against time (horizontal axis). (3 marks)

(b) (i) Use the graph to determine the volume of solution B that reacts with 1cm³ of reacting mixture after 3½ minutes. (1 mark)

(ii) Find the concentration of the reacting mixture after minutes. (2 marks)

(c) In terms of the rate of the reaction, explain the shape of your graph. (1 mark)

Procedure II

Filter solution P obtained in procedure I above into a clean conical flask. Pipette 25cm³ of the solution P obtained in procedure I into a 250cm³ conical flask. To this solution add 20cm³ of water. Rinse the burette and fill it with sodium hydroxide solution B and titrate using 2-3 drops of phenolphthalein indicator. Record in table **2 below** and repeat to complete the table.

Table 2

Experiment number	I	II	III
Final burette reading (cm³)			
Initial burette reading (cm³)			
Volume of B used (cm³)			

(4 marks)

(a) Calculate the average volume of B used. (1 mark)

(i) Determine the number of moles of excess hydrochloric acid in 25cm³ of solution P. (1 mark)

(ii) Calculate the number of moles of hydrochloric acid in 100cm³ of solution P. (1 mark)

(iii) Determine the number of moles of acid that reacted with active component of chalk. (2 marks)

APPENDIX E: Scheme of Work

1st WEEK	1	**Administration of CAT 1(PRE-TEST)**					
	2	**Grouping of students**					
	LESSON	**TOPIC**	**SUB-TOPIC**	**OBJECTIVES**	**T/L ACTIVITIES**	**RESOURCES**	**REFERENCES**
	3 & 4	Volumetric Analysis Molar solutions	Stoichiometry of chemical reactions	By the end of the lesson the learner should be able to: -Use stoichiometric equations to calculate: • Moles and molarity of solutions. • Reacting quantities	– W/B illustration – Note taking – Question answering – Teacher demonstration.	– Writing Board – Wall charts – Manila paper charts	- KLB Chemistry students Book 3 Page 41-45 - Teachers guide book 3 - Longman Chemistry Revision book Page 158-160
	5	Volumetric Analysis Molar solutions	Stoichiometry of chemical reactions	-Use stoichiometric equations to calculate: • Moles and molarities of reacting solutions.	– Computer simulations – Note taking – Question answering – Problem solving. – Peer teaching	– Computers	- KLB Chemistry students Book 3 Page 50-51 - Teachers guide book 3 - Longman Chemistry Revision book Page 158-160
2nd WEEK	1	**Computer simulations and self-check test** **MASTERY QUIZ 1**					
	2	**REMEDIATION**					
	3 & 4	Volumetric Analysis	Molar solutions. Accurate weighing and	-Use volumetric flasks to prepare a molar solution.	– Writing Board illustration – Note taking – Question answering	– Writing Board – Wall charts – Manila paper charts	- KLB Chemistry students Book 3 Page 41-45

			preparation of molar solutions.	-Use given values to calculate moles of solutions.	– Listening – Teacher demonstration		- Teachers guide book 3 - Longman Chemistry Revision book Page 158-160
	5	Volumetric Analysis	Calculations on molar solutions.	By the end of the lesson the learner should be able to: -Use the weighing scale to obtain accurate masses of substances. -Use volumetric flasks to prepare a molar solution. -Use given values to calculate moles of solutions.	– Computer simulations – Note taking – Question answering – Problem solving. – Peer teaching	– Computers	- KLB Chemistry students book 3 Page 41-45 - Teachers guide book 3 - Longman Chemistry Revision book Page 158-160
3rd WEEK	1	**Computer simulations and self-check test** **MASTERY QUIZ 2**					
	2	**REMEDIATION**					
	3 & 4	Volumetric Analysis	Further questions.	-Carry out a simple acid-base titration -Calculate moles of compounds in smaller and larger volumes.	– Class experiment – Writing Board illustration – T/P Discussion – Exercise – Note taking – Question answering	– Writing Board – Worksheets	- KLB Chemistry students Book 3 Page 58-62 - Explore Chemistry Teachers guide book 3 - Longman Chemistry

