

EFFECTS OF COMPUTER ASSISTED LEARNING ON  
INSTRUCTION IN ORGANIC CHEMISTRY IN PUBLIC  
SECONDARY SCHOOLS IN KWALE COUNTY, KENYA

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## DECLARATION

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

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**DEDICATION**

This work is dedicated to four very important people in my life. First to my wife Winnie for standing by me, sacrificing so much, for the encouragements and being there for our daughters. Secondly, to my mother Jennipher who taught me early in life to work hard and aim higher. Lastly, to my two daughters Mercy and Ellen for their moral support and challenge, wanting the very best from their daddy.

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## **ABBREVIATIONS AND ACRONYMS**

<b>ANOVA</b>	Analysis of Variance
<b>BOM</b>	Board of Management
<b>CAI</b>	Computer Aided Instruction
<b>CAL</b>	Computer Assisted Learning
<b>CDF</b>	Constituency Development Fund
<b>CHE</b>	Commission for Higher Education
<b>DQASO</b>	District Quality Assurance and Standards Officer
<b>HoD</b>	Head of Department
<b>GOK</b>	Government of Kenya
<b>ICT</b>	Information Communication and Technology
<b>IT</b>	Information Technology
<b>IWB</b>	Interactive White Board
<b>KCSE</b>	Kenya Certificate of Secondary Education
<b>KNEC</b>	Kenya National Examinations Council
<b>KESSP</b>	Kenya Education Sector Support Program
<b>MDG's</b>	Millennium Development Goal
<b>MLR</b>	Multiple Linear Regression
<b>MOE</b>	Ministry of Education
<b>NACOSTI</b>	National Commission for Science, Technology and Innovation
<b>NEPAD</b>	New Partnership for Africa's Development
<b>PTA</b>	Parents Teachers Association
<b>SCAT</b>	Students Chemistry Achievement Test
<b>SMASSE</b>	Strengthening of Mathematics and Sciences in Secondary Education
<b>SPSS</b>	Statistical Packages for the Social Sciences

### ABSTRACT

The study was informed by the need to contribute in mitigating the persistent poor achievement by a majority of students in chemistry, organic chemistry topic being a major contributor. With evidence indicating insignificant effect of interventions previously implemented, a change in pedagogical approach through use of Computer Assisted Learning (CAL) was proposed. However, paucity of empirical data on its efficacy with regard to instruction for organic chemistry limited discussion on relevance of use of the method. A Solomon's four quasi – experimental study was therefore designed in which 182 from four students and 37 chemistry teachers purposively selected from schools with ICT infrastructure took part. The students in whole class groups were categorized either as control or experimental groups. Two groups (control and experimental each) were pre-tested, intervention (CAL for experimental and conventional for control) administered for three weeks and all the four groups post-tested. Data was obtained using students' questionnaire, pre-test and post-test students chemistry achievement test, teachers' questionnaire, interview schedule and observation checklist. Qualitative data was analysed thematically while quantitative techniques were used for quantitative data with the aid of SPSS. Descriptive statistics including mean, percentages and frequencies as well as inferential statistics in the form of t-test, ANOVA and multiple linear regression were used for data analysis. Post-test results indicated significant mean achievement for students exposed to CAL and significant effect for low ability students in experimental group. Similarly, significant effect was reported for change in students' attitude, the effect being more for students with negative attitude in experimental groups. However, insignificant mean difference was observed for students based on their age and gender. The study thus established that integration of CAL positively impacts learners' achievement in organic chemistry, the impact being greater for low ability students. Additionally, it showed that the strategy positively impacts students' attitude, the change being more prominent for students with negative attitude. For teachers, main effect was reported for their gender, level of education, IT competence, attitude and computer anxiety. Specifically, while level of education, workload and ICT competence had a significant negative effect, effect of computer anxiety was positive. With regard to institutional factors, the effect was positive and significant for leadership support, insignificantly positive for access and negatively significant for technical support. Lastly, inadequate access to ICT facilities, limited leadership support and limited technical support were found to be posing challenges to integration of CAL. It is therefore recommended that stakeholders speed up the roll out of ICT program to all schools in the country, preference being given to county and sub-county schools populated with low ability students. At the same time, adequate ICT hardware, software and reliable internet connectivity should be provided to schools to ease the burden placed on existing infrastructure. At the same time, ICT technicians should be employed in every school to assist with technical cases. Lastly, administrative support to teachers on use of ICT should be enhanced.

## **CHAPTER ONE**

### **INTRODUCTION AND BACKGROUND TO THE STUDY**

This chapter gives an introduction to the research concept including a preview of background information, statement of the problem, the study purpose, objectives, hypothesis and research questions. Similarly, it contains significance of the study, issues limiting and delimiting the study, assumptions, the theoretical and conceptual frameworks of the study. Lastly, it defines terms used.

#### **1.1 Background to the Study**

The role of Information and Communication Technologies (ICTs) in the school classroom has increasingly become prominent, both because of the need for children to develop skills that can empower them in the modern society and the potential value of such technologies as tools for learning (Gill & Dalgarno, 2008; Oladosu, 2012). Various reasons for encouraging the integration of these technologies in the teaching and learning process have been cited. These include the need to equip learners with skills to participate and thrive in an informed society; the need to create highly skilled and flexible workforce (Atsumbe, Raymond, Enoch & Duhu, 2012; Baskin & Williams, 2006; Ottesen, 2006); the potential for enhancement of the “quality of the learning experience” and transformation of pedagogy (Oladosu, 2012, p. 46 - 47).

Computer assisted learning (CAL) is one of the ICT tools that have been shown to have great potential as instructional tools in the classroom. It is a method which uses a computer as a learning media to strengthen students' motivation, give opportunities to both students to learn by their own speed and combine active learning with computer technology (Akçay, Durmaz, Tuysuz & Feyzioğlu, 2006). Its use has dominated human activities since early 1980s when it was first introduced in American schools (Cheema & Zhang, 2013; Richardson, McLeod, Flora, Sauers, Kannan & Sincar, 2013). Research has shown that adoption of computer into education has often been premised on its potential to revolutionize the educational system and as such better prepare students for the information age, and/or accelerate national development efforts (Albirini, 2006). According to Gonzalez and Birch (2000), CAL has the ability to promote active learning in a wide variety of disciplines from literature to the social sciences and beyond. Similarly, Jonassen (2000) describes CAL as an ICT tool that support learning by allowing students to construct knowledge, explore and assess information with other students particularly in science subjects such as chemistry.

Chemistry is one of the science subjects offered in the secondary school curriculum in Kenya. Anecdotal reports show that it is a subject that though is an elective as per the curriculum planners, has been made compulsory for students at the form three and four level in most schools probably due to its presumed importance in students career related goals. However, inspite of this

and though it has been acknowledged that the subject plays an important role in learners' future educational and career-related outcomes (Sirhan, 2007; Twoli, 2006), learners have continued to post poor results in the subject, year in, year out (KNEC, 2013). Statistics show that students achievement in chemistry in the Kenya Certificate of Secondary Education (KCSE) examination in Kenya and in Kwale County has been poor over the years as is illustrated in Table 1.1 and 1.2.

**Table 1.1**  
*National KCSE Results Analysis by Percentage in Selected Subjects 2008 – 2012*

Year	Math	Chem	Bio	Phy	Agric	Geog	Eng
2008	21.29	<b>24.91</b>	30.32	36.71	43.15	41.72	39.76
2009	21.13	<b>19.16</b>	27.15	31.31	37.28	46.31	39.70
2010	23.04	<b>24.89</b>	29.19	35.11	48.52	37.01	33.78
2011	24.79	<b>23.65</b>	32.44	36.64	43.09	37.87	39.21
2012	28.65	<b>27.93</b>	26.21	37.86	44.65	42.78	40.67

Source: KNEC (2013)

Table 1.1 indicates that chemistry had the lowest mean rating by percentage in 2009 and 2011. Similarly in 2008 and 2010, the subject's mean rating was ranked lower than all the other subjects except Mathematics. Specifically, it shows that within the five year period, performance in the subject was mean rated at 24.11% (an equivalent of E). Against an expected achievement level of at least 55 % (an equivalent of a C<sup>+</sup>) in the subject required for one to qualify for uptake in any of the subject's career related areas, the achievement level indicate failure by a majority of candidates to qualify for uptake in chemistry career related disciplines. A similar trend in achievement is observed for chemistry in the case of Kwale County as is seen in Table 1.2.

**Table 1.2**  
***Kwale County KCSE results analysis of selected subjects 2004-2013 {Mean rating out of 12}.***

<b>Year</b>	<b>Math</b>	<b>Chem</b>	<b>Bio</b>	<b>Phy</b>	<b>Agric</b>	<b>Geog</b>	<b>Eng</b>
2004	2.02	<b>2.87</b>	3.58	3.46	4.41	3.81	3.47
2005	2.08	<b>3.11</b>	3.76	4.23	4.88	4.08	3.40
2006	1.90	<b>2.97</b>	4.03	3.75	4.49	3.90	4.16
2007	2.10	<b>3.61</b>	4.33	4.40	4.72	4.26	4.41
2008	2.30	<b>3.67</b>	5.23	4.45	4.42	4.03	4.32
2009	2.27	<b>3.37</b>	4.83	4.21	4.53	3.94	4.27
2010	2.18	<b>2.58</b>	4.54	2.88	4.33	4.17	4.29
2011	2.15	<b>2.65</b>	4.43	3.64	4.38	4.21	4.34
2012	2.19	<b>2.98</b>	4.51	3.93	4.23	4.25	4.38
2013	2.27	<b>3.25</b>	4.76	4.07	4.49	4.05	4.13

Source: Kwale County Education Office (2014)

Data in Table 1.2 shows that Kwale county students' achievement in chemistry was ranked lower than all the other subjects except mathematics in the period between 2004 to 2013. Within this period, performance was mean rated at 3.11 out of 12 (an equivalent of D).

Generally, the poor achievement in the subject has been attributed to among other factors, students' attitude towards chemistry (Dhindsa & Chung, 2003; Olatoye, 2002; Salta & Tzougraki, 2004), teachers' attitude towards students' abilities in chemistry (Abudu & Gbadamosi, 2014; Ogembo, 2012), inadequate teaching and learning resources (Twoli, 2006), and poor teaching methodologies (Sirhan, 2007). Relative to the theme of this study, some researchers have also suggested that chemistry curricula commonly incorporate many abstract concepts, a majority of which though central to further learning in both chemistry and other sciences, most students find difficult to grasp (Sirhan, 2007; Taber, 2002). The inability of such students to grasp the

concepts is what could be resulting into their poor achievement. The abstract concepts according to researchers play a key role in further learning of not only other concepts in the subject but also other related subjects. Erduran and Scerri (2003) for instance are categorical that learning of chemistry pose a challenge to a majority of students particularly in its sub-disciplines which include inorganic chemistry, organic chemistry and physical chemistry. Commenting on the underlying problem and quoting other researchers, Sirhan (2007) indicates:

“Chemistry is often regarded as a difficult subject, an observation that sometimes repels learners from continuing with studies in chemistry. One of the essential characteristics of chemistry is the constant interplay between the macroscopic and microscopic levels of thought, and it is this aspect of chemistry (and physics) learning that represents a significant challenge to novices (Bradley & Brand, 1985). In his early study, Johnstone (1974) reported that the problem areas in the subject, from the pupils' point of view, persisted well into university education, the most difficult topics being the mole, chemical formulae and equations, and organic chemistry.” (2007:3)

In Kenya, an analysis of the secondary chemistry syllabus shows that learners are required to master introductory concepts related to inorganic chemistry, physical, analytical and organic chemistry (MOEST, 2002) all of which are tested in the end of course chemistry examination. According to the syllabus, Organic chemistry require that learners master concepts related to nomenclature, nature, properties and uses of organic substances grouped in different families as well as those of their products. The overall effect is that many learners find many of these concepts abstract thus register poor

achievement not only in the subject generally but also in organic chemistry topics in particular (Taber, 2002).

Several researchers have acknowledged that many students find mastery of topics related to organic chemistry to be difficult (Ryles, 1990; Schmidt, 1992; Shani & Singerman, 1982; Simpson, 1983). Available records show that the difficulties in mastery is related to the many concepts, theories and processes that the topic entails. Thus, it would not be surprising that many of them find difficulty in answering questions related to content in organic chemistry. For Kenyan students, KNEC results analysis for Paper II in the last five years, shows that questions testing organic chemistry concepts were among some of the most challenging for candidates in the end of course examination (KNEC, 2010; KNEC, 2012; KNEC, 2013). Bhukuvhani, Zezekwa and Sunzuma (2011) on their part report that organic chemistry presents a lot of challenge to many teachers and students, a proposition also supported by Green (2002) in his comments based on an analysis of the content of chemistry sub-disciplines. Specifically, the researcher found that teachers have a challenge with pedagogical approaches for instruction which result in students poor mastery and subsequently poor achievement in the subject area.

Although the study of organic chemistry may be perceived to be complex by learners and to some extent teachers thus resulting in poor achievement, researchers acknowledge its importance. Sirhan (2007) for instance, is

categorical that organic chemistry is central in developing new products and improving those on which humankind have increasingly become dependent. This assertion is also supported by Twoli (2006) who holds that the subject area is very important, not only to those who are interested in science-related careers, but also to every individual living today and to the future generations.

Therefore, in an attempt to mitigate the poor achievement of learners in the subject in general and organic chemistry in particular, several remedies had been proposed and implemented. These include review and restructuring of not only the topic but the entire chemistry syllabus (Amadalo, 2012; Menjo, 2013; Wanjira, 2009), and inservicing of chemistry teachers through the SMASSE program among others. The review and reorganization according to the researchers, was done to provide learners with more time to grasp the abstract concepts among other reasons. In spite of this, achievement in the subject and more specifically organic chemistry has continued to be poor. This has ultimately led to the proposition that a look into pedagogical approach to classroom instruction of the topic be considered. Erduran and Scerri (2003) insist that a better understanding of concepts related to chemical knowledge could improve instruction and thus achievement in the subject. Taber (2002) and Zoller (1990) on their part have suggested that the abstract nature of organic chemistry along with other content related learning difficulties means approaches that equip learners with high-level skill set be adopted. Likewise,

Skemp (1987) and Jaji (1994) posit that learning of chemistry should be based on student-centred, participatory and problem solving methods and approaches.

In an attempt to be in tandem with the current prevailing conditions in the information age, World Bank (2007) suggested in its report that science curriculum has to be taught through the modern modes such as CAL so that learning can be enhanced and more curiosity and enthusiasm created in the learner. Other researchers have called for adoption of constructivist-based teaching methods such as CAL as a way of developing globally-connected knowledge societies (Bereiter, 2002; UNESCO, 2005; World Bank, 2008). They argue that students should no longer be exposed to learning methods that tend towards passive reception of sanctioned information through memorization and recall but need to be exposed to methods that promote gaining skills through active participation such as information gathering, evaluating source quality, collaborating, problem-solving, and ultimately knowledge creation. This, they suggest is best achieved through adoption of methods such as CAL in the teaching and learning process. Specifically, Anderson (2002) and Gyongyosi (2005) are categorical that adoption of CAL in instruction of organic chemistry is best placed for solving the pedagogy based problems that teachers and learners face in mastery of concepts in the topic and by extension the subject.

This is probably because previously, empirical studies have associated the use of CAL with improved student achievement in different subjects (Ghani, Mahmood, Halim & Rajindra, 2014; ImpaCT2, 2001; World Bank, 2007). ImpaCT2 (2001) for instance showed that teachers in schools where pupils were taught English using CAL tools reported higher mean scores for their pupils which was attributed to the fact that the use of the ICT tool in teaching and learning have positive effect on behaviour, motivation, communication and process skills and that it enables pupils to learn more autonomously. Other subjects in which CAL has shown positive impact include accounting (Kiboss & Tanui, 2013) and mathematics (Sulungai, Toili & Amadalo, 2011).

In the sciences, it has been suggested that CAL can be used in instruction of subjects such as physics and biology with the aim of imparting in the students skills such as collecting science information, interacting with resources such as images and video and encouraging communication and collaboration resulting in improved student achievement in the subjects (Ghani *et al.*, 2014). Emron and Dhindsa (2010) showed that integration of interactive white board technology significantly improved secondary science teaching and learning. Similarly, Serin (2011) in a study on the effect of computer based instruction on achievement and problem solving skills of the science and technology students reported a statistically significant increase in achievements and problem solving skills of students in the experimental group. Likewise, Yusuf and Afolabi (2010) in a study on the effect of computer assisted instruction

(CAI) on secondary school students' performance in biology confirmed that performance of students exposed to CAI either individually or cooperatively were better than their counterparts exposed to the conventional classroom instruction. Their observations are supported by Kevogo, Toili and Mutsotso (2013); Kiboss and Tanui (2013); Orora, Keraro and Wachanga (2014) and Wekesa, D., Wekesa, E. and Amadalo (2013) among others. Siddiqui and Khatoon (2013) maintain that CAL and its various modes such as computer simulations and games have the ability to support new, inquiry-based approaches to science instruction, through virtual laboratories or field learning experiences. These the researchers maintain can enable students overcome inherent practical and logistical constraints hindering learning of science subject. CAL tools, the researchers believe allow learners to visualize, explore, and formulate scientific explanations for scientific phenomena that would otherwise be impossible to observe and manipulate. Similarly, Linn, Chang, Chiu, Zhang, and McElhaney (2010) posit that CAL can help learners mentally link abstract representations of scientific phenomenon (e.g. equations) with the invisible processes underlying the phenomenon and learner's own observations.

Studies also indicate positive outcome of use of CAL in teaching chemistry generally (Ezeudu & Ezinwanne, 2013; Garanga, Amadalo, Wanyonyi, Akwee & Twoli, 2012). Henriques (2002); Dori and Barak (2000) as reported in Kargiban and Siraj (2009), maintain that the use of computer enhances learning

of the subject and develops interactive learning environment resulting in students improved achievement, an assertion supported by Akcay, Feyzolu and Tuysuz (2003) as well as Ezeudu and Ezinwanne (2013). Used in chemistry, Cotton (1991) found out that computer assisted instruction (CAI) enhances mastery exponentially with users learning as much as 40% faster and retaining learnt content better which ultimately lead to more positive attitude and achievement than conventional methods of instruction. Other benefits include increased attendance, motivation and collaboration among students. Bhukuvhani, Zezekwa and Suusuma (2011) citing Funkhouser (1993) reported significantly higher test score for students who used CAL related instructional tools than students who did not, implying that the tool also improved their problem solving capabilities. This observation is also supported by Knuth and Rodriguez (2000) as cited by Bhukuvhani *et al.* (2011) who also advises teachers to use CAL for discovery learning and in developing students' higher-order thinking skills. According to the researcher, CAL tools that enable visual representations enhances instruction of chemistry concepts by providing easier and clearer illustrations than those a teacher could make. Similarly, Yushau, Mji and Wessels (2003) in their findings reported that visual representations of CAL tools supports students' mastery of chemistry concepts more than diagrams in books, an assertion also supported by Shaw (2006).

On specific topical areas in the subject, Garanga *et al.* (2012) found that use of CAL positively impacts students' achievement in structure and bonding.

Hailegebreal (2012) tested its impact on electrochemistry with a finding similar to that of Talib, Mathews and Secombe (2005) who found that computer-animated instruction is an effective conceptual change strategy in teaching of electrochemistry in comparison to conventional method of instruction. Other positive outcomes of CAL supported instructional resources reported include use of eChem to aid students construct models and translate chemical representations (Hoffman, Wu, Krajcik & Soloway, 2003), use of computer-assisted instruction (CAI) to support students' understanding of chemical formulas and mole concept (Yalçinalp, Geban & Ozkan, 1995). In all these cases, it was reported that students in groups which were exposed to CAL tools scored significantly higher than those exposed to conventional methods of instruction. Additionally, results obtained showed significant improvement in attitude of students in the experimental group compared to those in the control group.

Though there exist a gap in research on how use of CAL could impact instruction of organic chemistry within the country, researchers have suggested that CAL tools can be used to help students in learning the nomenclature and general formulae of organic compounds for improved learning outcome (CIE, 2007). Similarly, they have suggested that computer graphics can also be used to illustrate the shape of molecules for improved learning outcome and that three-dimensional computer molecular models can be used to illustrate the concept of chirality and optical isomerism. Additionally, though records show

that there are studies that have been undertaken in Kenya dealing with the influence of CAL in classroom instruction, most of such studies are predominantly survey research based with a minority focusing on ICT integration in instruction in secondary chemistry. Experimental and quasi – experimental studies on use of CAL in instruction of chemistry generally are few. There was therefore need for experimental and quasi – experimental studies to illustrate how adoption and use of CAL in teaching and learning of organic chemistry could impact students’ achievement in the topic and by extension the subject.

### **1.2 Statement of the Problem**

Chemistry education has been shown to significantly contribute in enabling countries attain their science and technology development targets. Proficiency in the subject in collaboration with other science subjects enhances a country’s competitiveness in the industrial and technical fields. However, an analysis of students’ achievement in chemistry both at the County level in Kwale and nationally in Kenya in the past 10 years indicating a persistent poor achievement in the subject is a cause of concern. The persistent poor achievement has been attributed to several factors including students’ attitude towards chemistry, teachers’ attitude towards students’ abilities in chemistry, inadequate teaching and learning resources, and poor teaching methodologies. The adoption of and use of CAL in schools has been advanced as one of the major avenues that would help improve performance in the subject.

Though evidence show that the use of CAL in classroom instruction impacts students' achievement in different topics of secondary chemistry curricula, there is sparse information on how it could impact teaching and learning of organic chemistry specifically – an area in chemistry reported to pose challenge to a majority of learners. Additionally, many studies that attest to the advantages of use of CAL in developing countries such as Kenya in the subject have mainly been based on survey research which indicate an existing research gap in experimental or quasi-experimental research relative to use of CAL in instruction in chemistry in general and organic chemistry in particular. This study therefore used a quasi-experimental design to examine the effect of CAL in instruction of organic chemistry in public secondary schools in Kwale County, Kenya in an attempt to contribute in bridging the existing knowledge gap.

### **1.3 Purpose of the Study**

The overall aim of this study was to investigate the effect of chemistry teachers' use of CAL in teaching of secondary school chemistry on students' learning and achievement in chemistry.

## 1.4 Objectives of the Study

The study specifically sought to:

- i. Determine the difference in achievement in organic chemistry between students taught through CAL and those taught through conventional methods.
- ii. Determine the effects of CAL on achievement of low and high ability students in organic chemistry.
- iii. Determine the effect of student's attitude towards chemistry on their achievement in organic chemistry when taught through CAL.
- iv. Establish the effect of students' age and gender on their achievement in chemistry when taught through CAL.
- v. Establish the effect of teachers' factors on the use CAL.
- vi. Determine the effects of institutional factors on use of CAL.
- vii. Identify the challenges encountered in integration of CAL.

## 1.5 Research Hypotheses

The study sought to test the following null hypotheses

**H<sub>01</sub>**: There is no significant difference in achievement in organic chemistry between students taught through CAL and those taught through conventional methods.

**H<sub>a1</sub>**: There is a statistically significant difference in achievement in organic chemistry between students taught through CAL and those taught through conventional methods.

**H<sub>02</sub>:** There is no significant difference in achievement of low and high ability students in organic chemistry when taught through CAL.

**H<sub>a2</sub>:** There is a statistically significant difference in achievement of low and high ability students in organic chemistry when taught through CAL.

**H<sub>03</sub>:** There is no significant difference in achievement in organic chemistry between students with negative attitude and those with positive attitude when taught through CAL.

**H<sub>a3</sub>:** There is a statistically significant difference in achievement in organic chemistry between students with negative attitude and those with positive attitude when taught through CAL.

**H<sub>04</sub>:** There are no significant age and gender differences in achievement of students in organic chemistry when taught using CAL.

**H<sub>a4</sub>:** There are statistically significant age and gender differences in achievement of students in organic chemistry when taught using CAL.

## **1.6 Research Questions**

The study was also guided by the following research questions:

- i. How do teachers' factors affect use of CAL in teaching of chemistry?
- ii. How do institutional factors affect use of CAL in teaching of chemistry?
- iii. What are the challenges of use of CAL in instruction of chemistry in Kwale County public secondary schools in Kwale County?

### **1.7 Significance of the Study**

The aim of this study was to contribute to an improved chemistry teaching and learning environment at secondary school level. The findings are expected to contribute practically towards enhancement of implementation of CAL in the teaching and learning process to enhance teachers' pedagogical approach. Chemistry teachers would thus benefit from recommendations on best approach on the implementation of CAL in classroom practice. School administrators are expected to benefit from recommendations of the best approaches to adopt to provide an enabling environment for implementation of CAL in teaching and learning process. Lastly, policy makers are to benefit from recommendations emanating from the empirical data on best methods for management of CAL implementation process for teaching and learning process in secondary schools for appropriate policy formulation and dissemination.

### **1.8 Limitations of the Study**

In the course of the study, a number of limitations were encountered. These include:

- i. Respondents were drawn from selected schools in Kwale County only. However, the sample was drawn in such a way that it was representative of a majority of learners in public secondary schools within the county and the entire republic namely county and sub-county schools. Thus the results could be readily generalised to low ability

students as well as those with negative attitude towards chemistry in all the 47 counties within Kenya.

- ii. The study involved teaching and learning of chemistry subject only with particular focus on use of CAL in instruction of organic chemistry whereas ICT integration in Kenya is being undertaken in all subjects offered and tested in the KCSE. It is however anticipated that since the teaching and learning of the subject share pedagogical approach (constructivist) with other subjects, findings emanating from this study will be found useful in those other subjects.

### **1.9 Delimitations of the Study**

This study delimited itself to a number of parameters that focus on integration of CAL in instruction in Chemistry. These include:

- i. Although there were several secondary schools within Kwale County, only schools which were equipped with computer and ICT related infrastructure were involved in the study due to the availability of appropriate infrastructure required for this study.
- ii. Whereas there are both public and private schools in the county, the study was confined to public secondary schools only.
- iii. Though integration of CAL is anticipated for all subjects under the existing curriculum for secondary schools, the study confined itself to use of CAL in the teaching and learning of organic chemistry.

### **1.10 Assumptions**

In the course of the study, it was assumed that teachers to be interviewed had been teaching in secondary schools for reasonable period of time to be able to be conversant with the dynamics of their teaching environments and that student in different schools learn under similar conditions. In reality, the study established that a majority of teachers handling the subject in almost all the schools visited were professionally trained for the task.

### **1.11 Theoretical Framework**

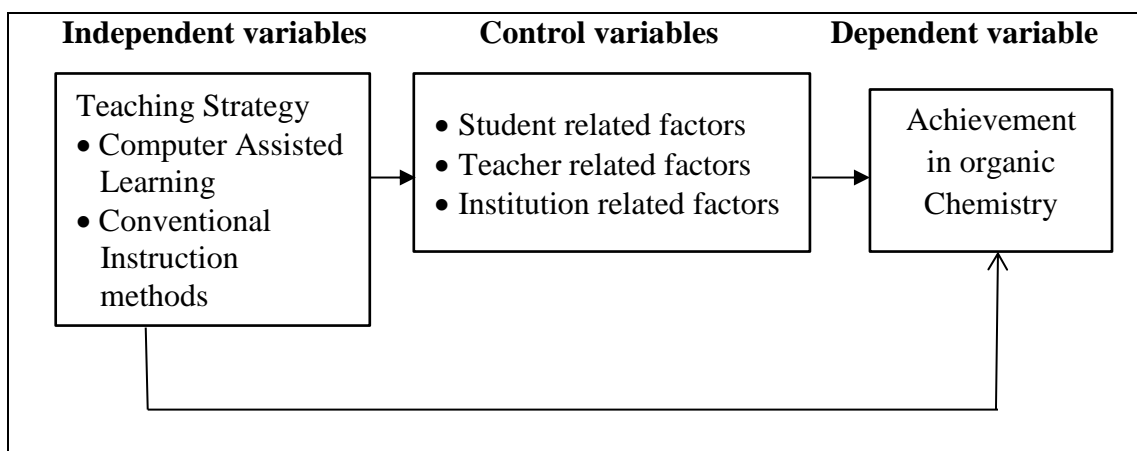
The study is premised on Constructivist theory of learning. According to Bodner (1986), constructivist learning theory holds that knowledge is constructed in the minds of the learner. In concurrence, Murphy (2003) posits that fundamentally, constructivism anticipates that people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. Simply put, the theory holds that learning is an active process and knowledge is constructed from (and shaped by) experience (Christie, 2005). Similarly, it holds that learning is a personal interpretation of the world and emphasizes problem solving and understanding of phenomenon through use of authentic tasks, experiences, settings and assessments of content presented holistically – not in separate smaller parts.

Thus, applied to high school chemistry instruction, constructivist approach emphasizes student's cognitive creation of chemical concepts via daily active

practical involvement with a number of chemical concepts. Rote procedures, formulas and rules are deferred until the student is given the opportunity to construct his/her own rules based on his/her assimilation of the observed chemical phenomena (Grabowski, 2004). To achieve this, the teacher should adapt curriculum to address students' suppositions, help negotiate goals and objectives with learners and pose problems of emerging relevance to students. The theory emphasizes hands-on, real-world experiences which seeks and values students' points of view. In short, the theory postulates that learning is best achieved in social context of content (Christie, 2005; Honebein, 1996). This theory was found fit for the study because CAL programs are interactive and thus can enable students to control the pace and sequence of their learning (Silverman & Casazza, 2000).

### 1.12 Conceptual Framework

Figure 1.1 conceptualizes the relationship between the elements identified as important in integration of CAL in instruction of organic chemistry.



**Figure 1.1 Elements of the Conceptual Framework**

The study intended to compare the impact of use of CAL and conventional methods of instruction in organic chemistry. It was hypothesised that achievement in organic chemistry is influenced by the teaching strategy employed and controlled for by student, teacher and school related factors. It is indicated that CAL packages can transform the way students understand and learn concepts (Anderson, 2002). The researcher insists that CAL media provide a variety of visual presentation such as simulations and games that support the new, inquiry-based approaches to science instruction, providing virtual laboratories or field learning experiences which are more appropriate for learning than the somewhat one-dimensional world of conventional methods. It therefore opens up new horizons for learners of all abilities, more so for learners who find verbally presented data more difficult to comprehend.

Students' achievement may also be affected by the instructional strategy indirectly through control variables. It is assumed that the instructional strategy chosen has a causal link with the identified control variables, in the direction shown. These variables, in turn impact student achievement in chemistry. The control variables include learners' ability in chemistry, their attitude towards chemistry and background characteristics such as gender and age. These, together with the chemistry teacher's characteristics, school related factors and challenges of the process of integration of CAL also impacts learner's achievement in chemistry. For instance, it is the classroom teachers who are primarily concerned with management of the teaching and learning process.

Their qualification, commitment, motivation, experience and instructional styles would therefore influence the extent to which instructional resources including CAL are engaged in the classroom practice.

Teachers however, work within the school which is dictated to by the competing forces of working environment such as the type of leadership, rules and regulations of engagement and the existing CAL resources for teaching and learning to be integrated (Al-Bataineh & Brooks, 2003). The environment that these forces generate work to facilitate or inhibit CAL integration as they can either motivate or inhibit the process of technology integration by the classroom teacher. For instance, school leadership plays an important role in finding out teachers' needs, interests, concerns, commitment (Earle, 2002) and work to ensure constant following-up on the commitment. This process is supported by policies generated by the school's Board of Management (BoM) and Parents Teachers Association (PTA) as well as other stakeholders of the school including its sponsor (KESSP, 2005).

### **1.13 Operational Definition of Terms.**

**CAL:** Use computer and computer supported programs in classroom instruction.

**Chemistry:** The branch of science that deals with the study of matter.

**Conventional instruction methods:** A teaching approach that focus more on classroom instruction aided by other resources in exclusion of computer and computer aided instructional materials.

**ICT integration:** Use of ICT tools to aid classroom learning process.

**High Achievement:** A satisfactory attainment level in chemistry equivalent to more than 40% in a standardised test

**Higher Order Skills:** Skills associated with critical, logical, reflective, metacognitive, and creative thinking.

**Low achievement:** An unsatisfactory attainment level in chemistry equivalent to less than 30% in a standardised test

**Organic chemistry:** A branch of chemistry that entails the study of hydrocarbons.

**Performance in Chemistry:** The competency level attained in Chemistry measured in terms of grades a student scores at KCSE level.

**Public Schools:** A tuition-free school, funded and operated by the government

**Technology:** The theory and practice of design, development, utilization, management, and evaluation processes and resources for learning.

## **CHAPTER TWO**

### **REVIEW OF RELATED LITERATURE**

#### **2.1 Introduction**

The chapter on literature review focuses on research work related to integration of CAL in the teaching and learning process with a bias towards chemistry education. The review focuses on integration of CAL in classroom teaching and learning, effect of integration of CAL, factors perceived to be affecting integration of CAL and challenges of integration of CAL in public secondary schools.

#### **2.2 CAL and Teaching of Organic Chemistry**

Pedagogy based research indicates that developing proficiency in science subjects such as chemistry is much more than knowing facts. It has been suggested that for learners, knowledge of the relationship between facts and ideas within the conceptual frameworks is important for mastery and although good instruction can facilitate this process, developing conceptual understanding of science is difficult and takes time (Siddiqui & Khatoon, 2013). Similarly, researchers believe that modern methods of instruction in sciences that carefully integrate scientific processes with other forms of instruction and target clear learning goals have the potential to increase interest, enhance scientific reasoning, and increase mastery of the targeted concepts. One of the new teaching approaches is CAL with its various modes such as simulations and games that can support the new, inquiry-based

approaches to science instruction, providing virtual laboratories or field learning experiences that overcome practical and logistical constraints to student investigations (Linn *et al.*, 2010).

Generally, the use of CAL in education is premised on its potential to revolutionize the educational system thus better prepare students for the information age and accelerate efforts of national development (Albirini, 2006). It is credited with having the ability to promote active learning in a wide variety of disciplines from literature to the social sciences and beyond (Gonzalez & Birch, 2000). Researchers have shown that the use of computer and computer supported programs such as CAL can greatly improve achievement (Cotton 1991; Brumbaugh & Rock, 2001; Ku, Harter, Liu, Yang, Cheng, 2005). Cotton (1991) found out that with regard to learning rate, CAL users sometimes learn as much as 40% faster than their counterparts and that they retain learnt concepts better; leading to more positive attitudes than conventional instruction methods.

Likewise, ImpaCT2 (2001) showed that use of CAL in classroom instruction impacts positively on behaviour, motivation, communication and process skills ultimately enabling pupils to learn more autonomously. The study showed that achievement of pupils in schools where teachers used CAL for classroom instruction were higher. This observation similar to assertions of Funkhouser (1993) who in a comparative study finding indicated that students who used

commercially available CAL supported problem solving software scored significantly higher on tests than groups of students who did not use the software. Additionally, it was observed that their problem solving capabilities also improved. Guhlin (1996) in Knuth and Rodriguez (2000) made similar observation thus advised teachers to use technology such as CAL for discovery learning and to aid their learners develop higher-order thinking skills.

Thus, Jonassen (2000) describes CAL as an ICT tool that support learning by allowing students to construct knowledge, explore and assess information with other students. The researcher asserts that CAL tools are advantageous in the sense that they teach much more effectively in technical sense. Similarly, CAL tools have been found to teach far more students keeping the students attention more focused on the subject matter. Osborne and Collins (2000) also suggested that the new technologies can be used to increase student motivation, facilitate clearer critical thinking and develop interpretational skills with data. Further, CAL is thought to offer viable solutions to overcrowded classrooms (Abdel-Wahab, 2008) an aspect of much significance to overcrowded Kenyan classrooms. Other benefits of use of CAL include enhanced motivation, collaboration and improved student attendance. Contradictory findings are however reported by among others Cheema and Zhang (2013) who noted that educational games do not necessarily have a similar effect on all domains of the curriculum. They categorically maintain that while use of internet as a homework support medium is expected to raise achievement, spending time

playing non-educational computer games is likely to have no effect or perhaps even a negative effect on achievement as it distracts students from learning.

In science subjects including physics, biology and chemistry CAL is applicable in collecting information and interacting with resources such as images and videos, and to encourage communication and collaboration (Bhagwan, 2005; Ghani *et al.*, 2014) resulting in improved student achievement in the subjects. From their research findings, the researchers concluded that integrating CAL in teaching of sciences can lead to increased students' learning competencies and increased opportunities for communication. Similarly, it has been observed that the advantage of inclusion of computers in classroom instruction particularly of sciences is threefold; first, one can programme a computer to execute a particular instructional strategy faithfully and therefore, one can simulate more or less perfectly certain learner-tutor interactions and study them in much greater detail than is possible in real-life situation. Secondly, the data collection, storage and analysis capabilities of a computer make it an ideal base for research. Thirdly, many cyberneticians would assert that the complexity of the teaching-learning process is such that only with the help of the data processing capabilities of a computer can we hope to improve the teaching/learning process from its primitive state of development (Akçay *et al.*, 2006).

In chemistry, use of CAL has been linked with an enhanced visual representations of chemistry concepts culminating into the positive effects of its use. Among the proponents of this school of thought, Bhukuvhani *et al.* (2011) and Yushau *et al.* (2003) maintain that with CAL tools, concepts which could otherwise be difficult to comprehend without the tools can be visualized by the learners. This is because according to the researchers, CAL tools provide easier and clearer illustrations than those a teacher can make. Specifically, the researchers reported that students indicated visual representations on a computer screen to be more beneficial to their understanding as compared to diagrams in books in a study on the influence of visualization, exploring patterns and drawing generalizations. The visual images are reported to go beyond spoken and written words in enabling learners comprehend concepts, some that appear difficult when conventional teacher instructional methods are used.

Consequently, Henriques (2002) as well as Dori and Barak (2000) as reported in Kargiban and Siraj (2009), maintain that the use of CAL tools enhances instruction in chemistry and enriches the learning environment resulting in students improved achievement, an assertion supported by Akcay *et al.* (2003) and Ezeudu and Ezinwanne (2013). Similarly, Bhukuvhani *et al.* (2011) observes that use of CAL in instruction in chemistry leads to achievement results superior to those obtained when conventional methods of instruction are used. Oloyede and Adenkunle (2009) also asserted that use of CAL to

complement conventional instructional method encourages chemistry teaching and learning. According to them, instruction in chemistry should be advantageously innovated by the use of CAL in association with practical experiment. They insist that it is educationally more effective for CAL to be used to run beforehand learning activities even in practical experiments in chemistry. This assertion is also supported by Aksela (2005) who adds that use of CAL provides rich learning environment and can be used to engage senior secondary level students in meaningful chemistry learning and higher-order skills.

Garanga *et al.* (2012) specifically observed that CAL positively impacts students' achievement in structure and bonding. This is also supported by Frailich, Kesner and Hofstein (2007) who in an investigation of the influence of integrating a website into chemistry teaching of chemical bonding found that the tool enhanced learners comprehension of chemistry concepts and increased their awareness of the relevance of chemistry to daily life. Similarly Akçay *et al.* (2006) in a study of the effect of CAL on achievement and attitude of college students in analytical chemistry found that achievement of experimental groups was significantly higher than the control group. Other areas in which efficacy of CAL has been tested with similar results include electrochemistry (Hailegebreal, 2012); acids and bases (Dasdemir, Doymus, Simsek & Karaçöp, 2008; Ozmen, 2008). In all these cases, the post-test scores showed a statistically significant difference in favour of the experimental group

indicating that integration of CAL enhanced students' understanding of chemical concepts and increased their motivation during the lessons. Similarly, Nduati (2015) found a statistically significant mean difference in achievement of students taught carbon and its compounds using CAL relative to those taught through conventional methods.

In organic chemistry introductory topics, computer software can be used to help students in learning the nomenclature and general formulae of organic compounds for improved learning outcome (CIE, 2007). Similarly, computer graphics can also be used to illustrate the shape of molecules; Three-dimensional computer molecular models can be used to illustrate the concept of chirality and optical isomerism (Barnea & Dori, 1999; Bhukuvhani *et al.*, 2011). The researchers specifically argue that use of CAL supported tools in instruction of chemistry particularly in topics such as organic chemistry could enhance students' spatial abilities in the subject and improve their attitude towards the subject. However, empirical data to specifically prove the veracity of such assertions for instruction in organic chemistry are non-existent especially for developing countries such as Kenya.

Globally, records show that developed and developing countries have endeavoured to support the use of CAL in classroom teaching by providing educational institutions within their scope with requisite hardware and software materials. Plante and Beattie (2004) for instance indicate that by the time of

their study (during the 2003/04 school year), almost all Canadian schools used either desktop computers or laptops for educational purposes. Similarly, Condie, Munro, Seagraves and Kenesson (2007) found that all schools in England had embraced the modern method with each school having achieved or exceeded projected target for computer to pupils ratio. Similar scenarios are depicted for Slovene schools as well as Indian schools (Sorgo, Verckovnik & Kocijancic, 2010). For American schools, classroom technology revolution seemed to have picked up pace as far back as the early 1980s and since then individual states have taken the initiative to provide ICT infrastructure to schools within their jurisdiction (Cheema & Zhang, 2013; Richard, Finholt-Daniel, Sales & Flora, 2012).

In Africa, by 2011, all private schools (100%) and almost all public (99.7% ) schools in Egypt were reported to have access to computer and computer accessories (Richardson *et al.*, 2012). Nigeria on its part launched an ICT-driven project known as School Net (Federal Republic of Nigeria, 2006) which was intended to equip all schools in Nigeria with computers and related communication technology tools for integration. Empirical data also show that Rwandese, Tanzanian and Ugandan governments have not been left behind and have endeavoured to revolutionize their classroom pedagogical approach through adoption and integration of ICT (Kituyi & Tusubira 2013; Richard *et al.*, 2012; Sife & Bernard, 2013).

In Kenya, CAL use in secondary education particularly with regard to public schools appears to be a relatively new area of research though computers were introduced in the country in the 1970s and internet became available in 1993 (Wanjira, 2009). However, available empirical data suggests that computer use in this sub sector in the country dates back to April 1983 when Computers in Education Project in Kenya (CEPAK) launched its first project of deployment of ICT tools and other support programs in a secondary school in Nairobi with funding from the Aga Khan Foundation (Wambui & Barasa, 2007). Since then, the government in conjunction with various stakeholders have attempted to make ICT tools including computer, internet connectivity and other peripherals available to schools.

Some of the notable contributors in equipping public schools with ICT hardware and software include the Aga Khan Foundation, International Development Research Centre (IDRC) and the Rockefeller Foundation, Computer for Schools program, New Partnership for Africa Development (NEPAD), Bill Gates Foundation and the Constituency Development Fund (CDF) among others (Ayere, Odera & Agak, 2010; Keengwe, Onchwari & Wachira, 2008; Makau, 1990; Wambui & Barasa, 2007). Thus, through the concerted efforts of these contributors and others, a number of secondary schools could be presumed to have adequate ICT infrastructure for integration. The CDF in conjunction with the Ministry of Education have specifically equipped eight schools in each sub-county with ICT infrastructure for

integration (MOE, 2013). Individual schools through the efforts of their Board of Managements (BoM) have also endeavoured to equip themselves with ICT infrastructure in an attempt to modernize their learning environment (Farrell, 2007). However, there is limited data on the extent and effect of the use of such facilities which could mitigate the massive investments that has been undertaken to date particularly with regard to subjects such as chemistry which have been shown to pose challenge to many learners in Kenya. Paucity in research especially as regards use of CAL in abstract topics such as organic chemistry demand that studies be undertaken to ascertain the efficacy of use of the method in supporting classroom instruction in such specific area of focus. This study therefore sought to examine the extent and effect of use of CAL in teaching and learning of organic chemistry in secondary schools in Kwale County with requisite ICT infrastructure for integration of CAL in an attempt to contribute to bridge the existing knowledge gap.

### **2.3 Students' Characteristics and the Use of CAL**

Students are the direct beneficiaries of any educational program. They constitute a significant group within the social system, and their perspectives play an important part in framing the activity that takes place in school settings (Deaney, Ruthven & Hennessy, 2003). Indeed, it had been argued previously that students should be seen as active participants in shaping social and educational processes rather than viewed as their passive recipients (Pollard & Tann, 1993). The study therefore attempted to assess the effect of integration of

CAL on students' learning outcome in chemistry lessons based on their demographic characteristics such as age and gender as well as their attitude and entry behaviour.

### **2.3.1 Students' Abilities and Use of CAL**

Assessment of individual ability is presumed to be one of the most widespread yet controversial exports both in academic and the real world (Deary, Strand, Smith & Fernandes, 2006). The assessment is mostly intended to provide an objective measure of individual differences based on cognitive aspects that undoubtedly exist within the society. The outcome from such assessment is indicated to have both practical and theoretical implications. Most importantly, it would justify the rationale for use of such tests as selection tools in a wide range of fields including educational and occupational fora. Empirical data shows that an attempt to predict individual differences in educational outcomes was the main reason for the first broad test of cognitive ability (Binet, 1905; Zenderland, 1998) and the discovery of general intelligence involved, in part, using individual differences in school examination scores (Spearman, 1904). Alongside occupational outcomes (Schmidt & Hunter, 1998), educational outcomes are the major target for the predictive validity of cognitive ability tests. This study purposed to assess the effect of CAL on students' learning outcome in organic chemistry based on their entry behaviour as a contribution in furthering this line of research.

Generally, there is a broad agreement that a moderate to strong correlation exist between cognitive ability and educational achievement. Previously, Jencks (1979) detailed an account of eight samples from six longitudinal studies and reported correlations ranging from 0.40 to 0.63 between cognitive test scores and amount of education obtained. Recently, overviews provided by various researchers indicate similar conclusions (Bartels, Rietveld, Van Vaal, & Boomsma, 2002; Sternberg, Grigorenko, & Bundy, 2001). Mackintosh's (1998) for instance reckoned that there is a correlation of 0.4 and 0.7 between IQ scores and school performance grades. Similarly, Deary *et al.* (2006) found a large contribution of general mental ability to educational achievement overall.

In chemistry, studies have shown that students' level of achievement is based on their mathematical and visual spatial abilities. Relative to mathematical ability, Salau (2000) pointed out that there exists an impregnable link between mathematics and other science subjects while Peters (2000) insist that mathematical ability of students is very important in the learning of chemistry especially in the present age of computer and information technology which owes a lot to mathematics.

Adesoji and Oginni (2012) on their part asserts that like any other school subject, chemistry requires mental ability of the students to be able to cope with the learning of the subject. Their findings showed that mental ability made the highest contribution followed by mathematical ability. Findings by

Ajewole, Oginni and Okedeyi (2006) showed that 36.2% of the total variance in the students' achievement in Chemistry is accounted for by the four students aptitude indices. Among the indices, mental ability made the highest contribution followed by mathematical ability. This shows that the performance of students depends largely on the students' aptitude indices in Chemistry.

Visuo-spatial aptitude which entails three components; spatial visualization, spatial orientation and spatial relations (Barnea & Dori, 1999 as cited in Wu & Shah, 2004) has been strongly linked to obtaining academic mastery of several science disciplines. For example, Siemankowski and MacKnight (1971) as cited in Wu and Shah (2004) found that science students, who were mostly physics majors, possessed more highly developed visualization skills than non-science students. Pallrand and Seeber (1984) as cited in Wu and Shah (2004) investigated and found spatial aptitude in successful students of physics. In the same way, Lord (1985) as cited in Wu and Shah (2004) found similar results for biology students while Baker and Taliey (1972) as cited in Wu and Shah (2004), and McIntosh (1986) as cited in Wu and Shah (2004), made similar studies for chemistry students and found similar results. Therefore, researchers have come to agree that visuo-spatial ability is an important cognitive operation for success in science due to correlation found between spatial ability and achievement in science.

Specifically, Delialioğlu and Askar (1999) found that there is a significant correlation between mathematical skills and physics achievement. Moreover multiple regression analyses of MST and SAT scores with PAT scores yielded a significant contribution of mathematical skills and spatial ability to physics achievement. Accordingly students' mathematical skills could explain about 21% of the variance in physics achievement when entered in a regression equation with spatial ability. Talanquer (2014) found that the main obstacles to developing spatial abilities in chemistry were insufficient understanding of the depth cues provided in two dimensional representations and inability to visualize the position of atoms after rotation. Thus they advocated for the use of instruction methods such as CAL that guide students to visualize three dimensional structures from their two dimensional representations and encouraged use of teaching aids that incorporate models, stereo-diagrams, mirrors, shadows and dynamic pictures that have been used in related remedial instruction programs and have proved to be useful in improving learner skills related to spatial ability.

Pribyl and Bodner (1987) as cited in Wu and Shah (2004) illustrated in their study finding that students with high spatial scores perform significantly better on questions which require problem solving skills, such as completing a reaction or outlining a multi-step synthesis, and questions which require students to mentally manipulate two-dimensional representations of a molecule. Spatial ability was not significant, however, for questions which

could be answered by rote memory or by the application of simple algorithms. Bodner and McMillan (1986) suggested a high correlation between spatial ability and performance in a general chemistry course for science and engineering majors. This correlation was seen not only on highly spatial tasks such as predicting the structures of ionic solids ( $r = 0.29$ ), but also on tasks such as multiple-choice stoichiometry questions ( $r = 0.32$ ) that do not involve spatial skills. According to Carter, Larussa and Bodner (1987) as cited in Wu and Shah (2004) scores on the spatial tests consistently contributed a small but significant amount to success on measures of performance in chemistry. Correlations were largest for subscores that grouped questions testing problem solving skills rather than rote memory or the application of simple algorithms, and correlations were also large for verbally complex questions that required the students to disembed and restructure relevant information.

Empirical data exist that attest to the effect of CAL on students' mathematical and visual spatial abilities thus overall abilities in chemistry. For instance, Morgil *et al.* (2005) worked together on the effect of computer-assisted learning on computational attitudes, three dimensional spatial visualization abilities, and learning styles of students in acids and bases. The findings showed that computational attitudes, three dimensional spatial visualization abilities, and learning styles of the students had no effect on their test scores. However, a 52% improvement was observed in the post test results of the students of the experimental group and 31% improvement was observed in the

post test result of the students of the control group. Thus a significant difference was found favouring the computer-assisted instruction signifying that the teaching strategy promotes more students' learning abilities. Similarly, Steffen, Gill, Gundersen and Nelson (1996) posit that when students actually construct and animate molecules, they get a chance to see how a chemist or organic chemist thinks about structure. This helps bridge the gap between the traditional chalkboard drawings and more sophisticated visualization techniques scientists use.

Barnea and Dori (1999) found that students who were exposed to computerized molecular modeling (CMM) software in a study of its effect on high-school chemistry students' performance and gender differences performed better than those who were not in all three performance aspects. Their achievement scores were higher and though students' spatial ability improved in both groups, students from the experimental group scored higher implying that they gained better insight into the model concept than the control group and could explain more phenomena with the aid of a variety of models. An analysis of the findings for the average students in both groups indicated a unique and discernible improvement in all three spatial ability sub-tests – paper folding, card rotation, and cube comparison – with that of experimental group being significantly higher. This was interpreted to imply that this group of learners gained better insight into the model concept and could explain more phenomena with the aid of a variety of models. It was thus concluded that

CMM helps in particular to improve the examined cognitive aspects of the average student more. This was attributed to a better understanding of chemical bonding and improved three dimensional perception of molecular structure gained through the CMM experience of students in the experimental group. This improvement in their perception of various geometrical shapes and the relation between the molecular formula and geometric structure is in accord with the findings of Gabel and Bunce (1994).

### **2.3.2 Students' Attitude and Use of CAL**

Attitude is an important concept in social judgment and behaviour and thus, is one of the most important concepts in decision making (Venkatesh, Morris, Davis, G. & Davis, F., 2003). Existing empirical data show contradictory research findings on effect of use of ICT tools such as CAL on student attitude and achievement in general and in chemistry in particular. Generally, Becta (2004), to begin with reported that negative attitude was a barrier towards integration of ICT in teaching and learning while findings by Kubiato and Halakova (2009) pinpointed that learners' attitude towards use of ICT in teaching and learning was mainly based on its perceived impact. Similarly, Selwyn (1999) suggested that integration of ICT to a great deal depend on teachers and student attitude towards their use. This view is also supported by Slouti and Barton (2007) who added that ICT can motivate students in their learning by varying stimulus in lessons presentation and even sustaining the teachers interest in teaching. Myers and Halpin (2002) on their part asserted

that attitude of both students and teachers towards ICT use is a major predictor of the future use of the instructional tools in the classroom.

Specific to chemistry, Ozman (2007) in an initial pre-test results, reported no statistically significant differences between control and experimental groups suggesting similarity of group composition in respect of attitude. Comparative analysis of pre-test and post-test scores using an independent t-test showed a statistically significant difference between groups in favour of the experimental group implying positive impact of CAL on students' attitude in chemistry. Similar findings with regard to the effects of use of CAL on students' attitude in chemistry had also been documented by among others Harwood and McMahon, (1997) and Akcay *et al.* (2003). The latter, in a similarly study of effects of computer simulations on students' success and attitudes in chemistry found out that though there was no significant different between pre and post-test of control group, a significant mean difference was found between pre and posttest of experimental group ( $p < 0.005$ ) indicating that computer-based education is more effective than conventional methods in moulding students' attitude towards chemistry. While empirical data show that students' attitude may influence adoption of CAL in teaching and learning, there exists a gap in studies to ascertain its effect in chemistry instruction in Kenya, a gap that this study sought to contribute in helping to seal.

### **2.3.3 Students' Age and Gender and Use of CAL**

There is abundant empirical data on the effect of learners' demographic factors of age and gender on academic performance. Specific to age, there are minimal research findings on the relationship between learners' age and use of ICT media resources such as CAL. While increased motivation is important, Drent and Meelissen (2008), in a study of the impact of use of ICT on students' age (14-19 years) concluded that the tools rather than directly impacting achievement based on the variables mediate between motivation and other variables that are linked to development of learner autonomy and higher order cognitive skills. This fact is also supported by Earle (2002) who also argued that CAL tools enable the development of metacognitive skills and self-regulation among learners thus an increasingly effective learning strategies amongst pupils, greater engagement with learning activities and, in turn, improved achievement.

Similarly Nduati (2015) observed that CAL as a method of instruction does not significantly affect a specific age of learners. His findings agree with that of DeMeis and Stearns (1992) who realised an insignificant mean difference in achievement of learners exposed to CAL based on age. They thus separately concluded that academic performance is a product of personal determination, cognitive development and motivation as well as several other positive correlates. Chansarkar and Michaeloudis (2001) and Ugoji (2008) also insist

that age is not a predictor of learner achievement but is to some extent associated with their entry behaviour.

With regard to gender, some researchers have proposed that male students due to certain attributes tend to benefit more than their female counterparts when ICT resources are scarce (Nawe, 2002). The researcher therefore advises that special consideration should be given to female students during allocation of the instructional equipments. This is due to the tendency of male students to assume predominant operator role in circumstances where the instructional environment is faced with inadequate CAL tools including computers. Sanga, Mageza and Kayunze (2011) commenting on the same scenario proposes that failure of female students to access proportionally ICT resources just as their males counterparts may be due gender factors. Additionally, Volman and van Eck (2001) in findings from Europe and North America identified boys' greater access to computers in schools as well as boys' dominance in computer related tasks and discussions. The research noted that boys tended to be more active in computer-related classroom discussions, made more spontaneous comments, and were also asked more questions by teachers. Girls, the report noted tended to lack confidence in computing and most oftenly underestimated their computer-related competence. Similarly, Whitley (1997) reported boys to be using computers more frequently than girls at their homes, their friends' homes, and after-school clubs. This they achieved through playing games with the computer, used educational software, and accessed the Internet. Girls were

reported to minimally use computers for purposes including email, instant messaging, and homework. In general, the report concluded that boys were more assertive and dominant about computer and related use while girls were generally more passive.

According to some researchers, the critical role that education can play in unlocking ICT-related opportunities demand that access to new information technologies such as CAL be made more available to girls and women (Hafkin & Taggart, 2001; Rathgeber, 2001). At the very least, they insist that ICTs should be equally accessible to boys and girls. Gender activist propose that since it is believed that as girls enter adolescence; large numbers of them tend to lose interest in science, math, and computer technology, focus on a curriculum that emphasizes learning specific computer skills out of context may discourage them from using computers. However, when conditions are provided where they can easily access the tools in more relaxed circumstances, they may benefit more thus facilitate their learning. This study attempted to observe Kenyan chemistry students predisposition to use of ICT facilities in their schools and the existence or otherwise of gender based stereotypes.

#### **2.4. Teachers' Characteristics and Use of CAL**

A teacher plays a pivotal role in the teaching and learning process. Trowbridge (2004), maintains teachers are the most important determinant of classroom climate and are therefore conceived as the most important agents for

influencing change in classroom practice and by extension students' attitude and performance in Mathematics and Sciences (Kwale SMASSE, 2004). This review therefore assessed the essence of the chemistry teacher in the process of use of CAL in instruction of organic chemistry by considering how various aspects of the chemistry teacher impacts use of CAL and ultimately achievement in the topic. It considers the teacher's personal characteristics such as age, gender, educational level, teaching experience and attitude which have been shown to influence adoption of technology (Bitner & Bitner, 2002; Schiller, 2003) in classroom practice.

#### **2.4.1 Teachers' Age and Use of CAL**

Age as a factor is assumed to be related to computer use. Existing findings show mixed results on the existing relationship between instructor's age and use of technology tools such as CAL. To begin with, Comber, Colley, Hargraeves and Dorn (1997) found no evidence linking teachers age and use of CAL. Also supported by Blankenship (1998), the researchers individually observed that more mature teachers had interests other than use of ICT tools, a majority of the respondents (>50%) being more interested in learning about computers rather than how to integrate it. Similarly, Honeyman and White (1987) reported insignificant correlation between age and level of computer anxiety in a study of school administrators and teachers. He therefore concluded that age was not a consistent factor related to computer use, a conclusion arrived at based on conflicting results obtained for the same study.

Specifically while age seemed to be a negative predictor of use by the P-2 grade-level group and years until retirement as well as at 6-7 grade level group, in other grade-level groups, years remaining until retirement were positively correlated to computer use.

Lau and Sim (2008), on their part found out that older teachers were more frequent users of ICT tools for classroom instruction than their younger counterparts. In a finding similar to this, Buabeng – Andoh (2012) attributes the high tendency of more mature teachers to use ICT with more experience in teaching, classroom management which when added to competence in the use of ICT tools enable them integrate the tools in teaching. Similar sentiments have been expressed by Russell, Bebell, O’Dwyer and O’Connor (2003). However, Alazzam, Bakar, Hamzah and Asimiran (2012) found no link between age and teachers’ readiness to integrate ICT tools such as CAL in classroom teaching. The findings are supported by Inan and Lowther (2009) as well as Yang, Mohamed and Beyerbach (1999). However, it contradicts findings by Lau and Sim (2008) who observed that teachers’ age influences their readiness and adoption to use ICT during the teaching process. With regard to Kenyan scenario, there seems to be sparse information on how age of the public secondary school teacher affects their readiness to integrate ICT in the teaching and learning process. This study therefore sought to seal this research gap by investigating the effect of chemistry teacher’s age on CAL integration in the teaching and learning of the subject.

### **2.4.2 Teachers' Gender and Use of CAL**

Studies concerning teachers' gender and use of ICT tools such as CAL have equally yielded conflicting results most of which have been based on survey studies. Reports have cited low levels of female teachers' uptake of technology use, a fact they have attributed to among other factors their limited access to the tools, low skills, and minimal interest (Volman & van Eck, 2001 as cited in Buabeng – Andoh, 2012). Researchers such as Kay (2006) as cited in Buabeng – Andoh (2012) maintain that male teachers' ICT use is always predominantly higher compared to females. Other supporters of this school of thought include Markauskaite (2006) and Jamieson-Proctor, Burnett, Finger and Watson (2006) as cited in Buabeng – Andoh (2012) who generally agreed that female teachers extent of integration of ICT in classroom instruction was less than their male counterparts.

Contradictory findings are reported by among others, Breisser (2006) and Yukselturk and Bulut (2009). For Breisser (2006), findings acknowledged improved female teachers' self-perceptions about technology competence when that of their male counterparts remained static. Yukselturk and Bulut (2009) specifically concluded based on their findings that female teachers were more likely to utilize ICT tools in classroom instruction than males. Additionally, Gordon (2003) and Norris, Sullivan, Poirot and Soloway (2003) as cited in Buabeng-Andoh (2012) concluded that gender as a variable is not a predictor of ICT integration into teaching. This study investigated the gender dynamism

in ICT integration in the teaching and learning of chemistry in Kwale County public secondary schools in an attempt to provide the Kenyan view.

### **2.4.3 Educational Background and Use of CAL**

Different researchers hold divergent opinion on the effects of teachers educational background on their extent of use of ICT tools such as CAL. For instance, while Alazzam *et al.* (2012) found relationship between teachers' educational background and their readiness to integrate ICT in teaching, Lau and Sim (2008) indicates an existence of effect of the level of teachers' academic qualification on ICT adoption. This observation is consistent with those of Mahmud and Ismail (2010) which indicated that ICT training contributed to teachers' ICT literacy significantly. Similarly, Tezci (2009), showed that teachers' level of training had a significant effect on their ICT skills and resulted in the effective use of ICT in classroom teaching. This study sought to provide the Kenyan view of the effect of teacher's background on technology integration in the teaching and learning of chemistry with specific focus on use of CAL in instruction of chemistry.