							Revision book Page 158-160
	5	Volumetric Analysis	Further exercise.	-Calculate molarities of compounds in smaller and larger volumes.	– Computer simulations – Note taking – Question answering – Problem solving. – Peer teaching	– Computers	- KLB Chemistry students Book 3 Page 62-63 - Explore Chemistry Teachers guide book 3 - Longman Chemistry Revision book Page 158-160
4th WEEK	1	**Computer simulations and self-check test** **MASTERY QUIZ 3**					
	2	**REMEDIATION**					
	3 & 4	Volumetric Analysis	Calculating concentration in moles per litre.	By the end of the lesson the learner should be able to: -Use given values to calculate moles then molarities of compounds in smaller and larger volumes.	– Writing Board illustration – Note taking – Question answering – Listening – Teacher demonstration	– Writing Board – Wall charts – Manila paper charts	- KLB Chemistry students Book 3 Page 65-66 - Teachers guide book 3 - Longman Chemistry Revision book Page 158-160
	5	Volumetric Analysis	Calculating concentration in mass per litre.	-Use given values to calculate moles then molarities of compounds in smaller and larger volumes.	– Computer simulations – Note taking – Question answering – Problem solving. – Peer teaching	– Computers	- KLB Chemistry students Book 3 Page 65-66 - Teachers guide book 3 - Longman Chemistry

							Revision book Page 158-160
5th WEEK	1	**Computer simulations and self-check test MASTERY QUIZ 4**					
	2	**REMEDIATION**					
	3 & 4	Volumetric Analysis	Titration. Using the pipette to obtain accurate volumes. Using the burette for titration	-Use the pipette to obtain accurate volumes of water. -Use the burette to obtain accurate volumes of water.	– Writing Board illustration – Note taking – Question answering – Listening – Lab equipment	– Writing Board – Wall charts – Manila paper charts	- KLB Chemistry students Book 3 Page 68-72 - Teachers guide book 3 - Longman Chemistry Revision book Page 158-160
	5	Volumetric Analysis	Problem solving.	By the end of the lesson the learner should be able to: -Use given values to calculate moles then molarities of compounds in smaller and larger volumes.	– Computer simulations – Note taking – Question answering – Problem solving. – Peer teaching	– Computers	- KLB Chemistry students Book 3 Page 71-72 - Teachers guide book 3 - Longman Chemistry Revision book Page 158-160
6th WEEK	1	**Computer simulations and self-check test MASTERY QUIZ 5**					
	2	**REMEDIATION**					
	3 & 4	**CPSAT POST-TEST**					
	5	**CAT & SMQ POST-TEST**					

APPENDIX F: SMQ Reliability Analysis

	Scale mean If item deleted	Scale Variance if item deleted	Corrected Item-Total Correlation	Cronbach's Alpha if item Deleted
I do not feel nervous at all in leaning chemistry	89.3764	171.6372	.2660	.8697
Learning chemistry is frustrating	88.5787	174.6972	.3667	.8643
I feel it is my choice to learn chemistry	88.6517	172.2961	.5983	.8599
I am pretty good in chemistry	89.2584	162.6673	.6676	.8545
I feel tense while learning chemistry	88.8876	171.8065	.4127	.8629
I do well in chemistry activities compared to other students	89.5899	164.3789	.5507	.8582
Doing chemistry tasks is fun	89.3427	168.9497	.4011	.8636
I feel relaxed while learning chemistry	90.0506	175.6867	.1426	.8759
I enjoy learning chemistry	88.6348	173.5778	.4641	.8622
I don't really have a choice in learning chemistry	89.0618	176.3634	.1776	.8716
I am satisfied with my performance in chemistry tasks	90.2191	161.7653	.5664	.8574
I am anxious while learning chemistry	89.1236	168.7078	.4877	.8606
Learning chemistry is very boring	88.4719	176.7591	.3941	.8642
The hours I spend learning chemistry are the ones I enjoy most	89.0000	173.7288	.3450	.8649