### **2.4.4 Teaching Experience and Use of CAL**

The experience that a teacher has amassed in the teaching and learning process has been shown to be an important predictor of their classroom practice (Buddin & Zamarro, 2009). Relative to technology integration, there are conflicting opinions by researcher on how experience impacts a teacher's

tendency to adopt ICT integration. From the divergent opinions, two trends emerge. The first trend denies the existence of any link between experience and teachers' use of CAL (Niederhauser & Stoddart, 2001 as cited by Buabeng – Anduh, 2012). Other supporters of this school of thought include Granger, Morbey, Lotherington, Owston and Wideman (2002) as cited by Buabeng-Anduh (2012); Russell, O'Dwyer, Bebell and Tao (2007). They each conclusively believe that there exist no statistically significant relationship between teachers' experience in teaching and use of ICT tools. Similar observations can be attributed to Alazzam *et al.*, (2012) and Mueller, Wood, Willoughby, Ross and Specht (2008) who each did not find any significant effect of teaching experience on teacher readiness to integrate ICT in teaching.

Proponents of the second school of thought maintain that there exist a link between teaching experience and use of ICT tools (Giordano, 2007; Hernandez-Ramos, 2005 as cited by Buabeng-Anduh, 2012; Wong & Li, 2008). Gorder (2008) for instance is categorical that teaching experience significantly affect use of technology, an assertion also corroborated by Baek, Jong and Kim (2008) as cited by Buabeng-Anduh (2012). Similar sentiments are held by U.S National Centre for Education as well as Inan and Lowther (2009) who found that years of teaching experience affect teachers' computer proficiency in a negative manner. Ertmer (2005) is equally categorical that teachers' work experience influence their readiness and beliefs in ICT

integration in teaching. This study intended to make its contribution by including a Kenyan dimension into the discussion.

#### **2.4.5 Teachers' Workload and Use of CAL**

Teaching is today one of the most demanding professions making teachers some of the most stressed professionals. Current research in trends in education the world over show that teachers face many challenges despite efforts on several fronts to address the pressures. Naylor (2001) in a report by British Columbia Teachers' Federation in Canada showed that teachers are stressed due to unmet needs of students, class composition, size of workload, attitudes of provincial government, and the inclusion of students with special needs in normal schools.

In Kenya, Sifuna and Sawamura (2009) in a paper entitled "the illusion of free primary education" paints a grim picture of the conditions prevailing in the country's basic education sub sector. The researchers allege that the free primary education program though praised as progressive has created considerable problems with regard to conditions and facilities for teaching and learning. Due to the high influx of new pupils, classrooms are congested and the existing facilities make a mockery of the free education program, an assertion supported by Itunga (2011), Otach (2008) and UNESCO (2005). The conditions, the researchers all agree have stretched the classroom teacher to the limit in terms of work load and class management.

Several studies have linked teachers' workload with use of technology in the classrooms. Notable examples include Samarawickrema and Stacey (2007) and Neyland (2011) as cited in Buabeng-Andoh (2012) who argue that increased workload impedes teaching with technology. Specifically, Neyland (2011) alleged that increased workload was alarming, that curriculum was overcrowded and teachers had too much work within the day which was pushing many of them to the limit. Therefore, Fullan (2003) recommends that to enable implementation of new initiatives such as CAL so as to provide quality education, teachers workload needs to be lessened. This study evaluated the effect of teacher work load on extent of integration of ICT in public schools.

#### **2.4.6 Professional Development**

Professional development is an important factor that is perceived to promote effective integration of ICT in the classroom. Some studies have alleged that though ICT tools such as CAL were accessible in schools, teachers were still mainly employing conventional instructional methods for classroom instruction and were not making the necessary effort to integrate ICT to create innovative learning experiences for their students (Jules-Van-Belle & Soetaert, 2001). Others maintained that though some were making effort to integrate technology, the level of use was still not effective enough (OECD, 2001). The malaise in ICT integration according to these studies are attributed to teachers' attitude towards computer use (Norris *et al.*, 2003) and an improper

instructional reform based on improper pedagogical beliefs (Selwyn, Dawes & Mercer, 2001). Teachers, the researchers argue need knowledge of appropriate ICT integration strategies and ICT skills to effectively integrate the tools in their lessons and optimize the benefits for their students' learning (Pedretti, Mayer-Smith & Woodrow, 1999). Therefore, teachers' professional development has to focus on both ICT skills training as well as appropriate ICT integration strategies in the curriculum (Divaharan & Koh, 2010) as an answer to the loophole.

Since ICT in education is considered as a relatively new innovation in education, professional development is a key factor to its successful integration into classroom teaching. Several studies have revealed that whether beginner or experienced, ICT related training programs develop teachers' competences in computer use (Bauer & Kenton, 2005; Franklin, 2007), influence teachers' attitudes towards computers (Hew & Brush, 2007; Keengwe *et al.*, 2008) as well as assisting teachers reorganize the task of technology and how new technology tools are significant in student learning (Plair, 2008). Muller *et al.* (2008) related technology training to successful integration of technology in the classroom. They showed that professional development and the continuing support of good practice are among the greatest determinants of successful ICT integration.

Additionally, researchers have shown that teachers' ICT skills as well as their intentions towards ICT use predict effectiveness of its integration (Vanderlinde, van Braak & Hermans, 2009; Venezky, 2004). To them, professional development is achieved by observing colleagues, learning from each other, observation of each others' ICT-integrated lessons, as well as the provision of opportunities for teachers to share and collaborate (Flanagan & Jacobsen, 2003; Prain & Hand, 2003). Sandholtz and Reilly (2004) as cited in Buabeng – Anduh (2012) acknowledge that teachers' ICT skills strongly predict the extent of ICT use in classroom teaching. Teachers, the researchers posit, should therefore be exposed to programmes that enhance their mastery of pedagogical skills related to ICT tools. This observation is also supported by other researchers including Brinkerhoff (2006), Diehl (2005) and Lawless and Pellegrino (2007) as cited in Buabeng-Anduh (2012). Buabeng – Anduh (2012) specifically posits that experts in technology should be accessible to teachers to guide them on how best to integrate ICT tools to facilitate students' learning an observation earlier supported by Chen (2008), Lawless and Pellegrino (2007) and Plair (2008) as cited by Buabeng-Anduh (2012). Collectively, the researchers agree that teachers' understanding of content knowledge and how to apply technology to support students' learning and attainment is linked to their increase in knowledge level, confidence and attitudes towards technology. This study attempted to further this line of research by exploring the perceived influence of chemistry teachers'

professional development with regard to knowledge in ICT and how it affects their use of CAL.

#### **2.4.7 Teachers' Attitude and Use of CAL**

Attitude is important in understanding human behaviour. Generally attitude is defined as a complex mental state involving beliefs (Hussain, Ali, Khan, Ramzan & Qadeer, 2011). It is an individual's prevailing tendency to respond favourably or unfavourably to an object, person or group of people, institutions or events. Attitude in science means the scientific approach assumed by an individual for solving problems, assessing ideas and making decisions in the scientific field (Olatunde, 2009). It determines an individual's predisposition towards a phenomenon including whether or not to adopt innovation (Rogers, 1995). Based on this observation, attitude appears to be a factor that could influence integration of ICT tools in classroom instruction. Previously, it has been shown that a successful launch and implementation of educational technology such as CAL in school's program depends strongly on the teachers' support and therefore could be an attribute of attitude.

Huang and Liaw (2005) as cited in Buabeng-Anduh (2012) are categorical that acceptance of the usefulness of technology by teachers and its integration into teaching is to a great extent predicted by their attitude towards the technology. Similarly, Russell and Bradley (1997) contend that anxiety, lack of confidence, competence and fear often implies ICT takes a back seat to conventional

learning mechanisms. In a study of factors influencing technology adoption in Europe, European Schoolnet (2010) as cited in Buabeng-Anduh (2012) reported that teachers' use of netbook positively impacted their learning by promoting individualized learning and helped to lengthen study beyond school day impacting positively their attitude.

Contradictory findings were however reported by Korte and Husing (2007) and Becta (2008) in Buabeng-Andoh (2012), both researchers indicating minimal or no effect of attitude particularly with regard to specific advantages of the ICT tools. Additionally, researchers including Hew and Brush (2007) and Keengwe *et al.* (2008) maintain that it is likely that teachers will not integrate technology when they consider its programs as neither fulfilling their needs nor that of their students. Similar to ascertions of Buabeng-Andoh (2012), the researchers conceive teachers' attitudes and beliefs as factors that are important in successful integration of CAL. According to them, teachers with positive attitudes towards technology integration easily seek for useful insight about its adoption and integration. This idea is also confirmed by Demirci (2009), Teo (2008) as well as Drent and Meelissen (2008) who separately concluded that positive attitude towards computers, computer experience and personal entrepreneurship of the teacher educator have a direct positive influence on the innovative use of ICT tools which is also echoed by Buabeng-Andoh (2012). A link has also been suggested to exist between teachers' computer experience and their computer attitudes. In particular, Rozell and Gardner (1999) posit that

the more experienced teachers are in use of computers, the more they are likely to show positive attitudes towards their use. Additionally, van Braak, Tondeur and Valeke (2004) as cited in Buabeng-Andoh (2012) are categorical that positive computer attitudes foster its integration in the classroom. Other proponents of positive impact of attitude on CAL use include Huang and Liaw (2005) as reported in Buabeng-Andoh (2012) as well as Russell and Bradley (1997).

In Kenya, Odera (2011) in a comparative study of the use of computers by secondary school teachers in the country found that 60% of the interviewees had a positive attitude, 30% being very positive and only 10% being negative. However, the study also established that moderate to high levels of computer phobia also existed. This phobia was presumed to be the main cause of their reluctance to integrate ICT tools even in situations teachers had suggested having positive attitude. Further studies are thus required to provide an insight on how the stated tendencies impacts on adoption and use of CAL in teaching and learning, a task that this study sought to make a contribution to.

#### **2.4.8 Computer Anxiety and Use of CAL**

Previous studies have noted the link between technology anxiety and technology integration in classroom instruction (Agbatogun, 2010). Anxiety is a long term physiological construct. Russell and Bradley (1997) reportedly found that teachers' levels of computer anxiety were related to their conception

of the usefulness of the tool. This is supported by Tsai and Tsai (2003) who found a significant association between students' meta-cognitive skills, computer achievement and their level of computer anxiety.

Studies have also shown that there exist a link between an individual's computer anxiety and other variables including age (Namlu & Ceyhan, 2002); frequency of computer use (Necessary & Parish, 1996); computer experience (Yaghi & Ghaith, 2002); neuroticism (Anthony, Clarke & Anderson, 2000) and individual's appraisal of computing situation (Cralle, Brodzinski, Scherer & Jones, 1994).

Findings by Agbatogun (2010) indicated that when computer anxiety was used as a predictor, results revealed significant prediction  $F(1, 452) = 243.872, p < 0.05$ ). Specifically, it indicated that computer anxiety singularly contributed 35.0% towards the prediction of teachers' attitude towards Interactive Computer Technology. In other words, research outcome intimated that computer anxiety is a significant potent predictor of teachers' attitude towards Interactive Computer Technology. Commenting on the outcome, the researcher asserted that one may be prompted to infer from the outcome of the study that since many secondary school teachers are still seemingly techno-phobic; their uptake of computer technology skills for onward transfer to the education system is relatively slow, low and insignificant. Similar observations were made by Papanastasiou and Angeli (2008), Pelgrum and Plomp as cited in

Russel and Bradley (1997). The study sought to assess the effect of chemistry teachers' computer anxiety on their extent of integration of CAL in teaching and learning of the subject.

#### **2.4.9 Teachers' Self-concept and Use of CAL**

Self-concept is the cognitive or thinking aspect of self (related to one's self-image) and generally refers to the totality of a complex, organized, and dynamic system of learned beliefs, attitudes and opinions that each person holds to be true about his or her personal existence (Huitt, 2004). It generally denotes the conscious reflection of one's own being or identity, as an object separate from others or from the environment. Accordingly, there are a variety of ways one could think about the self, two of the most widely used terms being self-concept and self-esteem. Malle (1999) considers self-concept as an individual's internal representation of who he/she is while Hattie (1992), conceives it as the product of all an individual's self-belief and self-evaluation. In simple terms self-concept is the way an individual view himself/herself.

Self-concept is said to be the main determinant of an individual's attitude, behaviour, and coping abilities (Agbatogun, 2010). It therefore holds that positive self-concept mean positive evaluation, while negative self-concept is associated with negative evaluation. Furthermore, Huitt (2004) indicates that individuals with poor self-concept tend to blame failure on external causes but take full credit for successes. In a simple sense, the researchers maintain that

whereas self-concept is a significant predictor of performance, task goals are associated positively with self-concept, and self-efficacy, performance-approach goals are also associated positively with self-concept; and performance-avoid goals are associated negatively with self-concept.

Relative to specific learning outcome, Marsh (1992) found out that there exist a specific relationship between self-concept and teacher related school achievement. The researcher established that though general self-concept and non-academic aspects of self-concept are not related to academic work; general academic achievement measures are related moderately to academic success and specific measures of subject-related self-concepts are highly related to success in content area. Similarly, Bandura (1997) provides evidence that self-efficacy or one's belief that he or she can perform a specific task is the best predictor for success on the task.

Agbatogun (2010) established a significant relationship between teachers self-concept and their attitude towards CAL. While commenting on the study finding, the researcher acknowledged that the issue of self assessment in relation to performance is important because no individual can out-perform himself or herself. What an individual thinks about his/her ability to perform dictates his/her attitude (positive or negative) towards such. By implication, what many teachers think about themselves in relation to CAL use often dictate their attitude towards its acceptance, acquisition of knowledge and skills,

integration and effective use the technology tool. Similar findings are attributed to Russell and Bradley (1997) as well as Deniz (2007). This study sought to further this work by providing the Kenyan case.

## **2.5 Institutional Factors and Use of CAL**

According to Buabeng – Andoh (2012), institutional factors to a great extent enhances teachers’ existing attributes. Citing other researchers including Vannatta and Fordham (2004) as well as Norris *et al.* (2003), the researcher is categorical that teacher’s time committed to teaching and amount of the teacher’s technology training are reliable predictors of their technology use in the classroom. Administrators should thus not only facilitate extensive training on educational technology for teachers, but also facilitate a contribution to teaching improvement. In the same breadth, researchers have proposed enhancement of professional development (Bauer & Kenton, 2005; Franklin, 2007), accessibility (Usluel, Askar & Bas, 2008; Yildirim, 2007), technical support (Becta, 2004; Jones, 2004) and leadership support (Lai & Pratt, 2004; Yee, 2000) for effective CAL integration. Therefore, this study conceived that an understanding of institutional characteristics that influence teachers’ adoption and integration of CAL is relevant and set to further this line of research in an attempt to provide an understanding of the influence of the Kenyan secondary school factors on the process of CAL integration in the teaching and learning process.

### **2.5.1 Access to CAL Teaching and Learning Resources**

Previous studies show that access to ICT infrastructure and resources in schools is a necessary condition for effective integration of ICT in education (Plomp, Anderson, Law & Quale, 2009). Buabeng-Andoh (2012) maintain that availability and accessibility of ICT resources such as hardware and software are important for effective adoption and integration of the tools. The researcher is of the opinion that teachers can only use what they can access. If they cannot access something, then they will not use it. This mean that access to computer, updated software and hardware are key elements for successful adoption and integration of CAL. This generally concurs with observations of Yildirim (2007) as well as Usluel *et al.* (2008). Specifically, Albirini (2006) in his research findings revealed that though 57% of the respondent teachers acknowledged having access to computers at home, only 33.4% could access the tool in school implying that teachers under this specific study had inadequate access to computer.

Inadequate access to ICT resources has been shown to impact integration of the resources. Buabeng-Andoh (2012) citing Afshari, Bakar, Luan, Samah and Fooi (2009) revealed that while over 50% of teachers who participated in their study indicated using computers for research and lesson preparation in their schools, about 78% of the respondents complained of inadequate access to computers in classroom. In particular, 38% maintained that while inadequate computers were not great barriers to ICT use in their teaching, improved

availability and fairness of access to the resources by teachers, students and administrative staff is essential. Citing Tondeur, Valcke and van Braak (2008), Buabeng – Andoh (2012) is categorical that access to the tools is not only important, but also the suitability of the available tools and program to support teaching and learning equally important. Friedhoff (2008) as cited in Chen (2010) maintains that access to appropriate technology means that affordances and constraints of a technological tool need to be carefully considered when the tool is being incorporated in a lesson. For instance, in a study of preservice teachers by Dexter and Reidel (2003), they revealed that 37.4% of the teachers had access to computers and 14.4% of the students had access to computers, implying that computers are more available to teachers than students. Obviously, to encourage student centred technology learning, it is necessary that learners have access to quality technology resources.

### **2.5.2 Technical Support.**

Technical support in relation to ICT integration entails installation, operation, maintenance, network administration and security of the tools (Sife, Lwoga & Sanga, 2007). These according to the researchers form an important component of the implementation and integration of ICT tools. Documentary evidence link ICT integration in most developing countries with minimal technical support (National Committee for WSIS Prepcom II, 2003, as cited in Sife, Lwoga & Sanga, 2007). In retrospect, researchers advocate for basic training to teachers and even at times students so that they are able to troubleshoot technical

problems whenever they arise. Where possible, it is advisable that appropriate strategies be put in place to ensure that integration of ICTs in teaching and learning process goes together with recruitment, training, retraining and retention of staff with appropriate skills and expertise in the tools.

Other researchers who concur with such observation include Jones (2004), Becta (2004) and Yilmaz (2011) as cited in Buabeng-Andoh (2012). While Jones (2004) reported that lack of technical assistance during breakdown of a computer causes interruptions thus discouraging teachers from using computers, Becta (2004) asserted that lack of technical support available in a school impede maintenance resulting in a higher risk of technical breakdowns. Yilmaz (2011), on his part advises stakeholders that in providing schools with ICT hardware and internet connectivity, it is also crucial that technical support be availed to enable repair and maintenance that would ensure the continued use of ICT tools in schools.

Empirical data associate lack of technical support for a school's technology needs with teachers' frustration and unwillingness to use the technology tools (Korte & Husing, 2007 and Tong & Triniada, 2005 as cited by Buabeng-Andoh, 2012). Collectively, the researchers insist that if there is no technical support, teachers in the course of integrating often become frustrated resulting in their unwillingness to use ICT tools. In particular, the study by Korte and Husing (2007) as cited in Buabeng-Andoh (2012) revealed that schools in

Britain and the Netherlands appreciate the significance of technical support to teachers effort in integrating ICT in classrooms. This was mainly because it was found to minimise time wasting in troubleshooting hardware and software problems. This study attempted to explore the quality of technical support available to public schools and how it impacts on ICT integration in the teaching and learning of chemistry.

### **2.5.3 Leadership Support**

As a key stakeholder in the day to day operations of a school, the administration play a critical and central role in the realization of targeted outcomes (Ayot & Patel, 1992). ICTs are increasingly used and viewed as important in all spheres of operation including education. This requires an effective and dynamic school administration. It has however been observed that the twenty-first century school administrator faces numerous challenges related to technology (Omwenga, 2005). This could be the main reason behind the minimal uptake of ICT integration in most schools even when the tools are readily available. Sife *et al.* (2007) link administrative support to the successful integration of ICTs. The researchers maintain that it is imperative that administrators provide the conditions that are needed, such as ICT policy, incentives and resources. This assertion is also supported by Ndiritu, Gakuu and Kidombo (2012) who affirms the fact that commitment and interest of an institution's top management and other leaders at every level is the most critical factor for successful implementation of ICTs within the institutions.

Consequently, Cameron and Ulrich (1986) as well as Dwyer, Ringstaff and Sandholtz (1997) as cited in Sife *et al.* (2007) proposed transformational leadership in schools ready to embrace fundamental change which is required for the institutions to adapt to changes brought about by the information society. Specifically, Dwyer *et al.* (1997) as well as Sife *et al.* (2007) emphasize that for the integration of ICTs to be effective and sustainable, administrators themselves must be competent in the use of the technology, and they must have a broad understanding of the technical, pedagogical, administrative, financial, and social dimensions of ICTs in education.

Similarly, it is the contention of Anderson and Dexter (2005) that though infrastructure support is imperative, school technology leadership is a stronger predictor of teachers' use of computer technology in teaching. Yee (2000) believed that a leader who implements technology plans and also shares a common vision with the teachers stimulate them to use technology in their lessons. Lai and Pratt (2004) suggests that for effective utilization of ICT by teachers, there is the need for a strong leadership to drive a well-designed technology plan in schools. Becta report on the effect of ICT on teaching in basic schools in United Kingdom also stressed on significance of good leadership (as cited in Lai & Pratt, 2004). The report identified five factors that are considered essential for schools if ICT is to be utilized properly. These

factors include ICT resources, ICT teaching, ICT leadership, general teaching and general school leadership.

Specific examples of significance of leadership support to ICT integration include observations of researchers such as Afshari *et al.* (2009), Ng (2008) as well as Wong and Li (2008) as cited in Buabeng-Andoh (2012). For instance, in citing Wong and Li (2008), Buabeng-Andoh (2012) indicates that good leadership promote collaboration, experimentation and teachers dedication to student-centred learning which influence ICT integration. Similarly, Ng (2008) as reported by the same researcher revealed that a transformational leadership with qualities of identifying and articulating a vision, promoting acceptance of group goals, providing individualized support, offering intellectual stimulation, providing an appropriate model, creating high performance expectations, and strengthening school culture could influence integration of ICT. Commenting on the same issue Afshari *et al.* (2009) concluded that transformational leadership could help improve integration of ICT into teaching and learning processes. Other researcher in support of this line of argument include Anderson and Dexter (2005) and Yuen, Law and Wong (2003).

Institutional leadership determines the direction and thrust of an institution towards learning programmes that are to be assimilated into the institution (Ayot & Patel, 1992). The rigour with which institutions implement e-learning among their students and staff is based on the institutional leadership's thrust

and initiatives towards the realization of this goal (Ndiritu *et al.*, 2012). There are considerations that institutional leaders have to make to enable implementation come to fruition. One of the most crucial prerequisites for successful implementation of e-learning is the need for careful consideration of the underlying pedagogy, or how learning takes place online (Govindasamy, 2002). This is the prerogative of institutional leaders to ensure that the right approach is adopted and the appropriate infrastructure and attitude is inculcated in those whose task it is to finally implement e-learning. This study sought to investigate the quality of leadership support that chemistry teachers in secondary schools in Kwale County are provided with and how it affects technology integration in the teaching and learning.

## **2.6 Challenges of use of CAL**

Implementation of ICT in schools according to available empirical data faces several challenges. These according to Mwalongo (2011) include limited ICT facilities, costly internet access, limited information sharing, limited skills for ICT integration and shortage of labour force due the failure of training institutions to produce ICT technicians and professionals needed for the labour market. Similar sentiments were reported by Mendes, Tuijnman and Young (2003) as well Swarts and Wachira (2010) as cited in Mwangolo (2011). Other challenges according to the researcher include limited electricity supply, poor telephone connectivity and inadequate number of computers which is also supported by Hesselmark (2003). Hare (2007) considered lack of policy

framework, inadequate infrastructure, high cost of bandwidth, and inadequate in-service training on ICT integration in education as some of the factors inhibiting ICT integration.

Mendes *et al.* (2003) as reported in Mwangolo (2011) in a study of extent of use of ICT resources indicate less emphasis on ICT training in learning institutions including primary and secondary schools in Tanzania due to limited facilities while Adomi and Kpangban (2010) in a study on causes of the low rate of ICT adoption and application in secondary schools in Nigeria found it to be attributable to several factors. These factors were found to include; limited/poor infrastructure, lack of/inadequate ICT facilities in schools, frequent electricity interruption, poor ICT policy/project implementation strategy, inadequate ICT manpower in the schools, high cost of ICT facilities and lack of/poor perception of ICTs among teachers and administrators. While some studies document challenges attendant to ICT integration into Kenyan education system, they are not specific to ICT integration in the teaching and learning of chemistry. This study attempted to provide an insight on challenges attributed to this specific area of focus.

## **2.7 Summary of Literature Review and Research Gap**

Despite the wide body of research done in respect of ICT integration in Kenyan educational institutions, no specific research that highlights the extent and effect of integration of CAL in organic chemistry is available. The generalized

outcomes from research done on ICT integration may or may not apply specifically to integration of CAL in teaching and learning of organic chemistry, an important area of chemistry education in the secondary schools curriculum. This is the basis upon which the researcher set out to assess the effects of use of CAL in teaching and learning of organic chemistry in public secondary schools in Kwale County. Whereas there is consensus from previous research findings that CAL positively impacts classroom pedagogy, it is also widely acknowledged that various ICT tools are best suited for instruction of specific areas of the curriculum. Equally, while a lot of resources have been used to provide the ICT tools such as those used in integration of CAL, availability of resources does not necessarily guarantee their use. Still, it is alleged that some of the resources availed may not necessarily be appropriate for classroom pedagogy.

More importantly, it has been seen in other instances that more effort has been expended in making the resources available while little regard is given to the users of the resources who could be ill prepared to use them. The existing research gap is to determine optimal levels of use of available ICT tools such as CAL to ensure an enriched classroom environment particularly with regard to chemistry, a subject in which a majority of students have persistently posted poor achievement in succeeding years both at the County level in Kwale and nationally in Kenya.

## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **3.1 Introduction**

This chapter describes the method that was used to carry out the study. It outlines the research design, study location, target population, sampling procedure and sample size. Also included in the chapter are instruments for data collection, the pilot phase for pretesting the instruments, reliability and validity, procedure used for data collection, methods of data analysis and issues of ethical consideration.

#### **3.2 Research Design**

The main aim of this study was integration of CAL in instruction of chemistry and its effect on secondary school students' learning and achievement in organic chemistry. In order to achieve this, the study adopted a quasi-experimental design of the Solomon's four group type. In this design, the study sample was divided into four groups, two of which were experimental while the other two were control. The first group was an experimental group and was tested before and after receiving treatment. The second group which was a control group, was tested before and after receiving no treatment. The third group, also an experimental group was tested only after receiving treatment. The fourth group (another control group) was tested only once, that is, no treatment and no pre-test. The Solomon's four group model is represented in Figure 3.1.

Group	Pre-test	Treatment	Post-test
E <sub>1</sub>	O <sub>1</sub>	X	O <sub>2</sub>
C <sub>1</sub>	O <sub>3</sub>	X <sub>1</sub>	O <sub>4</sub>
E <sub>2</sub>		X	O <sub>5</sub>
C <sub>2</sub>		X <sub>1</sub>	O <sub>6</sub>

**Key:** E: Experimental, C: Control, X: Treatment, X<sub>1</sub>: No treatment, O: Observation

**Figure 3.1 Research Rubric for Solomon's Four Group Design**

The Solomon's four group design according to Johnson and Onwuegbuzie (2004) provides strong evidence for intervention and allows assessment of both testing effects and confounding variables which is possible in neither the two-group pre-test-treatment post-test models nor the two-group treatment-post-test model. The Solomon four group model incorporates the advantages of the two-group pre-test-treatment post-test and the two-group treatment-post-test models but eliminates the disadvantages of the two. The model is actually a combination of the two models (two-group pre-test-treatment post-test and the two-group treatment-post-test models). Fraenkel and Wallen (2006) supports the use of this method because it is considered sufficiently rigorous and appropriate for experimental and quasi-experimental studies. Cohen, Manion and Morrison (2011), on their part find it appropriate since it provides adequate control of the extraneous variables that would have affected the internal and external validity of the study which include student attitude towards chemistry, student gender, achievement level and age.

Quasi – experimental design was adopted because it was not possible to assign individual participants to groups randomly. Receipt of permission to include

students from schools as participants in the study was also based on the understanding that they would be kept within their existing class units to guarantee negligible external interference with their learning programs. Further, entire classroom and not individual students were assigned to various treatment groups. Since random assignment was not possible, quasi experimental design was found most appropriate. Additionally, to minimize threats of internal validity, effort was made to include groups of students with similar characteristics as much as is possible. This also enabled the researcher to minimise possible effects from reactive arrangements (Gay, Mills & Airasian, 2009).

### **3.2.1 Variables**

The study assumed that student achievement in chemistry is dependent mainly on teachers' instructional strategy; the strategy investigated here being CAL based instruction. Therefore, the experimental groups were exposed to CAL instruction strategy while the control group were exposed to conventional methods of instruction. The independent variables therefore, are instructional strategies (CAL based or conventional) while the dependent variable is student achievement in organic chemistry. However, student achievement in chemistry (the dependent variable) may also be influenced by many other factors apart from the identified independent variable, which is, teaching strategy. These are control variables, which the researcher sought to build into the study. They include student attitude towards chemistry, student gender, students' ability

and their age. Attitude was categorized as either positive or negative while their ability was categorized as either high or low. The choice of samples was done in a manner that ensured that both the experimental and control groups had students with these attributes. This statistical procedure was meant to ensure high internal validity for the findings of the study. According to Mugenda and Mugenda (2003) when control variables are built into a study, their influences on the dependent variables are well catered for, thereby making the study findings more valid.

### **3.2.2 Research Methodology**

The study which was of mixed method aimed at determining the relationship between instructional strategy and student achievement (Cohen *et al.*, 2011) in organic chemistry. Being quantitative, it employed null hypothesis to assess the existing relationship between the targeted variables. Achievement tests were used to measure learners' level of achievement attributed to instructional strategy. Additionally, the study was deductive in nature since it aimed at making generalisation. In addition to the achievement tests, the study used questionnaires to collect quantitative data. Minimal qualitative data was collected using interview schedule to help fill the knowledge gaps that could not be sufficiently catered for by the achievement tests and the questionnaires.

### 3.2.3 Treatment and Control Procedures

The study involved two control and two experimental groups; one group in each school with a total of 182 students. Students in all the four groups filled questionnaires before treatment was administered to them. Then a group each from control and experimental category sat the pre-test SCAT followed by administration of the intervention. The study principally involved teaching the students organic chemistry using two teaching strategies – CAL and conventional methods. Learners in the two control groups were taught organic chemistry II for a period of 3 weeks beginning the second week of March 2015 upto the end of the month using conventional method. Learners in the two experimental groups were taught the same topic using CAL based teaching strategy over the same period.

Classroom instruction took place during normal chemistry lessons. Though treatment for the respective control groups took place mainly in their respective classes, the 3 practical sessions were carried out in the chemistry laboratory. Those for the experimental groups were given mainly in the computer laboratory, two students assigned to one desktop computer to which CAL instructional lesson material had been installed. Teachers handling CAL lessons had CAL instructional material installed in a laptop that was connected to a projector. This was made so as to enable the teacher be able to demonstrate to students how to consistently manipulate CAL instructional materials appropriately. CAL supported experimental procedures were carried out in the

chemistry laboratory with the CAL illustrations being projected for their observation before they embarked on individual experimental procedures. The CAL lesson materials provided to students and teachers in the experimental groups were CAL supported instructional materials developed by KICD. They contained drills, illustrations and exercises for users. These CAL supported lesson materials were installed in desktop or laptop computers which the students and teachers used.

Generally, teaching instructions were conducted by the respective chemistry teachers for all the groups though the schools' ICT technicians were at hand to assist chemistry teachers with technical issues where necessary. At the end of the three weeks, students in all the four groups were given a post-test SCAT developed by the researcher in consultation with respective chemistry teachers handling the experimental and control groups. Before administration, each of the instruments were independently validated by three senior KNEC chemistry examiners for Chemistry Paper II.

### **3.3 Study Location**

The study was conducted in Kwale County within the Coastal region of Kenya. Kwale County is in the southern part of the Coastal region of Kenya, about 500 kilometres South of Nairobi. It is bordered by Taita Taveta County to the West; Kilifi County to the North; Mombasa County and Indian Ocean to the East and United Republic of Tanzania to the South. It consists of Kinango, Kwale and

Msambweni districts. Chemistry performance in the County has been poor for a long time. Therefore, studies on intervention such as the current study were deemed necessary. The larger administrative unit had been selected so as to obtain a wide and varied study sample. A photographic illustration of the county is attached to the document as Appendix H.

### **3.4 Target Population**

The study targeted all public secondary schools in Kwale County, Kenya with ICT infrastructure for integration of CAL. Form four chemistry students and their chemistry teachers were target population for the study. At the time of the study, Kwale County had 22 public secondary schools with ICT infrastructure. The study therefore targeted 1980 form four students and 50 chemistry teachers. Form four students were considered for this study due to the fact that having had a longer period of exposure to secondary school life, they were better placed to provide a more concrete information required for this study. More importantly the topic selected for this study is offered at form three and form four with the form fours having had the introductory organic I in form three.

### **3.5 Sampling Technique and Sample Size**

#### **3.5.1 Sampling Technique**

Sampling was done at four levels starting with the county, followed by schools, then students and lastly teachers.

**County:** Kwale County was proposed as the research site purposively. This was mainly for logistical reasons. A study on use of CAL in instruction in chemistry in secondary schools has not been conducted in the region which mitigates the choice of the county.

**School Type:** The selection of school type was done through purposive sampling. The researcher used students from county and sub county schools only since students in these schools have comparable entry behaviour at KCPE and therefore were of interest to the researcher. More importantly, nearly all schools in the county fall into these two categories (over 95% of schools in the county) thus, by picking these as the only categories, the findings would be more generalizable to the whole county.

Similarly, a critical mass of students in secondary schools countrywide are found in these category of schools. With regard to individual schools, the researcher used stratified random sampling technique. This technique was deemed appropriate since it guarantees desired representation of relevant subgroups which in this case are mixed county schools and mixed sub county schools. There was a total of four schools participating in the study. Two of them were county schools while the other two were sub county schools. The experimental and control groups each contained one county school and one sub county school. Table 3.1 shows the sampling grid for study population:

**Table 3.1**  
***Sampling Grid***

School Type		Targets Population			Sampled Population		
		School	Teachers	Students	Schools	Teachers	Students
School	County	10	28	900	2	20	90
	Sub County	12	22	1080	2	17	92
Total		22	50	1980	4	37	182

**Streams/students:** Most schools in Kwale County have between two and three streams for every class level. Therefore, for the sampled schools, the researcher further sampled one stream randomly where the school had multiple streams per class. Students were engaged in their already existing groups/streams without random assignment to either control or experimental groups. Schools were randomly chosen as either an experimental centre or control centre such that no one sampled school had students in both groups. This was intended to ensure that members of the control group were not made aware of the existence of an experimental group and vice versa.

**Teachers:** Teachers who participated in the study were sampled purposively. This was done so as to ensure that teachers selected were those handling the candidate classes in their schools and that they were chemistry teachers by training. Therefore, 37 chemistry teachers participated in the study including the 4 teachers who handled students in the experimental and control groups involved in the study. Teachers handling the experimental classes were taken through a brief training on implementing the CAL lessons before they were asked to implement them during the treatment phase. Similarly, those who handled the

control group were inducted in using conventional methods to implement the lesson during treatment phase.

### **3.5.2 Sample Size**

Since the study adopted a quasi-experimental design, the researcher obtained the sample from already existing groups without manipulation of their membership. The study used a Solomon's four group model of quasi-experimental designs and therefore used four classes (Johnson & Onwuegbuzie, 2004) each with an average student population of 45. Therefore, for the student population, a sample size of 182 was used. A total of 37 form four chemistry teachers from the 22 purposively sampled schools were also used in this study who included the four chemistry teachers handling the four test groups. Thus the total study sample was 219.

## **3.6 Research Instruments**

A total of six instruments were used.

### **3.6.1 Pre-test SCAT**

The pre-test SCAT instrument was prepared on topics of choice that included atomic structure, the periodic table, chemical family and mole concept; topics which had previously been covered by all the learners involved in the study. The main aim of the pre-test instrument was to test the students' ability in chemistry. The instrument consisted of ten short structured questions of the

Chemistry Paper I type each 3 marks totalling 30. To ensure content and construct validity, all the questions were obtained from past KCSE Chemistry Paper I exams for 2005 to 2013. Before administration, the instrument was validated by three senior KNEC chemistry examiners. Additionally, its reliability was determined using results obtained from the pilot based on Kuder-Richardson formula 20 (KR-20) and found to be 0.70 signifying that it was reasonably reliable (Kothari, 2004). A copy of this instrument is attached to this document as appendix B.

### **3.6.2 Post-test SCAT**

The effect of intervention on students ability in chemistry was tested based on a post-test examination at the end of the treatment phase. The instrument – Students' Chemistry Achievement Test (SCAT) for posttest was prepared by the researcher in collaboration with the four teachers who administered the treatment. It comprised questions intended to measure students' chemistry proficiency in the two main domains of the topic; nomenclature and properties of organic substances. Each of the two questions were of Chemistry Paper II category and extensively tested the various domains of Organic Chemistry II subject content. Accumulatively, each question had a maximum score of 15 giving the instrument a total score of 30. The questions were also obtained from KNEC chemistry past papers from 2005 to 2013. Before its administration, the instrument was validated by the three senior KNEC chemistry examiners. Further, its reliability was determined based on the data

obtained from the pilot test using the Kuder-Richardson formula 20 (KR-20). The reliability was found to be 0.72 indicating that it was reasonably reliable (Kothari, 2004). A copy of this instrument is attached to this document as Appendix C.

### **3.6.3 Students' Questionnaire (SQ)**

This instrument was intended to measure students' attitudes towards chemistry. Items in the questionnaire were adopted from the Scale of High School Students' Attitudes towards Chemistry (SHSSA) as presented by Demircioglu, Aslan and Yadigaroglu (2014) for use in chemistry students' attitude inquiry studies. The instrument initially contained 37 items constituted by making use of Test of Science-Related Attitudes (TOSRA) which was designed to measure seven distinct science-related attitudes among secondary school students. They were tested on a sample consisting of 200 students (95 girls and 105 boys) in high school between the 9<sup>th</sup> and 12<sup>th</sup> grade by the developer and 17 items with low reliability index were dropped. The remaining 20 items were found mainly to assess two domains; students liking for chemistry lessons and their career plans for chemistry. Table 3.2 compares the reliability index of the test items as determined by the developer and the pilot study.

**Table 3.2**  
**Reliability Index (Cronbach's  $\alpha$ )**

Statement	Original			Test		
	Mean	SD	$\alpha$	Mean	SD	$\alpha$
Chemistry lessons are funny	3.22	1.04	.801	2.70	1.33	.805
I don't like chemistry.	2.78	1.12	.811	3.57	1.28	.742
Chemistry does not interest me.	3.81	1.10	.796	2.16	1.32	.665
Chemistry lessons bore me.	2.64	1.23	.783	3.36	1.28	.778
Chemistry is easy for me to learn.	3.24	1.15	.773	3.38	1.25	.599
I hate chemistry.	2.86	1.27	.758	2.81	1.33	.502
I have positive attitude towards chemistry.	3.59	1.16	.758	2.41	1.40	.856
I'm not good at chemistry.	3.37	1.31	.705	3.38	1.31	.743
Although I work hard, I didn't understand chemistry lessons.	2.96	1.24	.626	3.21	1.39	.568
I'm looking forward to chemistry lessons.	2.62	1.08	.582	2.71	1.36	.641
Chemistry is necessary to solve daily life problems.	3.11	1.15	.417	2.23	1.23	.618
Chemistry is one of the most interesting lessons.	3.44	1.32	.322	2.04	1.24	.574
Chemistry knowledge is important to find a good job.	2.57	1.05	.301	3.74	1.13	.347
It may be interesting to work in a laboratory to earn money.	3.67	1.19	.737	3.60	1.35	.784
I want to become a scientist after high school.	2.94	1.29	.721	3.44	1.30	.793
I don't want to work in a laboratory after graduating from high school.	2.84	1.12	.712	3.88	1.25	.753
After graduating, I would like to work with people who make discoveries for chemistry.	2.92	1.07	.687	3.62	1.29	.764
To be a scientist is boring.	3.47	1.16	.650	2.31	1.37	.796
To make career about chemistry is boring and routinized.	3.30	1.12	.619	3.61	1.24	.553
I like chemistry projects.	3.49	1.25	.421	2.64	1.52	.587
<b>Cronbach's <math>\alpha</math></b>			<b>0.89</b>			<b>0.83</b>

From the table it is evident that the instrument obtained Cronbach's reliability index of 0.83 from the pilot test which is almost comparable to the developers' 0.89. Since it is more than the anticipated 0.70, it was presumed to be reliable enough for use (Kothari, 2004). A copy of this instrument is attached to the document as Appendix A.

#### **3.6.4 Chemistry Teachers' Questionnaire (TQ)**

The chemistry class teachers were provided with a questionnaire (TQ) which was intended to gather data on chemistry teachers' perception of the dynamics of integration of CAL in the teaching and learning of chemistry in their schools. The items mainly were to assess their accessibility of CAL teaching and learning resources, their attitude towards the resources and extent of use of the resources. Also included in the questionnaire are statements that were intended to gauge issues related to institutional support, technical support, computer anxiety and perceived challenges that the teachers could be encountering in the process of integrating CAL in teaching and learning of chemistry.

To ensure construct validity, items in the questionnaire were adopted from previously validated instruments by researchers. These included Teachers Attitude towards Computers Scale (Gattiker & Hlavka, 1992), the Teachers Computer Anxiety Scale (Barbeite & Weiss, 2004) and self-concept instrument developed by Cambra and Silvestre (2003). The instrument was validated by supervisors and research specialists from the Department of Educational Communication and Technology, Kenyatta University. A copy of this instrument is attached to the document as Appendix D.

### **3.6.5 Chemistry Teachers' Interview Schedule**

An interview schedule was prepared to facilitate a follow-up interview particularly with the teachers who were implementing the intervention lessons. This was found to be important since it would enable capture of emerging issues during the process. The instrument contained statement on the teachers extent of integration of CAL in their teaching of chemistry and their perception of the effect of CAL on students attitude and achievement in chemistry. Other issues captured by the instrument include availability, relevance and usefulness of ICT tools (hardware and software) for integration of CAL, institutional support and challenges impacting integration of CAL. A copy of this instrument is attached to this document as Appendix E.

### **3.6.6 Observation Checklist**

Lastly, a check list prepared with the aim of ascertaining the CAL implementation extent including availability and use of CAL software and hardware was used. A copy of this instrument is attached to the report as Appendix F.

### **3.7 Pilot Study**

A pilot study was conducted in a mixed county boarding school and a mixed sub-county school purposively selected from the targeted public secondary schools of Kwale County who were not involved in the main study. Mixed schools were purposely targeted at this stage since they provided the researcher

with the categories of targeted population in one sitting (has both boys and girls students). The purpose of the pilot study was to pre-test the research instruments and familiarize the researcher with data collection procedures. Based on the findings of the pilot study, the researcher revised the research instruments accordingly.

### **3.7.1 Validity of the Instruments**

The pretest and posttest SCAT, students and teachers questionnaire and the interview were designed using items obtained from credible sources and researchers in chemistry education. For instance, the SCAT were developed from test items developed by examiners of chemistry at the KCSE level (2005-2013). They were then validated by three experienced secondary school teachers who are also senior KCSE chemistry examiners. The questionnaire drafts, interview schedule and observation checklist were prepared from previously validated instruments. They were then given to experts in measurement and evaluation in the Department of Educational Communication and Technology for validation.

### **3.7.2 Reliability of the Instruments**

The reliability of the instruments used was estimated using the internal consistency techniques. These techniques were chosen because they allow only one administration of the instruments hence saving on time and resources. The SCAT had two sections all of which had dichotomous items. This instrument

was intended to measure students's ability in chemistry as well as their achievement in chemistry. Since the items were of varied levels of difficulty, the reliability for this instrument was estimated using the Kuder-Richardson formula 20 (KR-20) given below:

$$KR20 = \frac{K (S^2 - \Sigma s^2)}{S^2 (K - 1)}$$

Where KR20 = Kuder Richardson reliability coefficient

K = Number of items used to measure the concept

$S^2$  = Variance of all scores

$s^2$  = Variance of individual scores

**Source:** Mugenda and Mugenda (2003)

Based on this formular, the reliability of pretest and posttest SCAT were determined as follows from the data obtained from the pilot test:

**a. Pretest SCAT**

$$KR20 = \frac{K (S^2 - \Sigma s^2)}{S^2 (K - 1)}$$

$$K=10$$

$$S^2=110.38$$

$$\Sigma s^2=41.2$$

$$KR20=0.70$$

**b. Posttest SCAT**

$$KR20 = \frac{K (S^2 - \Sigma s^2)}{S^2 (K - 1)}$$

Where  $K= 2$

$$S^2=331.62$$

$$\sum s^2=212.12$$

$$KR20= \mathbf{0.72}$$

For this study, a minimum coefficient of 0.6 was accepted. According to Kothari (2004) a Kuder Richardson coefficient of between 0.6 and 0.7 is acceptable while one more than 0.7 is considered to be very good. Since the coefficients of both the pretest and posttest were found to be 0.70 and 0.72 respectively, the instruments were presumed reliable.

The Students' Questionnaire (SQ) was meant to measure student attitude towards chemistry. This instrument had non-dichotomous items with a wide range of scoring weights. It contained 20 statements ten of which were positive and the remaining ten were negative. Each of the statement were of the Likert type ranked Strongly disagree with a value of 1 to Strongly agree with a value of 5. The negative statements in the questionnaire were reverse coded. The reliability of this instrument was then estimated using the Cronbach's alpha coefficient SPSS. The questionnaire (SQ) which had 20 items was found to have a Cronbach's reliability index of 0.83 based on the data obtained from pilot test. The instrument attained a reliability index of 0.68 in the study.

### **3.8 Data Collection Procedure**

Collection of data for this study took place between March and May, 2015. These dates correspond with the first and second term of the school year which was chosen because the topic used in the study is usually taught during those dates. First, the researcher sought permission to conduct research from the University through Graduate School. With the approval from Kenyatta University Graduate school, the researcher sought and obtained permission to conduct the research from the National Commission for Science, Technology and Innovation (NACOSTI). Further permission was sought and obtained from the government field offices including the County Commissioner, Kwale and the County Director of Education, Kwale. Upon obtaining consent from these field officers, the study proceeded in phases.

The first phase involved the researcher visiting participating schools in order to be introduced, familiarize, seek respondent's permission and cooperation and make appropriate appointments. The researcher administered the CAL lessons using chemistry class teachers. Therefore, during this initial period, the researcher met teachers and held discussions with them on CAL and how such lessons could be planned and executed. The researcher, together with the teachers then prepared the CAL lessons. At the same time the researcher with the help of the respective school's IT technician inspected and installed the CAL supported lesson programs in the desktops and laptops for use later in schools sampled for CAL lessons.

Phase two involved administration of the pre-test instrument to the students and took place in the first week of March, 2015. The sampled students were pre-tested on several topics including atomic structure, structure and bonding, the mole concept as well as measured on the identified control variables. These variables include students' attitude towards chemistry and chemistry achievement level. The Pre-test SCAT and the SQ were administered on the same day.

Phase three involved administration of CAL and conventional treatment methods to the students. The experimental class learnt using computer instructional materials which had been developed by the Kenya Institute of Curriculum Development (KICD) consisting of drills, tutorials and simulations. Teachers handling the experimental group were all trained by the researcher on how to administer the CAL enabled lessons. Teacher's role was not only to observe and assess but also to engage with the students while they completed activities, suggesting solutions and posing questions to the students for promotion of reasoning. The control class was taught using conventional methods. The researcher ensured that both control and experimental groups covered the topic within the stipulated time by providing the teachers with a common time- plan (three weeks). The researcher in the process of managing implementation of the treatment completed the checklist. Finally, the last phase entailed the researcher administering the post-test SCAT instrument to the students and took place at the end of the three week treatment duration.

### **3.9 Data Analysis**

Data obtained from the study was analysed qualitatively and quantitatively based on the study objectives.

#### **3.9.1 Quantitative Data**

Quantitative data was analysed using both descriptive and inferential statistics. The study had seven objectives, four based on research hypotheses and the remaining three on research questions. All hypotheses were tested at 0.05 level of significance. The first objective sought to determine the difference in achievement in organic chemistry between students taught through CAL and those taught through conventional method. Student achievement was measured at the ratio scale while teaching strategy (treatment variable) was measured at the nominal level as either CAL or Conventional. Data obtained for this objective was analysed using a one way Analysis of Variance (ANOVA). However, to measure the effects of treatment on post-test scores, independent sample t-test was done for the post-test mean scores of the experimental group and control group which was not pre-tested.

The second objective sought to compare student achievement in organic chemistry when taught through CAL and when taught through conventional means with student's ability level as an additional variable. Teaching strategy and ability are categorical variables. Students' ability was categorized as either High Ability (HA) or Low Ability (LA) while the teaching strategy was

categorized as CAL or conventional. Since the objective has two variables, that is, teaching strategy and ability level, the data obtained was analysed using a two-way analysis of variance (2 way ANOVA).

The third objective aimed at establishing the effects of CAL teaching strategy on student achievement in organic chemistry with students' attitude as a variable. Students' attitude was categorized as either Negative Attitude (NA) or Positive Attitude (PA) while the teaching strategy was categorized as CAL or conventional. Since the objective had two variables, that is, teaching strategy and student attitude, data obtained was analysed using a two-way analysis of variance (2 way ANOVA).

The fourth objective sought to establish the difference in achievement in organic chemistry between students taught through CAL and those taught through conventional means with respondents' (students) demographics as an additional factor. Data for this objective was analysed using two-way analysis of variance.

The fifth objective sought to determine the effect of teachers' demographic factors on integration of CAL in the teaching and learning of chemistry. Data for this objective was analysed using multiple linear regression analysis.

The sixth objective sought to assess the effects of institutional factors on use of CAL in teaching and learning of chemistry. Pearson's correlation was used to assess the association between the institutional factors. Additionally, multiple linear regression was used to assess the influence of each of the factors on use of CAL in the teaching and learning of chemistry.

The seventh objective sought to assess the challenges that the process of use of CAL in teaching and learning of chemistry could be facing. Mean ranking was used to categorise the perceived influence of the challenges. Finally, other analyses concerned with internal and external validity was done based on an independent sample t-test.

### **3.9.2 Qualitative Data**

Qualitative data obtained from chemistry teachers handling intervention through interview was analysed using thematic analysis. Grbich (2007, p. 16) as cited in Mathews and Ross (2010) defines thematic analysis as “a process of segmentation, categorisation and relinking of aspects of the data prior to final interpretation”. To this end, the following steps were undertaken:

- a) Recorded interviews were transcribed verbatim or “near verbatim” (Willig, 2008, p. 26) and each transcript read and short notes made to have a summary of statements of the main points of each respondent. Duplications within the main points of the respondents were deleted to reduce the number of similar categories and remain with relevant text.

The reduced categories were then grouped together and labelled as themes. According to Auerbach and Silverstein (2003) a theme is “an implicit topic that organises a group of repeating ideas” (p. 38). Factors from each transcript that fit in specific categories were grouped together.

- b) Specific themes were analysed during the study and auxiliary themes developed in the process. These content-based themes were developed in line with literature reviewed, theory and study objectives.
- c) Teachers’ subjective experiences regarding integration of CAL in the teaching and learning process were woven into narrative using their own words as much as possible. In the process, a bridge emerged linking research objective to raw data.
- d) For confidentiality, each respondent’s real name was changed to a case number when reporting findings following the recommendations of Berg (2001).

### **3.10 Legal and Ethical Considerations**

Permission from the Department of Educational Communication and Technology review board was obtained first. Upon the proposal approval, the researcher obtained research permits from both the NACOSTI and the Ministry of Education through its field officers to undertake the study. Then, during data collection, subjects were informed in a covering letter about the purpose for the research and issues of their confidentiality. This included the purposes and data

collection methods, assurance of subjects' anonymity, subjects' voluntary participation in this study, and subjects' freedom to participate or withdraw from the study at any time.

**CHAPTER FOUR**  
**PRESENTATION OF FINDINGS, INTERPRETATION AND**  
**DISCUSSION**

**4.1 Introduction**

This chapter presents research findings, their interpretations and discussion as per the objectives of the study. Both quantitative and qualitative research findings are presented.

**4.2 General and Demographic Information**

The study mainly sought to determine the effect of integration of CAL in instruction in organic chemistry on students' achievement. The study was guided by seven objectives which include:

- i. Determine the difference in achievement in organic chemistry between students taught through CAL and those taught through conventional method.
- ii. Determine the effects of CAL on achievement of low and high ability students in organic chemistry.
- iii. Determine the effect of students' attitude towards chemistry on their achievement in organic chemistry when taught through CAL.
- iv. Establish the effect of students' age and gender on their achievement in organic chemistry when taught through CAL.
- v. Establish the effect of teachers' factors on integration of CAL in instruction in organic chemistry.

- vi. Determine the effects of institutional factors on integration of CAL in instruction in organic chemistry.
- vii. Identify the challenges of CAL in instruction in organic chemistry.

The study employed both null hypotheses and research questions. Four hypotheses were formulated as follows:

**H<sub>01</sub>:** There is no significant difference in achievement in organic chemistry between students taught through CAL and those taught through conventional methods.

**H<sub>02</sub>:** There is no significant difference in achievement of low and high ability students in organic chemistry when taught using CAL.

**H<sub>03</sub>:** There is no significant difference in achievement in organic chemistry between students with negative attitude and those with positive attitude when taught through CAL.

**H<sub>04</sub>:** There are no significant age and gender differences in achievement of students in organic chemistry when taught through CAL.

Additionally, three research questions were used to assess the existing relationship between integration of CAL and various factors.

- i. How do teachers' factors affect integration of CAL in instruction in organic chemistry?
- ii. How do institutional factors affect integration of CAL in instruction in organic chemistry?

- iii. What are the challenges of integration of CAL in instruction in organic chemistry in Kwale County public secondary schools?

#### **4.2.1 General Information**

To achieve the study purpose, a quasi – experimental research design of the Solomon’s four type was employed. A total of 182 form four chemistry students from 4 public (2 county, 2 sub – county) secondary schools within the county with ICT infrastructure for integration of CAL participated in the study. Similarly, 37 form four chemistry class teachers from the public schools with these facilities including the 4 from schools from which students were drawn answered questions on the dynamics of CAL integration in the teaching and learning of chemistry in their schools. Compared to the projected sample of 180 students and 50 chemistry teachers, the study achieved a return rate of 101.1% for students and 74% for teachers. The exegerated return rate for students was due to an over enrolment of 2 students in one of the control groups who could not be excuded from participating in the study due to logistical reasons. The response rate is deemed reliable for data analysis as per Babbie and Muoton (2002) who reported that any response rate of 50% and above is adequate for analysis.

Students were divided into 4 groups with a group of students from each school serving as a study unit which were randomly assigned as either experimental or control group (two experimental, two control groups). An experimental and

control group were each pre-tested, treatment administered (use of CAL in teaching and learning of organic chemistry to the two experimental and use of conventional teaching and learning methods to the two control groups) and all the four groups post-tested. Raw data obtained were converted to Z-scores then the Z-scores converted to T-scores. The use of T-scores in the analysis rather than the raw scores was based on the need to normalise the test scores of students from different schools and the understanding that there is no significant variation of the test results of the raw scores and that of the T-scores in analysis as was shown by preliminary comparative analysis of the effect of use CAL on students' achievement in organic chemistry using both raw scores and T-scores.

#### **4.2.2 Demographic Information**

Respondents' demographic information considered for review include age, gender and school category for students while for teachers age, gender, level of education and work experience were considered.

##### **4.2.2.1 Students' Demographics**

The findings on students demographic information were as summarized in Table 4.1.

**Table 4.1**  
***Students' Demographic Information***

Variable		Test Groups Composition									
		E <sub>1</sub>		E <sub>2</sub>		C <sub>1</sub>		C <sub>2</sub>		Total	
		f	%	f	%	f	%	f	%	f	%
Age	Below16	2	1.1	1	0.5	1	0.5	1	0.5	5	2.7
	16 – 18	27	14.8	28	15.4	30	16.5	24	13.2	109	59.9
	Above18	16	8.8	16	8.8	16	8.8	20	11.0	68	37.4
	Total	45	24.7	45	24.7	47	25.8	45	24.7	182	100.0
Gender	Boys	26	14.3	19	10.4	27	14.8	22	12.1	94	51.6
	Girls	19	10.4	26	14.3	20	11.0	23	12.6	88	48.4
	Total	45	24.7	45	24.7	47	25.8	45	24.7	182	100.0
School	Sub- county	45	24.7	0	0.0	47	25.8	0	0.0	92	50.5
	County	0	0.0	45	24.7	0	0.0	45	24.7	90	49.5
	Total	45	24.7	45	24.7	47	25.8	45	24.7	182	100.0

Data on students' age shows that more students, (59.9%) were in the 16 – 18 age group as compared to those who were either below 16 years of age, (2.7%) or above 18 years, (37.4%). Results also show that students were fairly spread across the test groups. With regard to gender, students composition almost attained gender parity since there were 94 (51.6%) boys and 88 (48.4%) girls who were fairly distributed in the different test groups. Lastly, E<sub>1</sub>, E<sub>2</sub> and C<sub>2</sub> each had 45 (24.7) students while C<sub>1</sub> had 47 (25.8%) students.

#### **4.2.2.2 Teachers' Demographics**

Similarly, the findings on chemistry teachers' demographic information were as reported in Table 4.2.

**Table 4.2**  
***Chemistry Teachers' Demographic Information***

		Male		Female		Total	
		f	%	f	%	f	%
Age	Below 25	1	2.7	0	0.0	1	2.7
	25 – 34	6	16.2	5	13.5	11	29.7
	35 – 45	11	29.7	7	18.9	18	48.6
	Above 45	6	16.2	1	2.7	7	18.9
	Total	24	64.9	13	35.1	37	100.0
Education	Dip. in Ed.	3	8.1	1	2.7	4	10.8
	U/T Graduate	5	13.5	1	2.7	6	16.2
	Trained Graduate	8	21.6	11	29.7	19	51.3
	T. Post Graduate	8	21.6	0	0.0	8	21.6
	Total	24	64.9	13	35.1	37	100.0
Experience	Below 5	10	27.0	0	0.0	10	27.0
	5 – 10	7	18.9	5	13.5	12	32.4
	11 – 15	6	16.2	4	10.8	10	27.0
	Above 15	1	2.7	4	10.8	5	13.5
	Total	24	64.9	13	35.1	37	100.0
Workload	Below 25	5	13.5	4	10.8	9	24.3
	25 – 28	12	32.4	7	18.9	19	51.3
	Above 28	7	18.9	2	5.4	9	24.3
	Total	24	64.9	13	35.1	37	100.0
IT Training	Yes	14	37.8	9	24.3	23	62.2
	No	10	27.0	4	10.8	14	37.8
	Total	24	64.9	13	35.1	37	100.0

Results show that there were more male teachers, 24 (64.9%) as compared to the females, 13 (35.1%) who participated in the study. Of these, 67.5% of the teachers were found to over 35 years in age, a majority being males. As for their level of education, more (83.8%) were trained teachers. This means that the teachers who were handling the chemistry classes had requisite qualification for their jobs.

With regard to work experience, the study established that though a majority of the teachers were relatively young, 73.0% had five years or more teaching experience presumed to be long enough to enable them acquire appropriate

work experience to enable them provide relevant data for this study. Additionally, except for 24.3% who had a workload of over 28 lessons per week, the remaining majority were found to had fewer than 28 lessons, a work load presumed to offer them enough time for professional practice including integration of CAL in their teaching duties. Lastly, 23 (62.2%) teachers indicated that they were computer literate, each of them having had basic IT training in which they had sponsored themselves. Further analysis showed that IT competence was spread across the gender with slightly more male than female teachers being IT literate. It therefore can be deduced that these teachers could competently implement CAL supported lessons in their classroom practice. The particulars of chemistry teachers who participated in the interview and thus provided qualitative data are as summarised in Table 4.3.

**Table 4.3**  
***Interviewee Identity***

Participant Code	Type of School
A	E <sub>1</sub>
B	E <sub>2</sub>
C	C <sub>1</sub>
D	C <sub>2</sub>

Table 4.3 shows that four chemistry teachers pseudonamed A, B, C and D for the purposes of anonymity participated in the interview and thus provided qualitative data for the study. While A and B were drawn from experimental study groups, C and D were from control groups of the study. Their teaching experience ranged between 10 and 26 years and consisted of 2 males and 2 females.

In summary, the findings on respondents demographics showed that the study sample was adequately representative for the targeted respondents. Specifically, the findings show that the sample consisted of students with varied demographic variables relative to gender and age; variables significantly important for this study together with others such as ability and attitude that are discussed later in the chapter. The students were found to be fairly spread across the experimental and control test group relative to these variables thus indicating homogeneity of the groups. Further test on homogeneity based on each attribute are discussed under subsequent relevant sections of the study.

### **4.3 Findings of the Study**

The findings are presented sequentially as per the objectives beginning with descriptive statistics, hypotheses testing, qualitative data and lasty discussions.

#### **4.3.1 CAL and Students' Achievement in Organic Chemistry**

The first objective intended to determine the difference in achievement in organic chemistry of students taught through CAL and those taught using conventional methods. In order to achieve this, a group of students in control and experimental groups were pre-tested, intervention administered and then the students post-tested to assess the effect of intervention.

##### **a) Descriptive Findings of Effects of CAL on Students' Achievement**

The pre-test examination administered to two test groups  $E_1$  and  $C_1$  yielded results as summarized in Table 4.4.