I feel I am doing what I want to do while I am learning chemistry	89.4438	165.4347	.4710	.8612
I feel pretty skilled in chemistry activities	89.0899	160.1840	.7195	.8523
Learning chemistry is very interesting	88.8820	167.9013	.5491	.8589
I feel pressured while learning chemistry	89.2528	173.0035	.3142	.8662
I always look forward to chemistry lessons	88.9270	172.4636	.4555	.8620
I feel like I have to learn chemistry	88.8202	173.3121	.4441	.8624
I can describe chemistry lessons as very enjoyable	88.9663	162.9593	.6513	.8550
I believe I have a choice in learning chemistry	88.7697	170.6077	.5466	.8598
Having learnt chemistry for a while, I feel pretty competent	89.3090	165.6610	.5143	.8595

APPENDIX G: Letter of Introduction

KETER JOHN KIPROTICH
EGERTON UNIVERSITY
P.O BOX 536- 20115
EGERTON
Mobile: 0726696938
E-mail: johnketer96@gmail.com
28th April, 2016

THRO'

THE COUNTY DIRECTOR OF EDUCATION
BOMET COUNTY
P.O BOX 3-30040
BOMET

FORWARDED
COUNTY DIRECTOR OF EDUCATION
BOMET
Date: 5/5/16

Dear Sir/Madam,

RE: RESEARCH ON THE EFFECTS OF COMPUTER BASED COOPERATIVE MASTERY LEARNING ON SECONDARY SCHOOL STUDENTS' SKILLS ACQUISITION, MOTIVATION AND ACHIEVEMENT IN CHEMISTRY PRACTICALS IN BOMET COUNTY, KENYA

I am a post-graduate student of Egerton University pursuing a PhD in Science Education. I am carrying out a research on the above mentioned topic. The purpose of approaching you is to seek your input in this study. The exercise is purely for academic purposes and the information you provide is confidential and not transferable to other purposes. Please answer all the questions honestly and as freely as possible.

I sincerely thank you in advance.

Yours sincerely,

Keter J. K.
ED14/0447/14

APPENDIX H: Request for Research Permit

EGERTON UNIVERSITY

Tel: Pilot: 254-51-2217620
254-51-2217877
254-51-2217631
Dir.line/Fax; 254-51-2217847
Cell Phone
Extension; 3606

P.O. Box 536 - 20115
Egerton, Njoro, Kenya
Email: bpgs@egerton.ac.ke
www.egerton.ac.ke

OFFICE OF THE DIRECTOR GRADUATE SCHOOL

Ref: ED14/0447/14

Date: 14^th^ January, 2016

The Secretary,
National Council of Science and Technology,
P. O. Box 30623-00100,
NAIROBI.

Dear Sir,

RE: REQUEST FOR RESEARCH PERMIT – KETER JOHN KIPORTICH
REG. NO. ED14/0447/14

This is to introduce and confirm to you that the above named student is in the Department of **Curriculum, Instruction & Education Management, Faculty of Education & Community Studies.**

He is a bonafide registered Ph.D student in this University. His research topic is entitled **"Effects of Computer Based Cooperative Mastery Learning on Secondary School Students' Skills Acquisition, Motivation and Achievement in Chemistry Practicals in Bomet County, Kenya."**

He is at the stage of collecting field data. Please issue him with a research permit to enable him undertake the studies.