**Table 4.4**  
*Students' Achievement in Chemistry – Pre-test Results*

	Test Group Composition					
	E <sub>1</sub>		C <sub>1</sub>		Total	
	f	%	f	%	f	%
Below 50	31	33.7	23	25.0	54	58.7
50 – 59	9	9.8	13	14.1	22	23.9
60 and Above	5	5.5	11	12.0	16	17.4
Total	45	48.9	47	51.1	92	100.0
Mean	48.69		51.09		49.91	
SE	1.56		1.14		1.35	

Pre-test results show that generally, achievement of students from control group C<sub>1</sub> (M=51.09, SE=1.14) was higher than those from experimental group E<sub>1</sub> (M=48.69, SE=1.56). Specifically, slightly more than half of the students (58.7%) scored less than 50% in the test with more students (33.7%) being from E<sub>1</sub> as compared to those from C<sub>1</sub> (25%) indicating that more students from experimental group failed in the pre-test. For those who scored 50 – 59% whose performance was average and could be presumed to have passed, more students (14.1%) were from C<sub>1</sub> compared to those from E<sub>1</sub> group (9.8%). A similar observation was made with regard to those who scored 60 and above with 12.0% being from C<sub>1</sub> compared to 5.5% from E<sub>1</sub>. In general, the results indicate that more students from the control group C<sub>1</sub> (26.1%) passed in the pre-test examination as compared to their counterparts from experimental group E<sub>1</sub> (15.3%).

Subsequently, an independent sample t-test was performed on pre-test results to assess homogeneity in composition of the test groups based on students abilities in the subject. The findings are as presented in Table 4.5.

**Table 4.5**  
***Independent Sample Test for Pre-test Results***

Test Groups	N	Mean	Std. Error	df	t – value	p – value
E <sub>1</sub>	45	48.69	1.56	90	1.14	.260
C <sub>1</sub>	47	51.09	1.41			

Levene's test for equality of variance ( $F=0.067$ ,  $p = 0.796$ ) showed insignificant differences between variances of the experimental and control groups. This means that data obtained fits assumptions of homogeneity of variance for the combination of experimental and control groups. An analysis of test results for equal variance assumed showed no significant mean difference of mean for experimental ( $M = 48.69$ ) and control ( $M = 51.09$ ) groups,  $t(90) = 1.14$ ,  $p = 0.260$ . This means that these groups had comparably close mean thus contained learners with similarly comparable characteristics suitable for the study. Then, an assessment of the effect of the intervention of the teaching strategies (CAL and conventional methods) administered to students in their respective groups for a period of three weeks was undertaken through a post-test administered. Table 4.6 compares observation for students in E<sub>1</sub> and C<sub>1</sub> groups.

**Table 4.6**  
***Students' Achievement in Chemistry – Post-test Results for E<sub>1</sub> & C<sub>1</sub>***

	Test Group Composition					
	E <sub>1</sub>		C <sub>1</sub>		Total	
	f	%	f	%	f	%
Below 50	20	21.8	39	42.4	59	64.2
50 – 59	15	16.3	8	8.7	23	25.0
60 and Above	10	10.8	0	0.0	10	10.8
Total	45	48.9	47	51.1	92	100.0
Mean	52.93		42.98		47.85	
SD	9.69		7.28		9.86	

Results obtained show that generally, achievement of students in the post-test from E<sub>1</sub> (M = 52.93) was higher than those from C<sub>1</sub> (M = 42.98). Specifically, it was observed that about two thirds (64.2%) of the students scored less than 50% in post-test thus performed poorly in the subject consistent with their performance in the pre-test in which more students performed poorly. Of these, there were twice as many students (42.4%) from C<sub>1</sub> as compared to those from E<sub>1</sub> (21.8%) implying that more students from C<sub>1</sub> performed poorly in post-test examination as compared to their counterpart from E<sub>1</sub> contrary to the observation made in the pre-test. For those whose scores were average (50 – 59%), there were twice as many students from E<sub>1</sub> (16.3%) as compared to those from C<sub>1</sub> (8.7%).

Further, results showed that of the 10.8% who scored 60% or more in post-test and thus could be presumed to have passed well, all of them were entirely from experimental group E<sub>1</sub>. On the whole, results obtained imply that though a majority of students performed poorly in post-test examination, achievement level of students from E<sub>1</sub> (M = 52.93) was higher than their counterparts from C<sub>1</sub> (M = 42.98). A similar observation was made with regard to achievement levels of students in the other two groups which were not pre-tested as summarized in Table 4.7.

**Table 4.7*****Students' Achievement in Chemistry – Post-test Results for E<sub>2</sub> & C<sub>2</sub>***

	Test Group Composition					
	E <sub>2</sub>		C <sub>2</sub>		Total	
	f	%	f	%	f	%
Below 50	10	11.1	32	35.6	42	46.7
50 – 59	18	20.0	8	8.8	26	28.8
60 and Above	17	18.9	5	5.6	22	24.5
Total	45	50.0	45	50.0	90	100.0
Mean	57.64		46.84		52.24	
SD	8.79		7.48		9.76	

Results in Table 4.7 for E<sub>2</sub> and C<sub>2</sub> similarly show that achievement of students from experimental group E<sub>2</sub> (M = 57.64) was higher than that of students from control C<sub>2</sub> (M = 46.84). Specifically, it was observed that twice as many students from E<sub>2</sub> (20%) scored 50-59% in the post-test compared to those (8.8%) from C<sub>2</sub>. Similarly for those who scored either 60% or above in the post-test there three times as many from E<sub>2</sub> (18.9%) compared to those from C<sub>2</sub> (5.6%) confirming that more students from the experimental group performed better than their counterparts from control group in the post-test. Lastly, for this objective, an assessment for a probable effect of pre-test sensitization on the outcome of the process was made based on an independent sample t-test for the post test results of the two groups which were not pre-tested. The results obtained were as shown in Table 4.8.

**Table 4.8*****Independent Sample Test for Post-test Results***

Test Groups	N	Mean	Std. Error	df	t – value	p – value
E <sub>2</sub>	45	57.64	1.31	88	6.28	.000
C <sub>2</sub>	45	46.84	1.11			

Levene's test for equality of variance ( $F=1.52, p=0.221$ ) showed insignificant difference between variances in the achievement levels of students in the

experimental group  $E_2$  and control group  $C_2$ . This means that data obtained from post-test fits the assumptions of homogeneity of variance for the combination of experimental and control groups.

Consequently, an analysis of mean for the two groups were undertaken and the results,  $t(88) = 6.28, p < 0.001$ ; indicated that there was a significant mean difference between the scores of the two groups (experimental and control) which were not pre-tested with the mean score of students in experimental group being significantly higher than those in the control group. This observation was seen to be similar to the observed mean difference of achievement levels of students in the experimental and control groups that were pre-tested negating a probable presence of pre-test sensitisation.

#### **b) Hypothesis Testing for Effects of CAL on Students' Achievement**

The first hypothesis of the study sought to establish whether there is a statistically significant difference between achievement of students exposed to CAL and those exposed to conventional method. An inferential interpretation of the existing relationship was sought via a one way analysis of variance test on the post-test results of students in all the four test groups and the results were as presented in Tables 4.9 and 4.10.

**Table 4.9**  
***Effect of CAL on Students' Achievement (Descriptive)***

Groups	N	Mean	SD	SE	95% Confidence Interval of Mean		Min	Max.
					Lower Bound	Upper Bound		
E1	45	52.93	9.69	1.45	50.02	55.84	37.00	77.00
E2	45	57.64	8.79	1.31	55.00	60.28	42.00	77.00
C1	47	42.98	7.28	1.06	40.84	45.12	31.00	59.00
C2	45	46.84	7.48	1.11	44.59	49.09	33.00	66.00
Total	182	50.02	10.03	.74	48.55	51.49	31.00	77.00

Results from Table 4.9 show that students from experimental groups (E<sub>1</sub>) and (E<sub>2</sub>) registered a higher mean (M = 52.93 and M = 57.64 respectively) in the post-test examination as compared to their counterparts from control groups (C<sub>1</sub> and C<sub>2</sub>) (M = 42.98 and M = 46.84 respectively). Table 4.10 provides ANOVA interpretation of the existing relationship.

**Table 4.10**  
***Effect of CAL on Students' Achievement (ANOVA)***

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5781.91	3	1927.30	27.60	.000
Within Groups	12430.00	178	69.83		
Total	18211.91	181			

ANOVA results  $F(3, 178) = 27.60, p < 0.001$  in Table 4.10 shows that the observed mean difference was significant. Post Hoc test (Tukey HSD) results yielded results were as presented in Table 4.11.

**Table 4.11 Post Hoc Test Results (Tukey's HSD)**

(I) Test group	(J) Test group	Mean Difference (I - J)	SE	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
E <sub>1</sub>	E <sub>2</sub>	-4.71	1.76	.060	-9.28	-.14
	C <sub>1</sub>	9.95*	1.74	.000	5.43	14.47
	C <sub>2</sub>	6.09*	1.76	.004	1.52	10.66
E <sub>2</sub>	E <sub>1</sub>	4.71	1.76	.060	.14	9.28
	C <sub>1</sub>	14.67*	1.74	.000	10.15	19.19
	C <sub>2</sub>	10.80*	1.76	.000	6.23	15.37
C <sub>1</sub>	E <sub>1</sub>	-9.95*	1.74	.000	-14.47	-5.43
	E <sub>2</sub>	-14.67*	1.74	.000	-19.19	-10.15
	C <sub>2</sub>	-3.87	1.74	.122	-8.39	.65
C <sub>2</sub>	E <sub>1</sub>	6.09*	1.76	.004	-10.66	-1.52
	E <sub>2</sub>	-10.80*	1.76	.000	-15.37	-6.23
	C <sub>1</sub>	3.87	1.74	.122	-.65	8.39

The Post Hoc Tukey's (HSD) test showed that the post-test results for E<sub>1</sub> (M = 52.93) were significantly different from C<sub>1</sub> (M = 42.98) and C<sub>2</sub> (M = 46.84) with mean achievement of students in the experimental group being significantly higher than those in the control groups. Consistent with this, significant mean differences were found between post-test results for E<sub>2</sub> (M = 57.64) and those of C<sub>1</sub> (M = 42.98) and C<sub>2</sub> (M = 46.84), the mean achievement of students in experimental group being significantly higher than those from control groups. The observation implies that students in the experimental groups who were exposed to CAL performed significantly higher than their counterparts from control groups. The null hypothesis H<sub>01</sub> which stated that there is no statistically significant difference in achievement in organic chemistry between students taught through CAL and those taught through conventional methods was rejected.

### **c) Qualitative Analysis of Effects of CAL on Students' Achievement**

An inquiry was made from chemistry teachers who were handling the interventions on their conception of effectiveness of CAL teaching strategy. In response all the four interviewees concurred that compared to conventional methods, CAL is a better teaching strategy. According to interviewee A: "The superiority of the method could be attributed to the enthusiasm it generates in students. This was corroborated by interviewee C who maintained that CAL teaching strategy employs the use instructional resources that illustrates abstract concept, increases students level of participation and ultimately better

learning outcomes. In the same breath, interviewee B who seemed to have used the method longest categorically intimated that he has consistently observed an “upward” increase of mean achievement for his students in chemistry for the last three years since he began integrating CAL in his lessons.

#### **d) Discussion of Results of Effects of CAL on Students’ Achievement**

The main aim of the objective was to compare the effect of CAL and conventional teaching methods on students’ achievement in organic chemistry. To achieve this, learners in experimental and control groups were pre-tested, intervention administered and subsequently post-tested. Descriptive results obtained from pre-test and post-test showed that there was a general trend of poor achievement of students in both the two test with a greater number of students performing poorly in the pre-test and post-test. This observation is consistent with existing empirical data that attest to students’ poor achievement in chemistry. For instance, Abudu and Gbadamosi (2014), KNEC (2013), Ogembo (2012) and Salta and Tzougraki (2004) among others lament about persistent poor achievement in chemistry, a fact they attribute to various reasons.

Descriptive analysis of the post-test results showed that the mean achievement of students from experimental group was higher than that of students from control groups. Specifically, it was observed that twice as many students in the experimental group passed in the test (scored 50% or more) compared to those

in the control group though in the pre-test, more students in the control group passed implying that CAL is a better teaching strategy since students exposed to this method performed better in the post-test. This observation partly agrees with Dori and Barak (2000) as well as Henriques (2002) as reported in Kargiban and Siraj (2009), who maintain that use of CAL enhances learning of chemistry and develops learning environment resulting in students improved achievement. It is also supported by Akçay *et al.* (2003) as well as Ezeudu and Ezinwanne (2013). Used in chemistry, Cotton (1991) found out that computer assisted instruction (CAI) enabled users to learn as much as 40% faster than their counterparts with their retention of the learnt content being better thus leading to more positive attitudes and achievement than conventional methods of instruction.

ANOVA analysis indicated significant effect of CAL on achievement of students in organic chemistry with achievement of learners in experimental group being significantly higher than those of their counterparts in control groups. This finding corroborates that of Akçay *et al.* (2006) who assessed the effect of CAL on achievement and attitude of college students in analytical chemistry and found that achievement of experimental groups was significantly higher than those from the control group. It is also consistent with findings of Bhukuvhani *et al.* (2011) who observed that use of CAL in teaching of chemistry results in achievement that is superior to conventional methods. Similarly, Dasedmir *et al.* (2008), Hailegebreal (2012), Morgil *et al.* (2005)

and Nduati (2015) showed that when CAL is used to teach acids and bases, electrochemistry and carbon and its compounds respectively, the post-test scores were statistically and significantly different in favour of experimental group indicating that integration of CAL enhances students' understanding of chemistry concepts thus enabling students exposed to the teaching method to perform better.

Findings from qualitative analysis reported improved chemistry instruction with use of CAL. It was suggested by interviewees that use of CAL helps in illustrating abstract concept, increases students level of participation and enhances their level of interest in the subject with an overall improvement in their performance in the subject. This observation agrees with that of Aksela (2005) who asserted that use of CAL provides rich learning environment and engage senior secondary level students in meaningful chemistry learning and higher-order thinking skills. Teachers interviewed were convinced that CAL is a better teaching strategy compared to conventional method due to the inbuilt self directed activities and student motivating programs an assertion which conforms with that of Morgil *et al.* (2005) who found an increase in the success in achievement among learners exposed to the program more than those exposed to conventional methods due to the uniqueness and ability of its programs.

On the whole, it was noted from the finding that use of CAL in teaching of organic chemistry is a better teaching strategy which yields better students' achievement. This is consistent with findings of Brumbaugh and Rock (2001) as well as Ku *et al.* (2005). It also agrees with Ozman (2007) who postulates that teaching-learning of topics in chemistry related to chemical bonding can be improved by the use of computer-assisted teaching materials. Anderson (2002) is categorical that computer aided learning (CAL) packages have the capability to transform the way students understand and learn an aspect also supported by Bhukuvhani *et al.* (2011). The researchers insists that the richness and variety of the visual presentation of knowledge through these media, in contrast to the somewhat one-dimensional world of conventional methods opens horizons for learners of all abilities, but particularly to those who find verbally presented data more difficult to comprehend.

#### **4.3.2 CAL and Achievement of Low and High Ability Students**

The second objective intended to examine the effect of CAL on achievement of students based on their abilities. The study classified student in experimental and control groups as low ability (LA) and high ability (HA) based on their achievement in the pretest examination. Students who scored less than average (50%) were categorised as having low ability while those who scored more than average were categorised as having high ability.

### a) Descriptive Findings on Effects of CAL on LA and HA Students

Classification of students as LA or HA based on their achievement in the pretest examination yielded a group composition as summarised in Table 4.12.

**Table 4.12**  
*Students' Ability in Chemistry*

Ability level	E1		C1		Total	
	f	%	f	%	f	%
Low ability	31	33.7	23	25.0	54	58.7
High ability	14	15.2	24	26.1	32	41.3
Total	45	48.9	47	51.1	92	100.0

Data obtained showed that from the 58.7% of the students categorized as LA, more (33.7%) were from E<sub>1</sub> compared to those from C<sub>1</sub> (25.0%). For the 41.3% categorized as HA, slightly fewer students (15.2%) were from E<sub>1</sub> compared to those from C<sub>1</sub> (26.1%) implying that whereas there were comparably more LA students in E<sub>1</sub>, there were more HA students in C<sub>1</sub>. An independent sample t-test was performed to assess homogeneity or otherwise in composition of the groups with students. Levene's test for equality of variance,  $F = 7.57$ ,  $p < 0.01$  indicated significant differences between variances in achievement levels of students categorised as LA and HA. This means that data obtained fits assumptions of heterogeneity of variance for the combination of groups relative to ability of students in experimental and control groups. An analysis of test results for equal variance assumed showed no significant mean difference of the mean for experimental ( $M = 1.13$ ) and control ( $M = 1.15$ ) groups,  $t(90) = 1.19$ ,  $p = 0.05$ . This means that the groups having comparably close mean contained learners with similarly comparable characteristics important for the study.

### b) Hypothesis Testing for Effects of CAL on LA and HA Students

The second hypothesis,  $H_{02}$  of the study sought to establish whether there exist a statistically significant difference between achievements of low ability (LA) and high ability (HA) students exposed to CAL. An analysis of the effect of CAL on student abilities undertaken based on posttest results using two way ANOVA provided findings as summarized in Table 4.13.

**Table 4.13**

*Effect of CAL on Low and High Ability Students*

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2965.93	3	988.64	14.79	.000	.34
Intercept	200832.41	1	200832.41	3003.64	.000	.97
Ability	599.68	1	599.68	8.97	.004	.09
Group	2787.44	1	2787.44	41.67	.000	.32
Ability * Group	138.02	1	138.02	2.06	.154	.02
Error	5883.94	88	66.86			
Total	219476.00	92				
Corrected Total	8849.87	91				

a. R Squared = .34 (Adjusted R Squared = .31)

Results obtained showed that 34% of the total variance in student achievement was accounted for by the teaching method. This means that teaching method explained about a third of the total variance in achievement of learners in the test groups. As a model, ability and groups were significant implying main effect of CAL on student ability (LA or HA) and group (control or experimental). However, no significant interaction effect was found between students ability and group,  $F(1,88) = 2.06$ ,  $p = 0.15$ ,  $\eta^2 = 0.02$ . Significant differences were observed for achievement levels of HA and LA students,  $F(1,88) = 8.97$ ,  $p < 0.01$ ,  $\eta^2 = 0.09$  though the effect size was small (Cohen, 1992). Similarly, significant differences were found between groups (CAL and

conventional methods),  $F(1,88) = 41.67$ ,  $p < 0.001$ ,  $\eta^2 = 0.32$  with medium effect size (Cohen, 1992).

Specifically, it was observed that achievement of HA students ( $M = 51.34$ ) were significantly different from those of LA students ( $M = 46.03$ ). Pairwise comparison showed that the effect was significantly greater for LA ( $M = 50.46$ ) than HA ( $M = 59.75$ ). Similarly, results indicated that achievement levels of students from experimental group  $E_1$  ( $M = 54.42$ ) were significantly different from those of students in the control group  $C_1$  ( $M = 42.95$ ), pairwise comparison showing that achievement levels of students in experimental group being significantly different from those in control groups. Univariate test results were also significant for ability,  $F(1,88) = 8.97$ ,  $p = 0.004$ ,  $\eta^2 = 0.09$  and test groups,  $F(1,88) = 41.69$ ,  $p < 0.001$ ,  $\eta^2 = 0.32$ . This could be interpreted to imply that the effect of CAL on achievement of LA students is greater than that of HA. Consequently the null hypothesis which stated that there is no significant difference in achievement of low and high ability students in organic chemistry when taught using CAL was rejected.

### c) Qualitative Findings on Effects of CAL on LA and HA Students

Data obtained from interviewee indicated no difference in the effect of CAL on students based on ability. Teachers interviewed maintained that though use of CAL could be credited with improved student achievement in the subject, the improvement was seen to cut across all categories of learners. Specifically,

interviewee B who indicated being the most experienced with regard to use of CAL having used the strategy the longest compared to his peers said, “in my observation over the years, the effect has tended to be the same across different categories of learners.” This was corroborated by his peers who insisted that the effect is uniform for students of variable abilities.

#### **d) Discussion of Results on Effects of CAL on LA and HA Students**

Descriptive data explained the similarity of distribution of students with LA and HA across experimental and control groups of the study important for consideration. It also showed that there were more LA students in experimental group compared to control group. Findings from ANOVA showed significant effect of CAL on ability of students, 34% of the total variance being attributed to effect of teaching strategy consistent with Deary *et al.* (2006) who found a large contribution of general mental ability to educational achievement. Similarly, Mackintosh's (1998) found a correlation of 0.4 and 0.7 between IQ scores and school performance grades. Specifically for chemistry, Adesoji and Oginni (2012) maintain that like any other school subjects, chemistry requires mental ability of students to be able to cope with learning of the subject. Their study finding illustrated that mental ability made the highest contribution in students' achievement followed by mathematical ability. Findings by Ajewole *et al.* (2006) showed that 36.2% of the total variance in students' achievement in Chemistry is accounted for by four students aptitude indices. Among the indices, mental ability made the highest contribution followed by mathematical

ability. This shows that performance of students depends largely on their aptitude indices in chemistry a fact also supported by Anderson (2002).

Results specifically indicated greater effect of CAL for LA as compared to HA students as was seen from the mean posted by these category of learners. This implies that use of CAL in teaching and learning of organic chemistry significantly improves achievement of LA students compared to HA students. This findings partly agrees with that Barnea and Dori (1999) who found that students in experimental group performed better than control group students in all three performance aspects. Experimental group students scored higher than control group students in the achievement test on structure and bonding. Students' spatial ability improved in both groups, but students from experimental group scored higher implying that they gained better insight into the model concept than students from control group and could explain more phenomena with the aid of a variety of models. For the average students in the two groups, the improvement in all three spatial ability sub-tests – paper folding, card rotation, and cube comparison – was significantly higher for experimental group. Hence, the study concluded that CMM helps in particular to improve the examined cognitive aspects of the average student population. This was attributed to better understanding of chemical bonding and improved three dimensional perception of molecular structure gained through the CMM experience of students in the experimental group. The findings are in accord

with those of Gabel and Bunce (1994), Ugoji (2008) as well as Chansarkar and Michaeloudis (2001).

As was expected, achievement levels of students from experimental groups were significantly higher compared to those from control groups which illustrates the significant effect of CAL on achievement levels of both HA and LA students with each category of learners (LA and HA) in the experimental groups posting significantly higher mean as compared to their counterparts in the control groups. This finding is consistent with that of Barnea and Dori (1999), Funkhouser (1993) as well as Steffen *et al.* (1996). Steffen *et al.* posit that when students actually construct and animate molecules, they get a chance to see how a chemist or organic chemist thinks about structure. This helps bridge the gap between the conventional drawings and more sophisticated visualization techniques scientists use.

Qualitative findings seemed to provide contradictory results with teachers insisting that effect of CAL is uniform across different categories of learners based on their abilities. This is largely in agreement with observations of Adesoji and Oginni (2012), Ajewole *et al.* (2006) and Deary *et al.* (2006).

In general, the study established that CAL teaching strategy is a better method for instruction of organic chemistry which enhances instruction of low ability learners by providing them with more hands on activities which stimulates

their critical thinking, enhancing their retention and ultimately achievement levels. This observation as confirmed by data from experimental groups supports observations of SMASSE (2007) and Twoli (2006) who advocates for learners to be provided with more hands on activities during the learning process to enable them appreciate learning of science and mathematics. Similarly, Bhagwan (2005) postulates that a growing body of research in the cognitive science suggest that students learn and better retain what they learn when engaged in 'authentic' learning tasks. It is such environment for learning that CAL offer learners thus resulting in better achievement.

#### **4.3.3 CAL and Achievement of Students based on Attitude**

The third objective aimed at assessing two issues; the effect of CAL on achievement of students with different attitudes (negative and positive attitude) and the effect of CAL on students' attitude. Students' attitude was assessed based on data obtained from the questionnaire administered at the beginning of the study just before the intervention phase and at the end of the intervention phase. To determine the effect of CAL on achievement of students with different attitudes, students' attitude score at the pretest phase was compared to their achievement in the posttest. To determine the effect of CAL on students' attitude, a comparison of students score on the same instrument used to measure attitude during the pretest and posttest was made. Data obtained in each case was edited, coded and analysed using coding method.

### a) Descriptive Findings on Effects of CAL on NA and PA Students

Data obtained from students' score in the students questionnaire during the pretest phase were as summarized in Table 4.14.

**Table 4.14**  
*Students' Attitude towards Chemistry – Pre-test (N=182)*

Statement	1		2		3		4		5		Mean	SD	Min	Max
	f	%	f	%	f	%	f	%	f	%				
Chemistry lessons are funny.	43	23.6	48	26.4	30	16.5	42	23.1	19	10.4	2.70	1.33	1	5
Chemistry is necessary to solve daily life problems.	18	9.9	22	12.1	29	15.9	64	35.2	49	26.9	3.57	1.28	1	5
I hate chemistry.	76	41.8	50	27.5	25	13.7	12	6.6	19	10.4	2.16	1.32	1	5
I would like to work with people who make discoveries in chemistry after finishing school.	5	2.7	8	4.4	25	13.7	53	29.1	91	50.0	4.19	1.01	1	5
I'm not good at chemistry.	20	11.0	28	15.4	27	14.8	76	41.8	31	17.0	3.38	1.25	1	5
I don't want to work in a laboratory after finishing school.	37	20.3	46	25.3	39	21.4	35	19.2	25	13.7	2.81	1.33	1	5
Chemistry lessons bore me.	20	11.0	20	11.0	20	11.0	57	31.3	65	35.7	3.70	1.35	1	5
It may be interesting to work in a laboratory to earn money.	21	11.5	31	17.0	27	14.8	63	34.6	40	22.0	3.38	1.31	1	5
Chemistry is one of the most interesting lessons.	31	17.0	31	17.0	25	13.7	59	32.4	36	19.8	3.21	1.39	1	5
Chemistry is easy for me to learn	45	24.7	45	24.7	32	17.6	38	20.9	22	12.1	2.71	1.36	1	5
To make career about chemistry is boring.	8	4.4	19	10.4	34	18.7	50	27.5	71	39.0	3.86	1.17	1	5
To be a scientist is boring.	15	8.2	8	4.4	30	16.5	45	24.7	84	46.2	3.96	1.25	1	5
I'm looking forward to chemistry lessons.	12	6.6	16	8.8	25	13.7	83	45.6	46	25.3	3.74	1.13	1	5
Although I work hard, I don't understand chemistry lessons.	20	11.0	26	14.3	18	9.9	60	33.0	58	31.9	3.60	1.35	1	5
I want to become a scientist after high school.	22	12.1	20	11.0	41	22.5	54	29.7	45	24.7	3.44	1.30	1	5
Chemistry knowledge is important to find a good job.	15	8.2	12	6.6	27	14.8	53	29.1	75	41.2	3.88	1.25	1	5
I like chemistry projects.	18	9.9	25	13.7	16	8.8	72	39.6	51	28.0	3.62	1.29	1	5
I don't like chemistry.	16	8.8	30	16.5	20	11.0	44	24.2	72	39.6	3.69	1.37	1	5
I have positive attitude towards chemistry.	18	9.9	18	9.9	27	14.8	73	40.1	46	25.3	3.61	1.24	1	5
Chemistry does not interest me.	19	10.4	19	10.4	19	10.4	52	28.6	73	40.1	3.77	1.35	1	5
Grand Mean											3.45	1.28		

*Note:* \*Negative items were reverse coded\*

Strongly disagree=1, Disagree=2, Not sure=3, Agree=4 and Strongly agree=5

Respondents scored highly for attitude ( $M = 3.45$  out of 5) indicating that generally, a majority of the students had a positive attitude towards chemistry. Specifically, more than three quarters (79.1%) of the students indicated that they want to work with people who make discoveries in chemistry after high school as attested to by the highest mean rating ( $M = 4.19$ ), more than two thirds refuted the assertion that to be a scientist is boring (70.9%), a similar proportion acknowledged that chemistry knowledge is important to find a job (70.3%) and that to make a career out of chemistry is not boring (66.5%). Additionally, a similar proportion of respondents maintained that chemistry interests them (68.7%), that they always look forward to chemistry lessons (70.9%) and that chemistry does not bore them (68%) each of these statements equally attaining mean rating of more than 3.5 out of 5.

The findings on these statements among others could be interpreted to imply that a significant proportion of the students have a positive attitude towards chemistry thus the relatively higher mean rating of the statements with 16 out of 20 statements receiving a mean rating of more than 3 out of 5 from the students. However, the fact that 69.4% of the students acknowledged hating chemistry shows that there is equally strong negative feelings towards the subject among the students. Further analysis showed that students in the experimental,  $E_1$  &  $E_2$  and control,  $C_1$  &  $C_2$  groups each had a higher mean rating, ( $M = 3.40$  and  $M = 3.50$  respectively) in the scale of attitude with that of

students in the control groups being slightly higher than their counterparts in the experimental groups.

The study undertook a rating of the students' attitude based on a comparison of the average score for attitude and actual score in the scale of attitude. Consequently, with a minimum score of 52 and a maximum of 92 on the scale, those who scored 72 or less in the scale were classified as having negative attitude (NA) while those whose score were above 72 were classified as having positive attitude (PA) yielding data as summarised in Table 4.15.

**Table 4.15**  
***Rating of Students' Attitude in Chemistry***

Category	Test Group									
	E <sub>1</sub>			E <sub>2</sub>		C <sub>1</sub>		C <sub>2</sub>		Total
	F	%	f	%	f	%	f	%	f	%
Negative (NA)	34	18.7	31	17.0	31	17.0	27	14.8	123	67.6
Positive (PA)	11	6.0	22	7.7	16	8.8	18	9.9	59	32.4
Total	45	24.7	45	24.7	47	25.8	45	24.7	182	100.0

From Table 4.15, it is evident that there was a relatively fair distribution of students with PA and NA across the four test groups of the study. The results show that more students, 123 (67.6%) were in the NA category as compared to 59 (32.4%) who were of PA. For those classified as having NA, slightly more, 18.7% were in E<sub>1</sub>, 17.0% in E<sub>2</sub> and C<sub>1</sub> and 14.8% were in C<sub>2</sub>. For those classified as having PA, slightly more, 9.9% were in C<sub>2</sub>, 8.8% in C<sub>1</sub>, 7.7% in E<sub>2</sub> and 6.0% in E<sub>1</sub> implying that there were more students of the NA category in E<sub>1</sub> group than the other groups and more of PA in C<sub>2</sub> than the other groups. A one way ANOVA homogeneity of test for the test groups,  $F(3,178) = 1.80$ ,  $p = 0.15$  showed that the observed mean difference was insignificant. Post hoc test

(Tukey's HSD) also showed insignificant mean differences between attitudes of students in both the experimental and control groups illustrating that the test groups were made up of respondents with similar attitudinal characteristics. Consequently, students score on the elements of attitude at the end of the intervention stage was sought to help assess the effect of CAL on students' attitude. Data obtained were as summarised in Table 4.16.

**Table 4.16**  
***Students' Attitude towards Chemistry – Post-test (N=182)***

Statement	1		2		3		4		5		Mean	SD	Min	Max
	f	%	f	%	f	%	f	%	f	%				
Chemistry lessons are funny.	16	8.8	24	13.2	35	19.2	79	43.4	28	15.4	3.43	1.16	1	5
Chemistry is necessary to solve daily life problems.	10	5.5	12	6.6	19	10.4	88	48.4	53	29.1	3.89	1.07	1	5
I hate chemistry.	26	14.3	34	18.7	40	22.0	57	31.3	25	13.7	3.12	1.27	1	5
I would like to work with people who make discoveries in chemistry after finishing school.	-	-	3	1.6	29	15.9	59	32.4	91	50.0	4.31	.80	2	5
I'm not good at chemistry.	10	5.5	19	10.4	30	16.5	88	48.4	35	19.2	3.65	1.08	1	5
I don't want to work in a laboratory after finishing school.	12	6.6	30	16.5	45	24.7	66	36.3	29	15.9	3.38	1.13	1	5
Chemistry lessons bore me.	6	3.3	10	5.5	20	11.0	77	42.3	69	37.9	4.06	1.00	1	5
It may be interesting to work in a laboratory to earn money.	6	3.3	20	11.0	38	20.9	77	42.3	41	22.5	3.70	1.04	1	5
Chemistry is one of the most interesting lessons.	4	2.2	19	10.4	46	25.3	77	42.3	36	19.8	3.67	.98	1	5
Chemistry is easy for me to learn	6	3.3	34	18.7	53	29.1	67	36.8	22	12.1	3.36	1.02	1	5
To make career about chemistry is boring.	2	1.1	13	7.1	32	17.6	64	35.2	71	39.0	4.04	.98	1	5
To be a scientist is boring.	4	2.2	5	2.7	27	14.8	62	34.1	84	46.2	4.19	.94	1	5
I'm looking forward to chemistry lessons.	2	1.1	8	4.4	30	16.5	95	52.2	47	25.8	4.01	.84	1	5
Although I work hard, I don't understand chemistry lessons.	5	2.7	23	12.6	19	10.4	76	41.8	59	32.4	3.88	1.08	1	5
I want to become a scientist after high school.	5	2.7	13	7.1	33	18.1	83	45.6	48	26.4	3.86	1.30	1	5
Chemistry knowledge is important to find a good job.	5	2.7	5	2.7	26	14.3	71	39.0	75	41.2	4.13	1.25	1	5
I like chemistry projects.	3	1.6	15	8.2	19	10.4	93	51.1	52	28.6	3.97	.93	1	5
I don't like chemistry.	1	.5	19	10.4	31	17.0	59	32.4	72	39.6	3.99	1.02	1	5
I have positive attitude towards chemistry.	7	3.8	17	9.3	27	14.8	84	46.2	47	25.8	3.81	1.05	1	5
Chemistry does not interest me.	2	1.1	13	7.1	25	13.7	68	37.4	74	40.7	4.09	.96	1	5
Grand Mean											3.83	1.01		

*Note: \*Negative statements were reverse coded\**

Strongly disagree=1, Disagree=2, Not sure=3, Agree=4 and Strongly agree=5

Post intervention data assessing students' attitude towards chemistry (SQ<sub>2</sub>) show that the elements attained an overall mean rating of 3.83 out of 5. Specifically, about four out of five (82.4%) of the respondents want to work with people who make discoveries in chemistry after high school (M = 4.31), almost a similar number (over 80%) insisting that to be a scientist is not boring, that chemistry knowledge is important to find a job and that chemistry does not bore them. Similarly, more than two thirds of the respondents were categorical that they always look forward to chemistry lessons (78.0%), that to make a career out of chemistry is not boring (74.2%) and that chemistry interests them (78.1%), each of these statements equally attaining mean rating of more than 4.00 out of 5. The findings on these statements among others could be interpreted to imply that a significant proportion of the students have a positive attitude towards chemistry thus the relatively higher mean rating of the statements with 16 out of 20 statements receiving a mean rating of more than 3.5 out of 5 from the students.

Further analysis showed that when students' score for the elements in SQ<sub>2</sub> and SQ<sub>1</sub> were compared, there was an increase in mean rating for most of the elements, (SQ<sub>2</sub> – SQ<sub>1</sub>) giving a positive deviation of .38 (3.83 – 3.45) on the scale of attitude. It was also found that each of the groups (experimental and control groups) attained a positive deviation with a higher mean rating of the students attitude in SQ<sub>2</sub> compared to SQ<sub>1</sub>, 4.09 and 3.40 for experimental

groups and 3.57 from 3.50 for control groups in SQ<sub>2</sub> and SQ<sub>1</sub> respectively. Therefore, attitude change which was positive was greater for experimental groups, 0.69 (4.09 – 3.40) compared to control groups, 0.07 (3.57 – 3.50).

### b) Hypothesis Testing of Effects of CAL on Students' Attitude

The third hypothesis, H<sub>03</sub> of the study sought to establish whether there is a significant difference between achievement of students with negative and positive attitude exposed to CAL. Similarly, it intended to establish whether CAL had any effect on students' attitude. To assess whether integration of CAL significantly affected achievement of students with positive and negative attitude differently, a two way analysis of variance test of their pretest attitude score on their posttest SCAT score in organic chemistry was operationalised. The findings were as summarized in Table 4.17.

**Table 4.17**  
*Effect of CAL on Students' Attitude*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5976.29	7	853.76	12.14	.000	.33
Intercept	394392.79	1	394392.79	5608.57	.000	.97
Attitude	23.28	1	23.28	.33	.566	.01
Group	5232.84	3	1744.28	24.81	.000	.30
Attitude * Group	181.09	3	60.36	.86	.464	.02
Error	12235.63	174	70.32			
Total	473612.00	182				
Corrected Total	18211.91	181				

a. R Squared = .33 (Adjusted R squared = .30)

As a model, effect of CAL on groups was significant indicating main effect for groups, the effect size being medium (Cohen, 1992). The model, which was significant, was found to account for 33% of the total variance in achievement of students with different attitude. Results showed that the differences in

achievement between students with positive and negative students was insignificant,  $F(1,174) = 0.33$ ,  $p = 0.57$ ,  $\eta^2 = 0.00$ . Significant differences were however found between achievement of students in different groups (CAL and conventional methods),  $F(1,174) = 24.81$ ,  $p < 0.001$ ,  $\eta^2 = 0.30$ . No significant interaction effect between attitude and groups was found to exist,  $F(1,174) = .86$ ,  $p = .464$ ,  $\eta^2 = 0.015$ .

Specifically, it was observed that no significant difference in achievement existed between students with positive attitude ( $M = 50.74$ ) and those with negative attitude ( $M = 49.96$ ). However, significant differences were observed between achievement levels of students in the experimental group  $E_1$  ( $M = 54.06$ ) and control group  $C_1$  ( $M = 43.09$ ). Similarly, there were significant mean difference in achievement of students in  $E_2$  ( $M = 57.55$ ) and those in  $C_2$  ( $M = 46.69$ ). Pairwise comparison showed that test scores for students in  $E_1$  were significantly different from those of  $C_1$  and  $C_2$  and those of  $E_2$  were significantly different from those of  $C_1$  and  $C_2$ . Univariate test results were also significant for test group,  $F(1,174) = 27.88$ ,  $p < 0.001$ ,  $\eta^2 = 0.30$  but insignificant for attitude. Post Hoc test (Tukey HSD) yielded results as presented in Table 4.18.

**Table 4.18**  
***Multiple Comparisons for Effect of Attitude on Students' Achievement***

(I) Test group	(J) Test group	Mean Diff (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
	E2	-4.7111	1.76786	.062	-9.2970	-.1252
E1	C1	9.9546*	1.74895	.000	5.4178	14.4914
	C2	6.0889*	1.76786	.004	1.5030	10.6748
E2	E1	4.7111	1.76786	.062	.1252	9.2970
	C1	14.6657*	1.74895	.000	10.1289	19.2026
C1	C2	10.8000*	1.76786	.000	6.2141	15.3859
	E1	-9.9546*	1.74895	.000	-14.4914	-5.4178
C2	E2	-14.6657*	1.74895	.000	-19.2026	-10.1289
	E1	-3.8657	1.74895	.124	-8.4026	.6711
E1	C1	-6.0889*	1.76786	.004	-10.6748	-1.5030
	C2	-10.8000*	1.76786	.000	-15.3859	-6.2141
E2	E1	3.8657	1.74895	.124	-.6711	8.4026
	C1					

Note: The error term is Mean Square(Error) = 70.320.

\*. The mean difference is significant at the .05 level.

The Post Hoc Tukey's (HSD) test showed that achievement of students with negative attitude from E<sub>1</sub> (M = 54.06) were significantly different from that of their correspondents from C<sub>1</sub> (M = 43.09) and those from E<sub>2</sub> (M = 57.55) were significantly different from those from C<sub>2</sub> (M = 46.69) with the achievement of students in both the experimental groups being significantly higher than their counterparts from the control groups. Similar observation were made with regard to those with positive attitude, those from E<sub>1</sub> (M = 56.27) and E<sub>2</sub> (M = 57.29) having significantly higher achievement compared to those from C<sub>1</sub> (M = 43.44) and C<sub>2</sub> (M = 45.94). The observations imply that students in the experimental groups who were exposed to CAL reported significantly higher achievement in the post test than those from the control groups an aspect that could be attributed to CAL being a better teaching strategy compared to conventional methods. The results obtained thus failed to reject null hypothesis which stated that there is no significant difference in achievement in organic

chemistry between students with negative attitude and those with positive attitude when taught through CAL.

To assess whether integration of CAL in teaching and learning of chemistry affected attitude of students with positive and negative attitude differently, a one way analysis of variance test of the variation of students' score on the elements of attitude in  $SQ_2 - SQ_1$  against test groups (experimental or control) was done. Results obtained were as summarised in Table 4.19 and 4.20.

**Table 4.19**  
***Effect of CAL on Students' Attitude (Descriptive)***

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
					E1	45		
E2	45	12.9556	5.83857	.87036	11.2015	14.7097	1.00	28.00
C1	47	1.2553	1.53889	.22447	.8035	1.7072	.00	7.00
C2	45	1.5111	1.60429	.23915	1.0291	1.9931	.00	6.00
Total	182	7.5000	7.42383	.55029	6.4142	8.5858	.00	28.00

Results obtained show that the change in students' score on elements of attitude from  $E_1$  were highest ( $M = 14.56$ ) on the scale of change of attitude followed by those from  $E_2$  ( $M = 12.96$ ) then those in  $C_2$  ( $M = 1.52$ ) and lastly those from  $C_1$  ( $M = 1.26$ ) in decreasing order. Table 4.20 reports the ANOVA interpretation of the effect.

**Table 4.20**  
***Effect of CAL on Students' Attitude (ANOVA)***

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7026.30	3	2342.10	141.36	.000
Within Groups	2949.21	178	16.57		
Total	9975.50	181			

ANOVA results  $F(3, 178) = 141.36, p < 0.001$  in Table 4.19 shows that the observed mean difference was significant. Post Hoc (Tukeys) test gave results as summarised in Table 4.21.

**Table 4.21**  
***Multiple Comparisons of Attitude Change (Tukey HSD)***

(I) Test group	(J) Test group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
	E2	1.60000	.85813	.247	-.6255	3.8255
E1	C1	13.30024*	.84895	.000	11.0985	15.5020
	C2	13.04444*	.85813	.000	10.8189	15.2700
E2	E1	-1.60000	.85813	.247	-3.8255	.6255
	C1	11.70024*	.84895	.000	9.4985	13.9020
C1	C2	11.44444*	.85813	.000	9.2189	13.6700
	E1	-13.30024*	.84895	.000	-15.5020	-11.0985
C2	E2	-11.70024*	.84895	.000	-13.9020	-9.4985
	E1	-2.5579	.84895	.990	-2.4575	1.9459
E2	C1	-13.04444*	.85813	.000	-15.2700	-10.8189
	C2	-11.44444*	.85813	.000	-13.6700	-9.2189
	C1	.25579	.84895	.990	-1.9459	2.4575

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

Post Hoc Tukey's (HSD) test showed that the post test results for E<sub>1</sub> (M = 14.56) were significantly different from C<sub>1</sub> (M = 1.26) and C<sub>2</sub> (M = 1.51) with the change in attitude of students in experimental group being significantly higher than those in control groups. Similarly, significant mean differences were found between posttest results for E<sub>2</sub> (M = 57.64) and those of C<sub>1</sub> (M = 42.98) and C<sub>2</sub> (M = 46.84), the mean change of students' attitude in experimental group being significantly higher than those from control groups.

The observation imply that the effect on students attitude was greatest for experimental group as compared to control group which could be attributed to use of CAL in the experimental group. Consequently, the subsidiary hypothesis  $H_{03}$  which stated that there is no significant difference in the effect of CAL on students' attitude was rejected.

### **c) Qualitative Finding on Effects of CAL on NA and PA Students**

Results obtained from interviews with teachers noted their insistence on uniform effect of CAL on students' achievement with negative and positive attitude. Additionally, respondents indicated having observed a net positive impact of CAL on students attitude when used in teaching chemistry. In explaining his conception of the effect, interviewee B maintained that CAL "helps students with negative attitude change to positive and affirm the attitude towards the subject for those with positive attitude." The effect was manifested in positive deviation in terms of achievement and overall attitude score. Much of the effect according to him could be attributed to the strategy's ability to help students "demystify" concepts which initially appeared abstract, an aspect that according to researchers in the field of chemistry and sciences in general is one of the main causes of poor achievement of students in chemistry. The interviewee explained that this was made possible by simulations, animation and other CAL programs that made students conception of chemistry become easier in contrast to when the concepts are explained using conventional methods. This assertion was supported by interviewee D who was equally

categorical that CAL being a superior teaching methodology with illustrative instructional resources aids students with NA and PA attitude towards the subject to perform better.

#### **d) Discussion of Findings of Effects of CAL on NA and PA Students**

The main aim of this objective was to assess the effect of CAL teaching strategy on achievement of students with positive and negative attitude. Additionally, the study intended to establish whether integration of CAL affected students' attitude differently. Descriptives for pretest scores on attitude illustrated students scores of above average levels for a majority of the elements of attitude (16 out of 20 had mean of more than 3 out of 5) resulting into a mean rating of 3.45 out of 5 generally and 3.40 for E<sub>1</sub> and E<sub>2</sub> and 3.50 for C<sub>1</sub> and C<sub>2</sub> for students attitude towards chemistry in the pretest examination. This could be presumed to mean that descriptively, students general attitude towards chemistry is positive. It could also imply that the test scores of students with positive attitude were highly skewed to warrant their overall net positive effect on the students' mean score for attitude. This observation contradicts assertions of SMASSE (2004) and Adesokan (2002) who asserted that in spite of the importance accorded Chemistry among science subjects, it is evident that students still show negative attitude towards the subject, thereby leading to poor performance and low enrolment in the subject. However, it conforms to that of Ogembo (2012) who in a study of the determinants of students poor performance in Kwale county established that

students generally have positive attitude towards chemistry in spite of their poor performance. The researcher thus explained that their poor performance could be attributed to other factors other than their attitude towards the subject.

Descriptive post-test results for students' attitude showed higher rating for elements of attitude compared to corresponding pretest score with a positive deviation for both experimental and control groups. Comparative analysis showed that the deviation was greater for experimental groups, E<sub>1</sub> and E<sub>2</sub> (+.69) compared to control groups C<sub>1</sub> and C<sub>2</sub> (+.07) implying that descriptively, the effect was greater for experimental than control groups. One way ANOVA analysis indicated significant effect of CAL for experimental groups with students from experiment groups, E<sub>1</sub> (M = 14.56) and E<sub>2</sub> (M = 12.96) reporting higher mean compared to C<sub>1</sub> (M = 1.52) and C<sub>2</sub> (M = 1.26). This observation which confirmed the descriptive results showed that use of CAL in teaching and learning of organic chemistry significantly affects learners' attitude towards chemistry. Additionally, the results illustrated that attitude is affected positively implying a positive change in attitude. These results augur well with observations of researchers such as Pektas (2008), Pilli (2008), Tavukcu (2008), Tekmen (2006) and Yildiz (2009). Specifically, the findings agree generally with those of Telkem (2006) who tested efficacy of CAL in physics, Yildiz (2009) in mathematics each showing that posttest scores for attitude in experimental groups' were significantly different from those of control group, scores of experimental group being higher than those in

control groups. The concurrence of findings are even more particular for Pektas (2008) who tested the method in biology, Tavukcu (2008) in environmental science and Pilli in mathematics, each showing a positive significant effect of CAL on students' attitude towards the respective subjects. It also agrees with findings of Olgun (2006) who found that computer-assisted science instruction positively affected students' attitude toward science and their metacognitive skills.

With regard to the effect of CAL on achievement of students with different attitude, main effect was reported for groups with medium effect size (.300) according to Cohen (1992). Insignificant difference of effect of CAL on achievement of students with negative and positive attitude was reported with both students in experimental group reporting high mean achievement implying that CAL impacted achievement of NA and PA students positively with insignificant mean difference. This observation is in consonance with Geban *et al.* (1992); Harwood and McMahon (1997) and Hounshell and Hill (1989) each reporting positive effect of CAL on students performance based on their attitude with insignificant mean difference in their score based on attitude. However, significant effect was reported across groups with students from experimental groups registering significantly high mean achievement for those with negative and positive attitude compared to those in control groups. This observation implies that CAL affects achievement of students in experimental groups uniformly (both those with negative and positive attitude) enhancing

their achievement levels thus the high mean achievement for both categories in the experimental groups. This observation is consistent with previous findings and corroborates assertions of Ozman (2007) who showed that there exist a statistically significant difference between groups in favor of the experimental group but insignificant for attitude in a study of the influence of computer assisted instruction on students' conceptual understanding of chemical bond and attitude towards chemistry. Similar studies that reported insignificant effect of CAL on students achievement based on different attitudes include Geban *et al.* (1992); Harwood and McMahon (1997) and Hounshell and Hill (1989).

Qualitative findings showed that chemistry teachers were convinced that use of CAL in teaching and learning of chemistry benefits both students with positive and negative attitude towards chemistry by enabling those with negative attitude to change their attitude and those with positive attitude to affirm what they already believe in. This observation is in general agreement with Harwood and McMahon, (1997) who each alleged that CAI-based teaching improves student attitude toward science and chemistry.

On the whole, the findings for this objective showed that use of CAL had a significant effect on students' attitude towards chemistry. Additionally, it showed that it has a significant effect on achievement in organic chemistry of students with both positive and negative attitude, both categories of students exposed to CAL achieving significantly higher mean than their counterparts

who are not. This is in tandem with findings by Akcay *et al.* (2003) who in a study of effects of computer simulations on students' success and attitudes in teaching chemistry in which though there was no significant difference between pre and post-test of control group, there was a significant difference between pre and posttest of experimental group ( $p < 0.005$ ) indicating that computer-based education is more effective than traditional methods on students' attitude towards chemistry. It is also supported by Aksela (2005) and Hailegebreal (2012) among others.

#### **4.3.4 Students' Age and Gender and Integration of CAL**

This objective set to examine the existing relationship between integration of CAL and students' demographic factors such as age and gender. Data on students' age and gender were as presented in Table 4.1.

##### **a) Descriptive Results of Students' Demographics**

Preliminary analysis of information presented in Table 4.1 show that there were 94 boys and 88 girls distributed in each of the four test groups and that their ages were categorised as below 16, 16-18 and above 18 years. ANOVA statistics,  $F(3,173) = 1.01, p = 0.39$  and  $F(3,178) = 0.42, p = 0.74$  for the test of homogeneity of composition of the test groups in terms of age and gender indicated insignificant mean differences at 0.05 level of significance thus permitting further analysis.

## b) Hypothesis Testing of Students' Demographics and Integration of CAL

The fourth hypothesis sought to establish whether there are significant age and gender difference in achievement of students in organic chemistry when taught using CAL. A two way analysis of variance test was performed to determine the effects of CAL on achievement levels of students in organic chemistry with variable ages and gender. The outcome were as presented in Table 4.22.

**Table 4.22**  
*Students Age and Gender and the Use of CAL*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	61433.82	17	360.81	4.90	.000	.337
Intercept	68580.99	1	68580.99	931.21	.000	.850
Age	51.53	2	25.76	.35	.705	.004
Gender	34.85	1	34.85	.47	.492	.003
Group	5492.02	3	1830.67	24.86	.000	.313
Age * Gender	9.81	1	9.81	.13	.716	.001
Age * Group	75.27	3	25.09	.34	.796	.006
Gender * Group	105.70	3	35.24	.48	.698	.009
Age * Gender * Group	73.02	3	24.34	.33	.803	.006
Error	12078.09	164	73.65			
Total	473612.00	182				
Corrected Total	18211.91	181				

a. R Squared =.34 (Adjusted R Squared =.27)

The model was significant and accounted for 34% of total variance in use of CAL. Main effect for groups was found, the effect size being moderate. In particular, significant differences existed between groups (CAL and conventional methods),  $F(1,164) = 16.11$ ,  $p < 0.001$ ,  $\eta^2 = 0.23$ . No interaction effect was witnessed between age and gender, age and test group, gender and test group and age, gender and test group.

Significant differences were observed between achievement levels of students in the experimental group E<sub>1</sub> (M = 52.87) and C<sub>1</sub> (M = 42.99) which was similar to that between E<sub>2</sub> (M = 58.70) and C<sub>2</sub> (M = 46.66). Pairwise comparison showed that the test scores for students in E<sub>1</sub> were significantly different from those of C<sub>1</sub> and C<sub>2</sub> and those of E<sub>2</sub> were significantly different from those of C<sub>1</sub> and C<sub>2</sub>. Univariate test results were also significant for test groups,  $F(3,164) = 16.11$ ,  $p < 0.001$ ,  $\eta^2 = 0.23$  but insignificant for age and gender.

Post Hoc (Tukey's HSD) test showed significant mean differences between achievement levels of students in E<sub>1</sub> and those in C<sub>1</sub> and C<sub>2</sub>, those of students in experimental group being significantly higher than those of students in control groups. A similar trend was observed for achievement levels of students in E<sub>2</sub> and those in C<sub>1</sub> and C<sub>2</sub>. This could be interpreted to imply that though the use of CAL in teaching and learning of chemistry impacted students with different ages and across gender similarly thus the insignificant effect across age groups and gender, the difference in achievement levels across experimental and control group reflected its superiority as a method of instruction for the subject. The results obtained therefore failed to reject the fourth hypothesis, H<sub>04</sub> which stated that there are no significant age and gender difference in achievement of students in organic chemistry when taught using CAL.

**c) Qualitative Findings on Students' Demographics and Integration of CAL**

Information obtained from teachers' interview illustrated that effect of CAL on achievement of students in organic chemistry had no age or gender bias though respondents acknowledged that based on gender, boys were more assertive in CAL enabled lessons. Interviewees categorically stated that there was no particular trend of bias observed over the years of their use of CAL with regard to achievement based on learners' background factors including age and gender.

**d) Discussion of Results on Students' Demographics and Integration of CAL**

Findings from hypothesis testing showed insignificant effect of CAL on achievement of students based on age consistent with those of Drent and Meelissen (2008) who argue that the development of metacognitive skills and self-regulation leads to increasingly effective learning strategies amongst pupils, greater engagement with learning activities and, in turn, attainment. Similarly, Ugoji (2008) and Chansarkar and Michaeloudis (2001) also insist that performance of students is not affected by learner's age but is associated with their entry behaviour.

Similarly, findings showed insignificant effect of use of CAL on achievement of students based on gender implying that use of CAL affects achievement of

boys and girls equally. It is consistent with that of Barnea and Dori (1999) who in a study of high-school chemistry students' performance and gender differences in a computerized molecular modeling learning environment, illustrated that in achievement and spatial ability tests no significant differences between the genders existed. However, it contradicts that of Nduati (2015) who reported significant mean difference in achievement of boys and girls exposed to CAL in a study of carbon and its compounds, boys in experimental group reporting higher mean achievement compared to girls in the same groups. The study therefore concluded that CAL as a method for teaching and learning of chemistry promotes more achievement of boys than girls. Others who made similar observations include Becta (2007) who established that though boys and girls were similarly motivated by the use of ICT media resources such as CAL, there appeared to be a greater positive effect on boys than girls. These researchers based the difference in achievement based on gender on the traditionally held view that boys tend to work in 'burst' patterns of activity while girls are more persistent in their approach. CAL, they argue, enables boys to shift from working in 'burst' patterns towards more persistent patterns of working thus better achievement. Similarly research in Europe and North America identified boys' greater access to computers in schools and also noted boys' dominance in computer related tasks which lead to a better performance as postulated by Volman (2005).

Main effect of group was found with achievement levels of students in the experimental groups based on age and gender being significantly higher than their counterparts in the control groups. It agrees with among others, ImpaCT2 (2001), Knuth and Rodriguez (2000) as well as Linn *et al.* (2010) among others. ImpaCT2 (2001) showed that the use of CAL in teaching and learning have positive effects on behaviour, motivation, communication and process skills and that it enables pupils to learn more autonomously. On their part, Linn *et al.* (2010) maintain that computer assisted instruction with its various modes such as computer simulations and games can support the new, inquiry-based approaches to science instruction, providing virtual laboratories or field learning experiences that overcome practical and logistical constraints to student investigations.

#### **4.3.5 Teachers' Factors and Integration of CAL**

The fifth aim of the study was to determine the effect of chemistry teachers' factors on integration of CAL in teaching and learning of chemistry. Factors considered for review were demographic factors including age, gender, level of education, teaching experience, workload and ICT competence. Additionally, teachers perception on the existing relationship between CAL and their computer attitude, computer anxiety and self concept was sought. Data for this objective were obtained from teachers demographic factors as summarised in Table 4.2, teachers attitude towards computer, their computer anxiety as well

as their self concept. Each of these factors are discussed sequentially in succeeding section.

#### **a) Descriptive Finding on Teachers' Factors and Integration of CAL**

The discussion on factors related to chemistry teacher presumed to be impacting integration of CAL in teaching and learning of chemistry is undertaken beginning with a summary of the demographics already discussed, teachers' attitude towards computer, their computer anxiety and lastly their self concept.

#### **Teachers' Demographics**

As already illustrated in Table 4.2, data for teachers' demographic factors was obtained from 37 form four chemistry teachers from public secondary schools within the county with ICT infrastructure for integration. A majority of these teachers were 35 years and above (67.5%) and there were more males (64.9%) than females (35.1%) among them. Similarly, a greater number of the teachers were either graduates or postgraduate (78.4%) and a slight majority (56.8%) had over 10 years working experience. Further, about three quarters (75.7%) had a workload of over 25 lessons while about two thirds (62.2%) had basic training in IT which they indicated as having obtained through self- sponsorship. Exploratory correlational analysis indicated moderate to high level of correlation between integration of CAL and teachers' age, gender, level of education, work experience, workload and ICT competence.

Significant correlation were reported for level of education and ICT competence,  $r(-0.598)$  and  $r(-0.674)$  at  $p=0.01$ .

### Chemistry Teachers' Computer Attitude

An assessment of the influence of attitudinal factors on use of CAL in teaching and learning of chemistry yielded data as summarised in Table 4.23.

**Table 4.23**  
*Chemistry Teachers' Attitude on Use of CAL*

Statement	Response (A & SA)		Mean	SD
	f	%		
Use of instructional technology is complex	10	27.0	2.89	0.99
Use of instructional technology is intimidating	15	40.5	2.97	1.21
Use of instructional technology makes teaching more systematic	37	100.0	4.32	0.47
Use of instructional technology makes teaching more creative	34	91.9	4.05	0.46
Use of instructional technology lacks personal touch	27	73.0	3.49	1.30
Use of instructional technology requires high administrative support	34	91.9	4.30	0.62
Use of instructional technology is less time consuming	32	86.5	3.89	0.84
Use of instructional technology leads to greater student involvement	34	91.9	4.19	0.57
Use of instructional technology ensures greater instructor availability round the clock	22	59.5	3.35	0.86
Use of instructional technology leads to easier student assessment	32	86.5	3.89	0.84
Use of instructional technology gives a global orientation to students	29	78.4	3.81	1.05
Use of instructional technology leads to intellectual enhancement of the department	32	86.5	3.95	0.88
Grand Mean			3.76	0.84

*Note:* A= Agree, SA = Strongly Agree

Results obtained showed that teachers attitude towards use of CAL in teaching of chemistry is positive as is indicated by an overall mean rating of 3.76 out of 5. While slightly less than a third (27.0%) of the respondents considered use of instructional technology in the form of CAL to be complex and slightly less than half (40.5%) felt that it was intimidating, all the respondents (100%)

indicated that it made teaching systematic, almost all the respondents (91.9%) felt it made teaching more creative and lead to greater student involvement though it also requires high administrative support. Additionally, over three quarters (> 75.0%) insisted that use of CAL is less time consuming, gives a global orientation to the students, leads to easier students assessment and intellectual enhancement of the department.

### **Chemistry Teachers' Computer Anxiety**

Additionally, an inquiry of the perceived influence of chemistry teachers' computer anxiety provided data as summarised in Table 4.24.

**Table 4.24**  
*Chemistry Teachers' Computer Anxiety*

Statement	Response (A & SA)		Mean	SD
	f	%		
Computers do not scare me at all.	35	94.6	4.51	0.80
Working with a computer makes me nervous.	4	10.8	1.41	0.80
I do not feel threatened when others talk about computers	34	91.9	4.20	1.03
It wouldn't bother me to take computer courses	12	32.4	2.34	1.70
Computers make me feel uncomfortable	4	10.8	1.39	0.97
I feel at ease in a computer class	13	35.1	2.37	1.37
I get a sinking feeling when I think of trying to use a computer	7	18.9	1.87	1.19
I feel comfortable working with a computer	32	86.5	4.12	0.99
Computers make me feel uneasy	6	16.2	1.54	0.95
Working with computers is addictive	22	59.4	3.35	1.30
Makes us dependent on computers	19	51.3	3.19	1.20
Can be used to invade our privacy	14	37.8	2.95	1.20
Inhibit human critical thinking	13	35.1	2.65	1.18
Grand Mean			2.76	1.13

*Note:* A= Agree, SA = Strongly Agree

The findings showed that though more than three quarters of the respondents insisted that computers do not scare them at all (94.6%), that they do not feel threatened when others talk about computers (91.9%) and that they feel

comfortable working with a computer (86.5%), less than a quarter said computer make them feel uneasy (16.2%), working with computers make them nervous (10.8%) and uncomfortable (10.8%). Additionally, about a third indicated that they wouldn't be bothered to take a computer course (32.4%) and that they would feel at ease in a computer class (35.1%) though a similar number of respondents maintained that computers inhibit human critical thinking (35.1%) and that computers can be used to invade ones privacy (37.8%). Further, slightly more than a half maintained that working with computers is addictive (59.4%) while slightly less than this number of respondents (51.3%) insisted that use of computers makes one dependents on computers. The variable attained mean rating of 2.76 out of 5 implying that chemistry teachers generally had average levels of computer anxiety.