Yours faithfully,

14 JAN 2015

Prof. M.A. Okiror
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

MAO/ear

"Transforming Lives Through Quality Education"
Egerton University is ISO 9001:2008 Certified

APPENDIX I: NACOSTI Research Authorization Letter

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

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

Ref: No. **NACOSTI/P/16/0577/9314**

Date: **14th April, 2016**

John Kiprotich Keter
Egerton University
P.O Box 536-20115
EGERTON.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Effects Of computer based cooperative mastery learning on secondary school students' skills acquisition, motivation and achievement in chemistry practicals in Bomet County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Bomet County** for the period ending **4th April, 2017.**

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

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

DR. STEPHEN K. KIBIRU, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Bomet County.

The County Director of Education
Bomet County.

APPENDIX J: NACOSTI Research Clearance Permit

CONDITIONS

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

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 8669

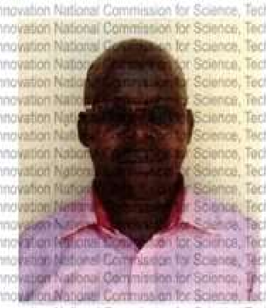
CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MR. JOHN KIPROTICH KETER
of EGERTON UNIVERSITY, 0-20402 LONGISA,has been permitted to conduct research in *Bomet County*

on the topic: *EFFECTS OF COMPUTER BASED COOPERATIVE MASTERY LEARNING ON SECONDARY SCHOOL STUDENTS' SKILLS ACQUISITION, MOTIVATION AND ACHIEVEMENT IN CHEMISTRY PRACTICALS IN BOMET COUNTY, KENYA*

for the period ending:
4th April,2017

Permit No : NACOSTI/P/16/0577/9314
Date Of Issue : 14th April,2016
Fee Recieved :Ksh 2000



....
Applicant's Signature

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

APPENDIX K: County Director of Education Research Authorization

MINISTRY OF EDUCATION SCIENCE AND TECHNOLOGY
STATE DEPARTMENT OF EDUCATION

Telegrams: "ELIMU",
Telephone: 052-22265
When replying please quote
EMAIL:CDEBOMETCOUNTY@GMAIL.COM
Ref/CDE/BMT/AUTHVOL1/37

COUNTY EDUCATION OFFICE,
BOMET COUNTY

P.O. BOX 3-30040
BOMET.

25TH APRIL, 2016

MR.JOHN KIPROTICH KETER,
EGERTON UNIVERSITY,
P.O BOX536-20115,
EGERTON.

RE: RESEARCH AUTHORIZATION:

Reference is made to the letter dated 14th April, 2016, Ref: NO. NACOSTI/P/16/0577/9314; the above mentioned person is authorized to carry out research on '**effects of computer based cooperate mastery learning on secondary school students, skills acquisition, motivation and achievement in chemistry practical's in Bomet county, Kenya**" for a period ending 4th April, 2017.

You should present this introduction letter to the head teacher of a school you visit for identification.

COUNTY DIRECTOR OF EDUCATION
BOMET COUNTY
BOMET.

WILIAM SUGUT
COUNTY DIRECTOR OF EDUCATION
BOMET COUNTY

CC
TSC COUNTY DIRECTOR

APPENDIX L: County Commissioner's Research Authorization

OFFICE OF THE PRESIDENT
MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telegrams: "DISTRICTER", Bo met
Telephone: (052) 22004/22077 Fax 052-22490
When replying please quote

COUNTY COMMISSIONER
P.O BOX 71
BOMET - 20400

REF:EDU.12/1 Vol.I/(160)

26th April, 2016

All Deputy County Commissioners
BOMET

RE: RESEARCH AUTHORIZATION
MR. JOHN KIPROTICH KETER

The above named has been authorized to carry out research on "Effects of computer based cooperative mastery learning on secondary school students' skills acquisition, motivation and achievement in chemistry practicals in Bomet County, Kenya" by the National Commission for Science, Technology and Innovation vide their letter Ref. No. NACOSTI/P/16/0577/9314 of 14th April, 2016.

Any assistance accorded to him would be much appreciated.

B. J. Leparmarai
County Commissioner
BOMET COUNTY

c.c. John Kiprotich Terer
Egerton University
P O Box 536-20115
EGERTON