### **Chemistry Teachers' Self – concept**

Lastly, an inquiry was made on teachers' self concept as an additional mechanism of assessing their preparedness and mental state in the course of classroom practice. Information obtained from the respondents were as presented in Table 4.25.

**Table 4.25**  
***Chemistry Teachers' Self concept***

Statement	Response (A & SA)		Mean	SD
	f	%		
My colleagues think I'm unfriendly.	1	2.7	3.14	0.86
Colleagues treat me well.	34	91.9	4.08	0.89
When I have a problem, I ask	37	100.0	4.35	0.48
I prefer to be on my own rather than with others	2	5.4	3.14	0.98
I think my colleagues like me	30	81.1	4.00	0.78
I am always unfriendly with others	4	10.2	3.24	0.95
After arguing with someone, I talk to them	34	91.9	4.27	0.80
Others want to work with me.	33	89.2	4.03	0.96
I am bad at a lot of things.	5	13.5	3.11	1.17
I am happy the way I am	37	100.0	4.65	0.48
Grand Mean			3.80	0.84

*Note:* A= Agree, SA = Strongly Agree

Data obtained show that almost all the respondents thought their colleagues were friendly to them, a majority (91.9%) were treated well by colleagues and all the respondents usually consulted with colleagues whenever they had a problem. Similarly, very few (5.4%) respondents preferred to be on their own rather than with others, over three quarters (81.1%) thought they were liked by colleagues, about a tenth were always unfriendly to others (10.2%) and slightly more than this number (13.5%) were bad at a lot of things. Lastly for this variable, almost all the respondents (91.9%) talk to others even after arguing with them, others liked to work with a majority and all of the respondents were happy the way they were. The variable thus attained an appreciable mean rating of 3.80 out of 5 implying that generally a majority of the respondents had a positive self – concept.

#### **b) Inferential Analysis of Effects of Teacher Factors on Use of CAL**

To assess the effects of chemistry teachers' demographic factors on extent of integration of CAL in teaching and learning of chemistry, a two way ANOVA

analysis was carried out on the variables to determine those with main effect, interaction effect and simple main effect on integration of CAL. The results obtained were as reported in Table 4.26.

**Table 4.26**  
***Effects of Teachers Demographic Characteristics on CAL***

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1609.973	18	89.443	22.054	.000	.957
Intercept	14349.081	1	14349.081	3538.130	.000	.995
Age	.531	3	.050	.012	.998	.002
Gender	70.548	1	70.548	17.395	.001	.491
Education	420.317	3	140.106	34.547	.000	.852
IT Competense	397.451	1	397.451	98.002	.000	.845
Attitude	119.841	1	119.841	62.557	.000	.683
Anxiety	136.111	1	136.111	71.050	.000	.710
Age * Gender	3.176	1	3.176	.783	.388	.042
Age * Education	4.080	4	1.020	.252	.905	.053
Age * IT Competense	3.000	2	1.500	.370	.696	.039
Gender * Education	.000	0	.	.	.	.
Gender * IT Compet	1.080	1	1.080	.266	.612	.015
Education * IT Comp	14.000	1	14.000	3.452	.080	.161
Error	73.000	18	4.052			
Total	28602.000	37				
Corrected Total	1682.973	36				

a. R Squared =.96 (Adj. R Squared =.91)

The model indicates that 96% of the total variance in use of CAL could be attributed to teachers' factors. Main effect for use of CAL were observed for gender, level of education, IT competence, attitude and computer anxiety,  $F(1, 18) = 17.40, p = 0.001, \eta^2 = 0.49$ ;  $F(3, 18) = 34.55, p < 0.001, \eta^2 = 0.85$ ;  $F(1, 18) = 98.00, p < 0.001, \eta^2 = 0.85$ ;  $F(1, 18) = 62.56, p < 0.001, \eta^2 = 0.68$  and  $F(1, 18) = 71.05, p < 0.001, \eta^2 = 0.71$  respectively. The effect on age was insignificant. No interaction effect were reported for age and gender, age and level of education as well as age and IT competence. Similarly, no interaction effect were reported for gender and IT competence as well as level of education and IT competence.

The findings indicate that teachers in the 25-34 years age bracket recorded the highest level of use of CAL ( $M = 35.00$ ), followed by those in the 35-45 age bracket ( $27.50$ ). Lowest mean were reported by those above 45 years of age ( $M = 26.83$ ). Male teachers recorded a higher level of use ( $M = 28.07$ ) as compared to their female counterparts ( $M = 25.13$ ) with males in the 25-34 age bracket reporting the highest levels of use of CAL ( $M = 35.00$ ). Relative to level of education, graduate teachers reported the highest mean for use of CAL ( $M = 35.00$ ) while those with postgraduate qualification reporting the least extent of use ( $M = 28.28$ ). As was expected, those with formal training in ICT reported the highest level of use ( $M = 32.05$ ) as compared to those without ( $21.13$ ). With regard to attitude, those with positive attitude reported higher level of use ( $M = 28.32$ ) compared to those with negative attitude ( $M = 23.00$ ). Lastly, teachers with high levels of computer anxiety also reported the highest extent of use ( $M = 32.00$ ) followed by those with low levels ( $M = 26.84$ ) and least of all those with moderate levels ( $M = 23.00$ ).

ANOVA results show an insignificant effect of age on use of CAL,  $F(3, 18) = 0.012$ ,  $p = 0.998$ ,  $\eta^2 = 0.002$ . However, significant effect were found for teachers' gender, academic qualification, ICT competence, attitude and computer anxiety;  $F(1, 18) = 17.40$ ,  $p = 0.001$ ,  $\eta^2 = 0.491$ ;  $F(3, 18) = 34.55$ ,  $p < 0.001$ ,  $\eta^2 = 0.852$ ;  $F(1, 18) = 98.00$ ,  $p < 0.001$ ,  $\eta^2 = 0.845$ ;  $F(1, 18) = 62.56$ ,  $p < 0.001$ ,  $\eta^2 = 0.683$ ;  $F(1, 18) = 59.85$ ,  $p < 0.001$ ,  $\eta^2 = 0.805$  the effect size being large for gender, academic qualification, ICT competence, attitude and

computer anxiety (Cohen, 1992). Pairwise comparison showed that the extent of use of CAL by teachers in the 25-34 years age bracket were significantly different from those in 35-45 age bracket, extent of use of CAL by male teachers were significantly different from their female counterparts and those of graduate teachers were significantly different from that of teachers with diploma in education and postgraduate qualification. Similar observation were observed for the difference for teachers competent in ICT and those who are not.

Additionally, extent of use of CAL by teachers with positive attitude were significantly different from those with negative attitude, teachers with high levels of computer anxiety were significantly different from those with low and moderate computer anxiety in terms of use. Univariate test results were also significant for age, gender, academic qualification, ICT competence, attitude and computer anxiety  $F(3,18) = 5.34, p = 0.008, \eta^2 = 0.47$ ;  $F(1,18) = 13.25, p = 0.002, \eta^2 = 0.42$ ;  $F(3,18) = 58.61, p < 0.001, \eta^2 = 0.91$ ,  $F(1,18) = 197.71, p < 0.001, \eta^2 = 0.92$   $F(1, 18) = 62.56, p < 0.001, \eta^2 = 0.683$  and  $F(1, 18) = 59.85, p < 0.001, \eta^2 = 0.805$  respectively.

A hierarchical regression analysis was conducted to establish the respective contributions of factors such as age, gender, level of education, teaching experience, the teachers' workload, ICT competence, attitude, computer

anxiety and self-concept on use of CAL in the teaching and learning of chemistry. The results were as in Table 4.27.

**Table 4.27**

***Effect of Teachers Demographic Characteristics (Regression)***

Variables	B	$\beta$	t	p	R <sup>2</sup>	Adj.R <sup>2</sup>	R <sup>2</sup> change
Age	-.959	-.107	-.638	.528	.011	-.017	.011
Gender	-1.871	-.132	-.776	.443	.029	-.028	.017
Education	-4.859	-.589	-4.265	.000	.374	.317	.345
Experience	.828	.128	.628	.536	.381	.304	.008
Workload	-3.146	-.306	-2.178	.036	.464	.378	.083
ICT Training	-10.269	-.738	-5.349	.000	.726	.671	.262
Attitude	.032	.002	.006	.995	.728	.659	.002
Anxiety	5.310	.715	4.997	.000	.855	.814	.127
Self-concept	-0.065	-.057	-.734	.469	.858	.810	.003

It was found that 1.1% of the variance in use of CAL in teaching and learning of chemistry was accounted for by age,  $F(1, 30) = -0.64$ ,  $p = 0.528$ . When entered, gender accounted for 1.7% of variance in use of CAL beyond that accounted for by age,  $F(2, 29) = -0.78$ ,  $p = 0.44$ . Level of education accounted for 34.5% of the total variance, experience explained 0.8%, workload 8.3% and ICT competence 26.2 % of the total variance in use of CAL respectively,  $F(3, 28) = -4.27$ ,  $p < 0.001$ ;  $F(4, 27) = 0.63$ ,  $p = 0.381$ ;  $F(5, 26) = -2.18$ ,  $p = 0.036$  and  $F(6, 25) = -5.35$ ,  $p < 0.001$ . Similarly, teachers attitude explained .2%, computer anxiety 12.7% and self-concept .3% of the total variance in use of CAL respectively,  $F(7, 24) = 0.01$ ,  $p = 0.995$ ;  $F(8, 23) = 5.00$ ,  $p < 0.001$  and  $F(8, 22) = -0.73$ ,  $p = 0.469$ .

The regression equation for effect of teacher related factors on use of CAL in teaching and learning of chemistry which was found to be significant ( $p <$

0.001) showed that the factors accounted for 85.8% of the total variance. Specifically, level of education, workload and ICT competence were found to have a significant negative effect on chemistry teachers' use of CAL; age, gender and teachers' self-concept each had an insignificant negative effect, experience and attitude towards computer each had an insignificant positive effect while computer anxiety had a significant positive effect. Based on magnitude, ICT competence had the greatest effect on use followed by computer anxiety, then level of education and workload in decreasing order of effect while teachers' attitude towards computer had the least effect.

**c) Qualitative Findings of Effects of Teacher Factors and Use of CAL**

Information obtained from interviewee indicated that teachers handling chemistry had requisite academic and professional background that could enable them handle CAL lessons. Of those interviewed, two were males and two were females indicating the presence of both gender. Additionally, teachers were found to be between 30 – 40 years age bracket with more than 5 years teaching experience the best placed for CAL integration according to previous research findings. Lastly, each of the interviewee had a basic training in ICT which they had sponsored themselves to.

**d) Discussion of Results on Effects of Teacher Factors and Use of CAL**

Descriptive data obtained showed that there were more male teachers than females in Kwale county for chemistry consistent with the findings of Yawa

(2015) who illustrated in a study entitled implementation of gender mainstreaming policy in public secondary schools in Msambweni sub county in Kwale county that only 31% of the teaching staff in public schools within the study area were females. This observation of existence of a wide gender gap in the distribution of teachers in public schools in Kwale county is also supported by findings of Ogembo, Ayot and Ondigi (2015).

Additionally, the study illustrated that a majority of teachers had more than 5 years teaching experience, were graduates and had basic training in ICT showing that they had requisite background to enable them integrate CAL lessons in teaching of chemistry. Pearsons correlation indicated moderate to high levels of correlation between most of teachers' background factors and their integration of CAL implying direct and indirect relationship between the factors and integration of CAL. This is similar to observations by Ogembo *et al.* (2015) and Ogembo, Ayot and Twoli (2015) who each reported moderate to high correlation between teachers' demographic factors and either their willingness to use ICT tools or in predicting their extent of use of ICT tools.

ANOVA analysis indicated main effects for gender, level of education and ICT competence each of the variable having moderate to high effect size implying that amongst the factors, the three were the main contributors in terms of variance in teachers use of CAL in teaching of chemistry. This corroborates Bitner and Bitner (2002) and Schiller (2003) who asserted that teacher's

personal characteristics such as age, gender, educational level, teaching experience and attitude significantly influence adoption of technology such as CAL in classroom practice.

Specifically, age was found to have an insignificant negative effect on teachers' use of CAL. ANOVA test showed that teachers in the 25-34 years age bracket reporting highest extent of use while those above 45 years reporting the least extent of use. This implies that according to a majority of the respondents, age does not affect their extent of use of CAL in teaching chemistry. This observation concurs with Alazzam *et al.* (2012) who reported insignificant effect of age on teachers' readiness to use ICT. It is also supported by Inan and Lowther (2009) as well as Yang *et al.* (1999). However, it contradicts findings by Lau and Sim (2008) who stated that teachers' age influences their readiness and adoption of ICT during the teaching process. Russell, *et al.* (2003) explains that new teachers who are highly skilled with technology more than older teachers may not incorporate ICT in their teaching with the reason being that either their focus could be on acquisition of knowledge in ICT instead of how to incorporate ICT in their teaching an observation also held by Buabeng-Andoh (2012). Alternatively, the researchers felt that new teachers could be experiencing some challenges in their first few years of teaching and therefore spend most of their time in familiarizing themselves with school's curriculum and classroom management at the expense of ICT integration.

Regression analysis indicated that gender has an insignificant effect on teachers' use of CAL in teaching chemistry. ANOVA analysis showed that the demographic factor had moderate effect size in terms of variance of use of CAL, male teachers being more active users than females. Particularly, males of 25-34 years reported the highest level of use. The finding which implies that gender has an insignificant influence on chemistry teachers' use of CAL is contrary to Volman and van Eck (2001) who cited female teachers' low levels of computer use due to their limited technology access, skill, and interest; Jamieson-Proctor, *et al.* (2006), Kay (2006), Markauskaite (2006) who stated that males use computers more than female teachers.

On the other hand Breisser (2006) found that females' self-perceptions about technology competence improved while males' self-perceptions about technological dominance remained unchanged. Buabeng-Andoh (2012) felt that female teachers applied ICT more than male teachers while Yukselturk and Bulut (2009) have also intimated that gender gap in teacher ICT integration into the teaching and learning has reduced over the past years and suggested that a greater number of females than males were using internet and web 2.0 technologies. However, the findings agree with Kay (2006) and Norris *et al.* (2003) as cited in Buabeng – Andoh (2012) who assert that gender variable is not a predictor of ICT integration into teaching. Specifically, Kay (2006) as cited in Buabeng – Andoh (2012), found that though male teachers had relatively higher levels of computer attitude and ability before computer

implementation, there was no difference between males and females regarding computer attitude and ability after the implementation of the technology.

Teachers' level of education was however found to have a significant effect on their use of CAL in teaching. ANOVA analysis indicated large effect size for the variable relative to total variance in use of CAL, graduate teachers recording the highest extent of use. This means that according to a majority of the respondents, teachers level of education affects their extent of use of CAL which contradicts Alazzam *et al.* (2012) who found no significant effect of teachers' educational background on their overall readiness to integrate ICT in teaching. It however supports Lau and Sim (2008) as cited in Alazam *et al.* (2012) who reports that there is an effect of the level of teachers' academic qualification on ICT adoption. Similarly, Tezci (2009) as cited in Alazam *et al.* (2012), showed that teachers' level of training had a significant effect on their ICT skills and resulted in effective use of ICT in classroom teaching.

The experience that a teacher has amassed in the teaching and learning process has been shown to be an important predictor of their classroom practice (Buddin & Zamarro, 2009). In this study, teaching experience was reported to be an insignificant positive determinant of use of CAL in teaching of chemistry indicating that though more experienced teachers were expected to use CAL more in their classroom practice, the reality was not so. This observation conforms to Niederhauser and Stoddart (2001) but contradicts Giordano

(2007), Hernandez-Ramos (2005) as well as Wong and Li (2008). While Niederhauser and Stoddart (2001) concluded that teachers' experience in teaching does not influence their use of computer technology in teaching and learning, his contemporaries found that teaching experience influences the successful use of ICT in classrooms.

Gorder (2008) as cited in Buabeng-Andoh (2012) for instance is categorical that teachers' experience is significantly correlated to actual use of technology. This is attributed to a study finding in which she revealed that effective use of computer was related to technological comfort levels and the liberty to shape instruction to teacher-perceived student needs. Her assertion is also supported by Baek et al. (2008) as cited in Buabeng – Andoh (2012) who claimed that experienced teachers are less ready to integrate ICT into their teaching. U.S National Centre for Education Statistics (2000) as cited in Buabeng-Andoh (2012) reported that teachers with less experience in teaching are more likely to integrate computers in their teaching than teachers with more experience in teaching. Specifically, the report allege that teachers with up to three years teaching experience were found to be spending 48% of their time utilizing computers, those with between 4 and 9 years teaching experience were spending 45% while teachers with between 10 and 19 years teaching experience were spending 47% of the time and those with more than 20 years teaching experience spent 33% of their time with computers showing that generally teachers tendency to use computer diminish with increasing

experience. The reason to this disparity was attributed to the fact that fresh teachers are more experienced in using the technology. Other supporters of this school of thought include Russell, *et al.* (2007).

Workload was found to have a significant negative effect of teachers use of CAL implying that teachers work overload could be one of the major inhibitors of their underuse of this teaching strategy. Samarawickrema and Stacey (2007) and Neyland (2011) concur that teachers' workload influence their acceptance of technology in classrooms. Neyland (2011) showed that increased workload of teachers was alarming, the curriculum was overcrowded and teachers had extremely busy work day which was pushing many of them to the limit and in some cases beyond. In the Kenyan case, Itunga (2011), Otach (2008), Sifuni and Sawamura (2009) and UNESCO (2005) laments on a public school system replete with high influx of new pupils, classrooms that are congested and existing facilities which make a mockery of the free education program initiated by the government. This condition, they all agree has stretched the classroom teacher to the limit in terms of work load and class management which could be impacting negatively on their preparation to integrate CAL.

The study also illustrated that as was expected, IT competence had a significant effect on teachers use of CAL and accounted for a significant 26.2% of the total variance. ANOVA analysis showed that the variable had a large effect size. Previous studies have revealed that whether beginner or experienced, ICT

related training programs develop teachers' competences in computer use (Bauer & Kenton, 2005; Franklin, 2007), influence teachers' attitudes towards computers (Hew & Brush, 2007; Keengwe *et al.*, 2008) as well as assist teachers reorganize the task of technology and how new technology tools are significant in student learning. Mueller *et al.*, (2008) related technology training to successful integration of technology in the classroom. The study indicated that professional development and the continuing support of good practice are among the greatest determinants of successful ICT integration.

Researchers have also established that effective use of computers is dependent on the teachers' ICT skills as well as their intentions towards ICT use (Vanderlinde *et al.*, 2009; Venezky, 2004). To them, relevant professional development can take the form of observing colleagues, learning from each other, observation of each others' ICT-integrated lessons, as well as the provision of opportunities for teachers to share and collaborate with each other (Flanagan & Jacobsen, 2003; Jacobsen, 2002; Prain & Hand, 2003). Sandholtz and Reilly (2004) on their part claim that teachers' technology skills are strong determinant of ICT integration, but they are not conditions for effective use of technology in the classroom. They argue that training programs that concentrate on ICT pedagogical training instead of technical issues and effective technical support, help teachers apply technologies in teaching and learning.

Teachers' attitude towards computer was reported to be positive (mean of 3.76 out of 5). Inferential analysis showed that Kwale public secondary school chemistry teachers' computer attitude have a positive though insignificant effect on their integration of CAL in teaching of chemistry. This is in line with observations of several researchers who maintain that teachers' attitude towards technology influence their acceptance of the usefulness of technology and its integration into teaching. For instance, Hew and Brush (2007) as well as Keengwe *et al.* (2008) are categorical that among the factors that influence successful integration of ICT into teaching are teachers' attitudes and beliefs towards technology. Other researchers who have expressed similar sentiments include, Demirci (2009) Teo (2008) Drent and Meelissen (2008) as well as Odera (2011). In the case of this study, majority of teachers felt that integration of CAL is not complex, made teaching more systematic, is more creative and leads to greater students involvement and intellectual enhancement which is consistent with observations of Oladosu (2012, p. 46-47) who insists that integration of CAL in teaching and learning has the potential for enhancement of the "quality of the learning experience" and transformation of pedagogy. Similarly, a majority felt that use of CAL gave students a global orientation, leads to easier students' assessment as well as enhancement of departmental cohesion an observation which concurs with Albirini (2006); Atsumbe *et al.* (2012); Baskin and Williams (2006) and Ottesen (2006).

Relative to computer anxiety, respondents reported having moderate levels (mean of 2.76 out of 5). A majority indicated they were not scared by a computer neither did they feel threatened talking about it. Inferential analysis indicated that the variable has a positive significant effect on integration of CAL. Agbatogun (2010) maintain that computer anxiety levels of teachers are significant in the consideration of the integration of computer technology into teaching and learning. Findings by the researcher indicated that when computer anxiety was first entered in to an analysis as a predictor, results revealed significant prediction. Specifically, it indicated that computer anxiety singularly contributed 35.0% towards the prediction of teachers' attitude towards Interactive Computer Technology. In other words, research outcome intimated that computer anxiety is the significant potent predictor of teachers' attitude towards Interactive Computer Technology. Similar observations were made by Papanastasiou and Angeli (2008); Pelgrum and Plomp cited in Russel and Bradley (1997).

Data obtained showed that Kwale County chemistry teachers' had positive self-concept (mean of 3.80 out of 5). Self-concept was found to have an insignificant negative effect on integration of CAL in teaching of chemistry. The findings partly contradicts Deniz (2007) who found that teachers who see themselves as being computer competent and confident are more favourably disposed to computer usage. Russell and Bradley (1997) reported that teachers' opinion about their ability to use computers has a relationship with their

attitude towards computers while Agbatogun (2010) maintain that what an individual thinks about his/her ability of performance in a thing, an event, or a task dictates his/her attitude (positive or negative) towards such. By implication, what many teachers think about themselves in relation to computer use often dictate their attitude towards the acceptance, acquisition of knowledge and skills, integration and effective use of computer technology, hence the relevance of this outcome in educational technology arena.

On the whole, chemistry teacher related factors were found to account for a significant proportion of total variance (72.6%) in integration of CAL in teaching and learning of chemistry indicating that the factors greatly contribute in teachers' extent of use of CAL. This is consistent with assertions of Bitner and Bitner (2002) as well as Schiller (2003) who insists that teacher's personal characteristics such as age, gender, educational level, teaching experience and attitude influence adoption of technology in classroom practice.

#### **4.3.6 Institutional Factors and Integration of CAL**

The sixth aim of the study was to determine the effect of institutional factors on use of CAL in teaching and learning of chemistry. The institutional factors considered for this study include access, leadership support and technical.

##### **a) Descriptive Finding on Institutional Factors and CAL**

The findings are presented based on the themes stated that include access, leadership support and technical support.

### Access to CAL Teaching Resources

Data obtained as regards elements of access were as summarised in Table 4.28.

**Table 4.28**  
*Accessibility of CAL Tools for Chemistry Teaching*

Statement	Response (A & SA)		Mean	SD
	f	%		
We have adequate access to CAL resources for chemistry	16	43.2	2.73	1.17
I can readily access Internet on my own	25	67.5	3.49	1.30
There is adequately equipped computer laboratory in the school.	24	64.8	3.41	1.42
There are sufficient computers for students and teachers	15	40.5	2.95	0.94
Each chemistry teacher has an access to a computer connected to the internet for their own personal use	7	18.9	1.81	1.15
The computer laboratory is readily available whenever I need it	16	43.2	3.11	1.17
Classrooms, lighting, air condition and arrangement are suitable for computer aided instruction in chemistry	21	59.4	3.32	1.47
Internet speed is sufficient in our school	11	29.7	2.38	1.26
Computers are fast enough to use for instructional activities	14	37.8	2.84	1.24
There are sufficient licensed software programs for Chemistry	13	35.1	2.59	1.52
Grand Mean			2.86	1.26

*Note:* A= Agree, SA = Strongly Agree

Information obtained show that though more of the respondents (64.8%) indicated that there was an adequately equipped computer library within their school, fewer (43.2%) had access to adequate resources for chemistry. For instance, less than half (43.2%) said that the computer laboratory was readily available whenever they need it, a similar proportion, (40.5%) said there was sufficient computers for students and teachers and about a third (37.8%) acknowledged that the computers were fast enough to use for instructional activities. With regard to softwares, only about a third of the respondents indicated having access to sufficient licensed software programs for chemistry. Access to internet connectivity also seemed to be a challenge to most of the schools since though a majority (67.5%) acknowledged that they could access

internet on their own, the internet speed was sufficient for only about a third (29.7%) while slightly less than a fifth (18.9%) said that each chemistry teacher in their school had access to a computer connected to the internet.

Consequently, the most common CAL related programs and practices chemistry teachers acknowledged using in teaching of chemistry included storing and sharing of information (100%), photocopying (100%), typing (78.4%), using educational material (75.8%), surfing the internet and word processing (70.3%) among others. Other important practices such as designing, programing and downloading softwares were completely not practised while taking pictures (35.1%), desktop publishing (21.6%) training on the web (32.4%), drawing, painting or graphics (32.4%) were attempted but by a minority of the respondents.

### **Leadership Support**

Findings on elements of leadership support were as presented in Table 4.29.

**Table 4.29**  
*Extent of Leadership Support for Use of CAL in Chemistry Teaching*

Statement	Response (A & SA)		Mean	SD
	f	%		
There is CAL skills development for students in our school	15	40.5	2.68	1.16
There is CAL skills development for teachers	15	40.5	2.68	1.16
There is adequate support for CAL development in teaching learning of Chemistry in our school	8	21.6	2.41	0.98
There are sufficient opportunities to improve my technology knowledge	24	64.9	3.43	1.12
Sufficient technology training is provided	5	13.5	1.92	0.95
The computer training offered by the school system has helped me to use computers in my teaching	8	21.6	2.16	1.07
Administrators ask our opinions for their innovative applications	9	24.3	2.19	1.20
We are informed about the administration's prospective technological endeavors.	9	24.3	2.54	1.02
My principal is supportive of use of computers in the classroom	15	40.5	3.22	1.27
The School Board is supportive of use of computers in the classroom.	15	40.5	3.00	1.29
Parents are supportive of use of computers in the classroom	15	40.5	3.14	1.11
Grand Mean			2.67	1.23

*Note:* A= Agree, SA = Strongly Agree

Data obtained from the respondents showed that there was minimal levels of leadership support to use of CAL in classroom teaching in a majority of the schools as exemplified by low rating of the elements of this factor by the respondents (mean of 2.67 out of 5). While a majority (64.9%) insisted that there are sufficient opportunities for the teachers to improve their technology knowledge, less than a half (40.5%) maintained that there is CAL skill development for students and teachers in their schools, a similar number of respondents ascertained that their principals, school board and parents were supportive of use of computers in classroom. Additionally, about a quarter (24.3%) indicated that administrators ask their opinion for innovative applications and that they were always informed about the administrations' prospective technological endeavours. Further, about a fifth (21.6%) were

certain that there is adequate support for CAL development in teaching – learning of chemistry in their school and that the computer training offered by the school system had helped them to use computer in their teaching. Lastly, very few respondents (13.5%) felt that sufficient technology training had been provided to them by their schools.

### Technical Support

An assessment of the accessible institutional technical support by the chemistry teachers yielded data as captured in Table 4.30.

**Table 4.30**  
*Extent of Technological Support for Use of CAL*

Statement	Response (A & SA)		Mean	SD
	f	%		
There are user manuals for technological devices I use	13	35.1	2.51	1.17
Whenever I have problems with technological devices, there are warnings and user manuals to help me with what to do	10	27.0	2.35	1.09
Whenever I have a problem in laboratories or technology classrooms, I get quick and efficient technical assistance.	19	51.4	2.81	1.29
The school system has a computer technician I can call with computer-related questions and problems	15	40.5	2.54	1.68
There is a person in my building with enough computer expertise to answer my computer-related questions	18	48.6	2.86	1.23
Grand Mean			2.61	1.29

*Note:* A= Agree, SA = Strongly Agree

Findings on technical support indicated minimal to moderate levels. While about a half of the respondents (51.4%) acknowledged being able to get quick and efficient technical assistance whenever they encountered a problem in technology classroom, slightly less than a half (48.6%) maintained that there was a person within their building with enough computer expertise to answer their computer related questions and even fewer (40.5%) indicated that their school system had a computer technician they could call with computer related

questions and problems. Additionally, only about a third (35.1%) maintained that there were user manuals for technology devices that they use while slightly less than this number (27.0%) indicated that whenever they had problems with technological devices, there were warnings and user manuals to help them with what to do.

In conclusion, a summary of the descriptive data on effect of institutional factors yielded information as shown in Table 4.31.

**Table 4.31**

***Descriptives for Institutional Factors (N=37)***

Variables	Mean	SD	Access	Leadership S.	Technical	CAL
1. Access	28.62	7.17	-	.465**	.557**	.105
2. Leadeship S	29.35	9.11		-	.537**	.661**
3. Technical S	13.08	4.72			-	-.009

Means, standard deviation and intercorrelations for scores on each of the variables sought were as presented in Table 4.29 for the total sample. Use of CAL in classroom teaching was positively and significantly correlated with leadership support. Access to CAL tools was positively and highly correlated to leadership support and technical support. Leadership support was strongly correlated with use of CAL and technical support. On the whole, teachers scored highly for leadership support ( $M = 29.35$ ) and access ( $M = 28.62$ ) while technical support received the lowest mean rating ( $M = 13.08$ ).

### b) Inferential Analysis

A regression model was used to estimate the effects of institutional factors on use of CAL and findings were as summarized in Table 4.32.

**Table 4.32**

***Effect of Institutional Factors***

Variables	B	$\beta$	t	p	R <sup>2</sup>	Adj.R <sup>2</sup>	R <sup>2</sup> change
Access	.100	.105	.625	.536	.011	-.017	.011
Leadership S.	.587	.781	5.644	.000	.489	.459	.478
Technical S.	-.695	-.480	-3.468	.001	.626	.592	.136

The hierarchical regression model used showed effect of access of ICT tools accounted for 1.1% of the total variance on use of CAL  $F(1, 36) = 0.63$ ,  $p = 0.536$ , leadership support on the whole accounted for 47.8% of the total variance  $F(2, 35) = 5.64$ ,  $p < 0.001$  and technical support accounted for 13.6% of the total variance,  $F(3, 34) = -3.47$ ,  $p = 0.001$ . The models which were generally significant ( $p < 0.001$ ) also showed that individually, access is an insignificant positive determinant of chemistry teachers integration of CAL in classroom teaching, leadership support is a significant positive determinant while technical support is a negative significant determinant. On the overall, the model which was significant showed that institutional factors accounted for 62.5% of the total variance of teachers' use of CAL in teaching and learning of chemistry.

### c) Qualitative Findings on Institutional Factors and CAL

Data obtained from observation showed that almost all the schools sampled and the ones whose teachers were available to respond to the questionnaire

items had a computer laboratory with adequate hardware such as desktop computers for students. The hardware were available for a class of 45 students or less at a ratio of two students per computer. There was also a laptop for teachers which could be connected to a projector, copiers or a printer each of these hardware being readily available and accessible. Almost all the schools visited were found to be relying on chemistry educational softwares developed by KICD which were available to them in form of CD – ROM. In most schools, such software were found to be readily available for form one and two while those of form three and four were not there. As indicated earlier, internet connectivity was found to be limited in most schools, a majority of the schools relying on internet connectivity through purchase of airtime from a local service provider safaricom which depended on availability of funds. Thus most schools had either limited or no access to chemistry internet sites, chat rooms and chemistry video games. Additionally, only a small proportion of the respondents had access to global chemistry websites (8.1%) and lists of chemistry websites (29.7%).

In general, data obtained from interviewees indicated teachers appreciation of the institutional support available although some lamented on its minimal level. The support was important in enhancing their competence in use of ICT tools, training learners to use the technology tools, acquire new tools, repair and maintenance of existing infrastructure including internet connectivity.

#### **d) Discussion of Results on Institutional Factors and CAL**

Descriptives for institutional factors showed average levels of effect. Relative to access of CAL instructional tools, results indicated respondents had average levels of access to adequate CAL tools to support chemistry instruction, some elements meriting high percentage scores. The variable thus merited slightly above average mean rating ( $M = 2.86$  out of 5) indicating that though important, its potentiality was yet to be fully exhausted. This observation was confirmed by regression analysis which showed that access accounted for a paltry 1.1% variance in use of CAL tools. Its effect was also found to be positive but insignificant. This observation partly agrees with Norris *et al.*, (2003) who pointed out the importance of access to technology. Similarly, Usluel *et al.* (2008) and Yildirim (2007) proposed enhancement of accessibility to ICT tools for effective CAL integration.

Leadership support also obtained average mean rating ( $M = 2.67$  out of 5). Regression analysis showed that the variable accounted for 47.8% of total variance in use of CAL tools. It was also shown that generally the effect of leadership support was positive and significant. This conforms to previous research findings. For instance, Anderson and Dexter (2005) indicate that though infrastructure support is imperative, school technology leadership is a stronger predictor of teachers' use of computer technology in teaching. Yee (2000) believed that a leader who implements technology plans and also shares a common vision with the teachers stimulate them to use technology in their

lessons. Similarly, Schiff and Solomon as cited in Lai and Pratt (2004) suggested that for effective utilization of ICT by teachers, there is need for a strong leadership to drive a well-designed technology plans in schools. Becta report on the effect of ICT on teaching in basic schools in United Kingdom also stressed on significance of good leadership (Lai & Pratt, 2004). The report identified five factors that are considered as essential for schools if ICT is to be utilized properly. These factors include ICT resources, ICT teaching, ICT leadership, general teaching and general school leadership.

Lastly, an analysis carried showed average descriptive score for the elements of technical support ( $M = 2.61$ ). This observation coheres with that of National Committee for WSIS Prepcom II (2003) who observed that in most of the developing countries, there are very few technical experts to implement and maintain ICTs. The finding which showed technical support to be a limiting factor for the process of integration of CAL contradicts Korte and Husing (2007) who in their study revealed that schools in Britain and the Netherlands have appreciated the significance of technical support in helping teachers integrate technology into their teaching. They argued that ICT support in schools influence teachers to apply ICT in classrooms without wasting time troubleshooting hardware and software problems.

Generally, results obtained showed that teachers were being accorded average levels of institutional support in the course of integration of CAL. This support

was found to be very significant for the process and for about 62.6% of total variance in use of CAL. Previous research has shown that institutional factors help to improve teachers' existing attributes. According to Vannatta and Fordham (2004), teacher's time committed to teaching and amount of technology training are reliable factors of technology use in the classroom. Norris *et al.* (2003) also pointed out the importance of access to technology. Likewise, researchers have proposed enhancement of professional development (Bauer & Kenton, 2005; Franklin, 2007), accessibility (Usluel *et al.*, 2008; Yildirim, 2007), technical support (Becta, 2004; Jones, 2004) and leadership support (Lai & Pratt, 2004; Yee, 2000) for effective CAL integration.

#### 4.3.7 Challenges of Integration of CAL

The last objective intended to identify the challenges that teachers encountered in the process of integration of CAL in teaching and learning of chemistry in public secondary schools in Kwale county.

##### a) Descriptive Finding

To determine the challenges, respondents were provided with several statements to score. Their responses were as displayed in Table 4.33.

**Table 4.33**  
*Effects of Challenges on Use of CAL*

Statement	Response (A & SA)		Mean	SD
	f	%	%	
Lack of control over inappropriate materials	22	59.5	3.27	1.22
Lack of class time for use	27	73.0	3.68	0.82
Lack of technical/administrative/social support	25	67.5	3.57	1.17
Incompatible with current assessment practices	21	56.7	3.43	0.93
Incompatible with pedagogical belief	29	78.4	3.65	0.92
Lack of training	20	54.1	3.30	0.85
Grand Mean			3.48	0.99

Results show that the respondents categorized the belief that CAL is incompatible with teachers pedagogical belief as the most challenging factor for its use in teaching of chemistry according to more than three quarters (78.4%) followed by inadequate class time for use and lack of technical, administrative and social support according to slightly less than three quarters of them (73.0% and 67.5% respectively). Similarly, slightly more than half of the respondents indicated lack of control over inappropriate materials (59.5%), incompatibility of CAL content with current assessment practices (56.7%) and lack of training (54.1%) as some other challenges.

#### **b) Qualitative Finding on Challenges of Integration of CAL**

Interviews conducted highlighted several issues which chemistry teachers' consider to pose challenge to integration of CAL in teaching and learning of chemistry. Key issues mentioned include inadequacy of CAL teaching and learning resources, inadequate leadership and technical support and time constraint. Specifically, though each school had an equipped computer laboratory with most CAL infrastructure, the single laboratory with its facilities was said to be incapable of sufficiently satisfying for the integration needs of all subjects and classes considering that most schools were either double or triple streamed. Classes were thus forced to share CAL facilities which constrained quality of their use in the teaching and learning process. Each subject was allocated one lesson per week for integration in most schools which most teachers complained was not enough. Additionally, though most

schools had KICD softwares for junior classes (form 1 and 2), those for form three and four were not available which made CAL integration for these classes a challenge. The situation was further compounded by inadequacy of internet connectivity which could have enabled downloading of such softwares from the internet. Further, some of the available software were either said to be too shallow while others were either incompatible with the existing hardware or could not operate well due to poor preparation.

Teachers also complained about inadequate technical support. This is due to the fact that most schools lacked trained IT technician who could be able to give technical aid when required. Such schools thus relied on a teacher who had been trained most of who they indicated did not have the technical expertise required for most critical operations. Additionally, teachers lamented about inadequate leadership support. Though a majority of acknowledged that their respective administration were generally supportive in the venture to integrate CAL in classroom practice, the support given were not concentrated on their technological requirements. For instance, they were yet to receive sponsorship that could enable them enhance their IT knowledge and skills, rarely are they consulted on issues related to acquisition of ICT infrastructure and even when they make requisition for purchase of tools including softwares, they are rarely bought. Students' poor ICT skills was also suggested as a challenge impacting integration of CAL as well as inadequate internet connectivity.

### **c) Discussion of Finding on Challenges of Integration of CAL**

Data obtained illustrates the existence of several challenges that were seen by interviewees to be hindering integration of CAL in teaching and learning of chemistry in public schools in Kwale county. The challenges revolve around five themes which include infrastructure related, internet connectivity, technical support, leadership support and skills related. It was observed that ICT infrastructure available were inadequate thus hindering the process of CAL integration. Similarly, most teachers indicated that their schools had inadequate internet connectivity, inadequate leadership support and inadequate technical support. Lastly, most teachers did not feel that they had adequate technical skills which could enable them thrive in technology rich environment. At the same time, most of their students lacked requisite IT skills for CAL integration. The prevailing scenario is similar to previous research findings. For instance, Swartz and Wachira (2010) laments that Kenyan schools face several ICT integration challenges which include limited ICT facilities, costly Internet access, limited information sharing, limited skills for ICT integration.

Other challenges include limited electricity supply, poor telephone connectivity and inadequate number of computers according to Hesselmark (2003). Hare (2007) considered lack of policy framework, inadequate infrastructure, high cost of bandwidth, and inadequate in-service training on ICT integration in education as some of the factors inhibiting ICT integration. Mendes et al

(2003) as reported in Mwangolo (2011) in a study of extent of use of ICT resources pointed out that there is less emphasis on ICT training in primary and secondary schools in Tanzania due to limited facilities while Adomi and Kpangban (2010) in a study on causes of the low rate of ICT adoption and application in Nigerian secondary schools found it to be attributable to several factors. These factors were found to include; limited/poor information infrastructure, lack of/ inadequate ICT facilities in schools, frequent electricity interruption, poor ICT policy/project implementation strategy, inadequate ICT manpower in the schools, high cost of ICT facilities and lack of or poor perception of ICTs among teachers and administrators.

## CHAPTER FIVE

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Introduction

This chapter presents a summary of the research findings, conclusions, recommendations and suggestions for further research. The main purpose of this study was to determine the effect of CAL method of instruction on achievement of secondary school students in organic chemistry with specific focus on form four students in public schools in Kwale county with ICT infrastructure.

To achieve the study purpose, a Solomon's four group quasi-experimental research design was adopted. In this design participating students were divided into four groups, two experimental and two control. Students in two groups were pre-tested (one control and one experimental), all students in the four test groups were exposed to intervention which involved teaching them organic chemistry II topic using CAL teaching strategy for experimental groups and conventional method for control groups. Finally, all the four groups were post-tested. Results obtained from the pre-test and post-test were compared to assess the impact of the intervention.

Data for analysis was obtained through an array of instruments including student achievement tests, students' and teachers' questionnaires, teachers' interview schedule and an observation checklist. Information obtained was

analysed both qualitatively using thematic analysis as well as quantitatively with the aid of SPSS version 20 computer software.

## **5.2 Summary of Findings**

The contents of the study findings are summarized based on preliminary information, information on respondents' demographic variables and the seven study objectives.

### **5.2.1 Respondents' Demographic Information**

The study respondents were from four students taking chemistry and their chemistry teachers. The students were purposively drawn from four public secondary schools (2 county, 2 sub-county) while teachers were drawn from all public secondary schools within Kwale county with ICT infrastructure for integration. For the 182 students who participated in the study, 51.6% were boys while 48.4% were girls. Additionally, 59.9% were in the 16-18 age group. Generally, the students were fairly spread across the test groups based on their attributes.

With regard to the 37 teachers who returned fully filled questionnaires, 64.9% were males, 67.5% were 35 years or more in age while 83.8% were either diploma in education graduates, trained graduates or trained postgraduates. Additionally, 73.0% had 5 years or more teaching experience, 75.7% had either 28 lessons or less work load and 62.2% were computer literate, each having

had basic IT training through self sponsorship. The four teachers who conducted the intervention phase also responded to an interview.

### **5.2.2 CAL and Students' Achievement in Organic Chemistry**

Descriptive data from pre-test examination indicated that more students in control group (26.1%) passed in the pretest examination as compared to their counterparts from experimental group (15.3%) implying that achievement of students from control group was slightly better than that of those in experimental group. Data from post-test for the groups pre-tested showed that mean achievement of students from experimental group was higher than their counterparts from control group, the group from experimental posting high mean achievement compared to the control group. Additionally, results showed that those who passed in the post-test from experimental group were three times as many (27.1%) compared to those from the control group (8.7%). This was further confirmed by results of the groups which were not pre-tested with more students from experimental group (38.9%) passing in the post-test as compared to those from control group (14.4%) thus posting higher mean achievement. These results showed that generally achievement levels of students from experimental group was better than their counterparts in the control group.

A one way ANOVA analysis used to infer on the existing relationship between the elements showed that students from experimental groups ( $E_1$ ) and ( $E_2$ )

registered a higher mean in the post-test examination as compared to their counterparts from control groups ( $C_1$  and  $C_2$ ). ANOVA results  $F(3, 178) = 27.60, p < 0.001$  showed that the observed mean difference was significant. Post Hoc Tukey's (HSD) test also showed that the post test results for  $E_1$  ( $M = 52.93$ ) were significantly different from  $C_1$  and  $C_2$  with the mean achievement of students in experimental group being significantly higher than those in control groups. Similarly, significant mean differences were found between post-test results of  $E_2$  and those of  $C_1$  and  $C_2$ , the mean achievement of students in experimental group being significantly higher than those from control groups.

### **5.2.3 CAL and Achievement of Low and High Ability Students**

Categorization of students as low and high ability based on pretest results showed that 58.7% were low ability students, 33.7% who were from  $E_1$  and 25.0% from  $C_1$ . For the 41.3% categorized as high ability, 15.2% were from  $E_1$  while 26.1% were from  $C_1$  indicating that more of the low ability students were in the experimental group as compared to those from control group. Likewise, the study established that more of the high ability students were found in the control group as compared to those from experimental group.

Two way ANOVA test conducted to show effect of CAL reported main effect for ability and group. Significant differences were observed for achievement levels of HA and LA students, though the effect size was minimal. Similarly,

significant differences were reported between groups (CAL and conventional methods) with medium effect size. The results also indicated that achievement of HA students were significantly different from those of LA students. Pairwise comparison showed that the effect was significantly greater for LA than HA. Similarly, results indicated that achievement levels of students from experimental group  $E_1$  were significantly different from those of students in the control group  $C_1$ , pairwise comparison showing that achievement levels of students in experimental group being significantly different from those in the control group. Univariate test results were also significant for ability and test groups.

#### **5.2.4 CAL and Achievement of Students Based on Attitude**

Effect of CAL on students achievement in organic chemistry based on their pretest attitude and its effect on their attitude was achieved by comparing students' change in attitude with their test groups and their pretest attitude score and posttest SCAT score. Descriptive data obtained showed that students scored relatively highly for attitude in the pretest score on attitude implying that generally, a majority of the students had a positive attitude. For example, 79.1% of the students would want to work with people who make discoveries in chemistry after high school, 70.9% were certain that to be a scientist is not boring and 70.3% insisted that chemistry knowledge is important to find a job. Generally, 16 out of 20 statements used to assess students' attitude towards chemistry received a mean rating of more than 3 out of 5.

The categorization process thus yielded groups composed of more students with negative attitude towards chemistry (67.6%) compared to students with positive attitude (32.4%). There were more of the NA students in E<sub>1</sub> compared to those in the other test groups and more of PA in the C<sub>2</sub> group compared to those in the other test groups. However, a one way ANOVA test performed to assess the spread of learners in the test groups showed in significant mean differences illustrating similarity of the spread of respondents in the test groups based on their attitude thus warranting further analysis.

A two way analysis of variance of the students' posttest SCAT and their pretest score on attitude showed that the effect of CAL on groups was significant indicating main effect for groups, the effect size being moderate. Results showed that the differences in achievement between students with positive and negative students was insignificant. Significant differences were however found between achievement of students in groups (CAL and conventional methods). No significant difference in achievement existed between students with positive attitude and those of negative attitude. However, significant differences were observed between achievement levels of students in the experimental group E<sub>1</sub> from those of students in the control group C<sub>1</sub>. Similarly, there were significant mean difference in achievement of students in E<sub>2</sub> and those in C<sub>2</sub>.

Pairwise comparison showed that test scores for students in  $E_1$  were significantly different from those of  $C_1$  and  $C_2$  and those from  $E_2$  were significantly different from those of  $C_1$  and  $C_2$ . Univariate test results were also significant for test group but insignificant for attitude. The Post Hoc Tukey's (HSD) test showed that achievement of students with negative attitude from  $E_1$  were significantly different from that of their correspondents from  $C_1$  and those from  $E_2$  were significantly different from those from  $C_2$  with the achievement of students in both the experimental groups being significantly higher than their counterparts from the control groups. Similar observation were made with regard to those with positive attitude, those from  $E_1$  and  $E_2$  having significantly higher achievement compared to those from  $C_1$  and  $C_2$  implying that the effect of CAL was felt by both students with negative and positive attitude in the experimental groups thus the higher achievement.

To assess the effect of CAL on students attitude towards chemistry, students attitude score at the beginning ( $SQ_1$ ) and at the end ( $SQ_2$ ) of the study on the same elements of attitude were compared. Data obtained showed an overall increase in the mean rating of the students' attitude towards the subject for most of the elements, the change in attitude being positive (score for  $SQ_2 - SQ_1 = .38$ ). Critical analysis showed that while each of the groups (experimental and control groups) attained a positive deviation,  $SQ_2 - SQ_1$  for experimental groups was greater than  $SQ_2 - SQ_1$  for the control groups.

The findings show that the change in students' score on elements of attitude from E<sub>1</sub> were highest on the scale of change of attitude followed by those from E<sub>2</sub> then those in C<sub>2</sub> and lastly those from C<sub>1</sub> in decreasing order. ANOVA results shows that the observed mean difference was significant implying that the change in attitude thus effect of CAL was greatest for the experimental group. Post Hoc Tukey's (HSD) test showed that the post test results for E<sub>1</sub> were significantly different from C<sub>1</sub> and C<sub>2</sub> with the change in attitude of students in both the experimental group being significantly higher than those in the control groups. Similarly, significant mean differences were found between posttest results for E<sub>2</sub> and those of C<sub>1</sub> and C<sub>2</sub>, the mean change of students' attitude in the experimental group being significantly higher than those from the control group.

#### **5.2.5 Students' Age and Gender and Integration of CAL**

Information on respondents' gender indicated that there were 94 boys and 88 girls distributed in each of the four test groups and that their ages were categorized as below 16, 16-18 and above 18. A two way analysis of variance test was used to determine the effects of CAL on achievement levels of students in organic chemistry with variable ages and gender. The model which was found to be significant and accounted for 34% of total variance in use of CAL indicated main effect for groups, the effect size being moderate. ANOVA results showed significant differences between groups (CAL and conventional methods).

Pairwise comparison showed that the test scores for students in  $E_1$  were significantly different from those of  $C_1$  and  $C_2$  and those of  $E_2$  were significantly different from those of  $C_1$  and  $C_2$ . Univariate test results were also significant for test groups but insignificant for age, and gender. Post hoc (Tukey's HSD) test showed that there is a significant mean difference between achievement levels of students in  $E_1$  and those in  $C_1$  and  $C_2$ , those of students in the experimental group being significantly higher than those of students in control groups. A similar trend was observed for achievement levels of students in  $E_2$  and those in  $C_1$  and  $C_2$ .

#### **5.2.6 Teachers' Factors and Integration of CAL**

The study sought to assess how teacher related factors influenced integration of CAL. The influence of demographic factors including age, gender, level of education, teaching experience, workload and ICT competence were sought. Additionally, those of computer attitude, computer anxiety and self concept was sought. Data for teachers' demographic factors was obtained from 37 form four chemistry teachers from public secondary schools within the county with ICT infrastructure for integration. More than two thirds (67.5%) of these teachers were 35 years and above, 64.9% were males, a greater number of the teachers were either graduates or postgraduate (78.4%) and a slight majority (56.8%) had over 10 years working experience. Further, about three quarters (75.7%) had a workload of over 25 lessons while about two thirds (62.2%) had

basic training in IT which they indicated as having obtained through self- sponsorship.

Exploratory correlational analysis indicated moderate to high level of correlation of use of CAL with the respondents' age, gender, level of education, work experience, workload and ICT competence. Significant correlation were reported for level of education and ICT competence at  $p=0.01$ . Teachers' attitude towards integration of CAL in teaching of chemistry was found to be positive as was indicated by an overall mean ranking of 3.76 out of 5. All the respondents (100%) indicated that it made teaching systematic, almost all the respondents (91.9%) felt it made teaching more creative and lead to greater student involvement though it also requires high administrative support. Additionally, over three quarters ( $> 75.0\%$ ) insisted that use of CAL is less time consuming, gives a global orientation to the students, leads to easier students assessment and intellectual enhancement of the department.

Findings on level of computer anxiety show that though more than three quarters of the respondents said computers do not scare them at all (94.6%), that they do not feel threatened when others talk about computers (91.9%) and that they feel comfortable working with a computer (86.5%), less than a quarter said computer make them feel uneasy (16.2%), working with computers make them nervous (10.8%) and uncomfortable (10.8%). Additionally, about a third of indicated that they wouldn't be bothered to take a computer course (32.4%)

and that they would feel at ease in a computer class (35.1%) though a similar number of respondents maintained that computers inhibit human critical thinking (35.1%) and that computers can be used to invade ones privacy (37.8%). The variable attained mean rating of 2.76 out of 5 implying that chemistry teachers generally had average levels of computer anxiety.

Data on teachers' self-concept show that almost all the respondents thought their colleagues were friendly to them, a majority (91.9%) was treated well by colleagues and all the respondents usually consulted with colleagues whenever they had a problem. Similarly, very few (5.4%) respondents preferred to be on their own rather than with others, over three quarters (81.1%) thought they were liked by colleagues, about a tenth were always unfriendly to others (10.2%) and slightly more than this number (13.5%) were bad at a lot of things. The variable thus attained an appreciable mean rating of 3.80 out of 5 implying that generally a majority of the respondents had a positive self – concept.

Two way ANOVA analysis indicated main effect for integration of CAL for gender, level of education, IT competence, attitude and computer anxiety. No interaction effect was reported for age and gender, age and level of education as well as age and IT competence. Similarly, no interaction effect was reported for gender and IT competence as well as level of education and IT competence. The findings indicate that teachers in the 25-34 years age bracket recorded the highest level of use of CAL while lowest means were reported by those above

45 years of age. Male teachers recorded a higher level of use as compared to their female counterparts with males in the 25-34 age bracket reporting the highest levels of use of CAL.

Relative to level of education, graduate teachers reported the highest mean for use of CAL while those with postgraduate qualification reporting the least extent of use. As was expected, those with formal training in ICT reported the highest level of use as compared to those without. With regard to attitude, those with positive attitude reported higher level of use compared to those with negative attitude. Lastly, teachers with high levels of computer anxiety also reported the highest extent of use followed by those with low levels and least of all those with moderate levels.

Significant effect of integration of CAL were found for teachers' gender, academic qualification, ICT competence, attitude and computer anxiety, the effect size being moderate for gender and high for academic qualification, ICT competence, attitude and computer anxiety. Pairwise comparison showed that the extent of use of CAL by teachers in the 25-34 years age bracket were significantly different from those in the 35-45 age bracket, extent of use of CAL by male teachers were significantly different from those of their female counterparts and those of graduate teachers were significantly different from those of teachers with diploma in education and postgraduate qualification.

Similar observation was made for the difference with training in ICT and those without.

Additionally, extent of use of CAL by teachers with positive attitude were significantly different from those with negative attitude, teachers with high levels of computer anxiety were significantly different from those with low and moderate computer anxiety. Univariate test results were also significant for age, gender, academic qualification, ICT competence, attitude and computer anxiety.

A hierarchical regression analysis showed that 1.1% of the variance in use of CAL in teaching and learning of chemistry was accounted for by age while gender accounted for 1.7% of variance in use of CAL. Level of education accounted for 34.5% of the total variance, experience explained 0.8%, workload 8.3% and ICT competence 26.2 % of the total variance in use of CAL respectively. Similarly, teachers attitude explained .2%, computer anxiety 12.7% and self-concept 0.3% of the total variance in use of CAL respectively. The regression equation which was found to be significant ( $p < 0.001$ ) showed that teacher related factors accounted for 85.8% of the total variance. Specifically, level of education, workload and ICT competence were found to have a significant negative effect on chemistry teachers' use of CAL; age, gender and teachers' self-concept each had an insignificant negative effect, experience and attitude towards computer each had an insignificant positive

effect while computer anxiety had a significant positive effect. Based on magnitude, ICT competence had the greatest effect on use followed by computer anxiety, then level of education and workload in decreasing order of effect while teachers' attitude towards computer had the least effect.

### **5.2.7 Institutional Factors and Integration of CAL**

Institutional factors whose effects were reviewed include access, leadership support and technical support. Data on accessibility of CAL teaching and learning tools show that though more of the respondents (64.8%) indicated having an adequately equipped computer library within their school, fewer (43.2%) had access to adequate resources for chemistry, less than half (43.2%) said that the computer laboratory was readily available whenever they need it, a similar proportion, (40.5%) said there was sufficient computers for students and teachers and about a third (37.8%) acknowledged that the computers were fast enough to use for instructional activities. With regard to software, only about a third of the respondents indicated having access to sufficient licensed software programs for chemistry.

Data on leadership support also showed that there were minimal levels of leadership support for use of CAL in classroom teaching in a majority of the schools thus an overall low rating of the elements of this factor by the respondents. Though 64.9% of teachers insisted that there were sufficient opportunities for them to improve their technology knowledge, less than a half

(40.5%) had CAL skill development for students and teachers in their schools, a similar number ascertained that their principals, school board and parents were supportive of use of computers in classroom. Additionally, about a quarter (24.3%) indicated that administrators ask their opinion for innovative applications and that they were always informed about the administrations' prospective technological endeavours.

Findings on technical support indicated minimal to moderate levels, 51.4% acknowledging being able to get quick and efficient technical assistance whenever they encounter a problem in technology classroom, 48.6% had a person within their building with enough computer expertise to answer their computer related questions and 40.5% indicated that their school system had a computer technician they could call with computer related questions and problems.

Pearson's correlation showed that of CAL in classroom teaching was positively and significantly correlated with leadership support. Access to CAL tools was positively and highly correlated to leadership support and technical support. Leadership support was strongly correlated with use of CAL and technical support. On the whole, teachers scored highly for leadership support and access while technical support received the lowest mean rating.

A hierarchical regression model used showed that effect of access to ICT tools accounted for 1.1% of the total variance on integration of CAL, leadership support on the whole accounted for 47.8% of the total variance and technical support accounted for 13.6% of the total variance. The models which were generally significant ( $p < 0.001$ ) also showed that individually, access is an insignificant positive determinant of chemistry teachers integration of CAL in classroom teaching, leadership support is a significant positive determinant while technical support is a negative significant determinant of extent of integration of CAL tools in classroom teaching. On the whole, the model which was significant showed that institutional factors accounted for 62.5% of the total variance of teachers' use of CAL in teaching and learning of chemistry.

### **5.2.8 Challenges of Integrating of CAL**

Lastly, the study inquired on the challenges that integration of CAL in teaching and learning of chemistry is facing as per the teachers' perspective. Interviews conducted highlighted several issues which chemistry teachers' consider to pose challenge to integration of CAL. Key issues mentioned include inadequacy of CAL teaching and learning resources, inadequate leadership and inadequate technical support. For instance, though each of the school visited were found to have an equipped computer laboratory with most CAL infrastructure, the single laboratory with its facilities could not cater for the needs of all subjects and classes considering that most schools were either double or triple streamed. Thus, classes were forced to share CAL facilities

which constrained quality of use of these facilities in the teaching and learning process. Similarly, software was not adequate especially for forms three and four. Lack of adequate internet connectivity from which software could be accessed online even further worsened the already bad situation.

With regard to technical support, most schools did not have a trained IT technician who could be able to give technical aid when required. Such schools thus relied on a teacher who had been trained as an IT champion. Teachers interviewed however indicated that they did not have the technical expertise required for most critical operations thus were unable to answer to some unique technical challenges whenever they arose.

Leadership support though available was found to be inadequate. Though respective administrations were generally supportive of teachers' venture to integrate CAL in classroom practice, the supports given were not concentrated on technological requirements for CAL integration. For instance, teachers interviewed were yet to receive sponsorship that could enable them enhance their IT knowledge and skills, they also indicated that rarely were they consulted on issues related to acquisition of ICT infrastructure and even when they made requisition for purchase of tools including software, they were rarely bought.

### 5.3 Conclusions

From the results discussed in the preceding sections, the study draws four main conclusions. First and foremost and in line with the main purpose of the study which was to establish the effect of integration of CAL in teaching and learning of organic chemistry on students' achievement, post-test results obtained indicate that the mean achievement of students exposed to CAL were significantly different from those of students exposed to conventional methods. The study illustrated that mean achievement of students in the experimental groups was significantly higher than that of students in the control groups. It is therefore concluded that CAL method is a better teaching strategy as compared to conventional methods as it improves students' achievement.

Secondly, the study aimed at establishing which category of students benefit most from CAL teaching strategy in the course of its use in teaching and learning process. To achieve this, the effect of the strategy on students' learning outcome was assessed based on categorization of their attributes in three cadre; their ability in chemistry, their attitude towards chemistry and their demographic characteristics of age and gender. Results obtained showed that as was expected, mean achievement of students from the experimental groups in organic chemistry in the post-test were significantly different from those of their counterparts in the control groups confirming the efficacy of the method across the various aspects of categorization including ability, attitude and demographic factors of age and gender.

Specifically, though the results obtained indicated significant effect of CAL on students' attitude with students' in the experimental group posting a significant higher score for change in attitude, insignificant mean difference in achievement levels was reported for students with negative and positive attitude in the experimental groups. Similarly, insignificant mean difference was reported for students based on their demographic factors of age and gender. However, a comparison of effect on achievement levels based on ability indicated that the effect was significantly greater for low ability than high ability students in the same experimental group. It can thus be concluded that integration of CAL impacts learners achievement uniformly based on their attitude or demographic factors of age and gender. However, the findings show that the effect of integration of CAL on students' achievement in chemistry though appear to be similar based on their ability in chemistry is greater for low ability students. The study also established that the effect on students' attitude change is greater for students with negative attitude towards the subject.

Third, the study intended to assess how various factors affect integration of CAL in teaching and learning of chemistry. Factors considered for review were either those presumed to be teacher related or institutional based. Results obtained indicated main effect for integration of CAL in the case of teachers' gender, level of education, IT competence, attitude and computer anxiety

implying that these are the main teacher related factors impacting integration of CAL in the teaching and learning of chemistry. Specifically, level of education, workload and ICT competence were found to have a significant negative effect on chemistry teachers' use of CAL while computer anxiety had a significant positive effect. Based on magnitude, ICT competence had the greatest effect on use followed by computer anxiety, then level of education and workload in decreasing order of effect while teachers' attitude towards computer had the least effect. For institutional factors, results show that leadership support is a significant positive determinant, access is an insignificant positive determinant while technical support is a negative significant determinant of extent of integration of CAL tools in classroom teaching. It can therefore be concluded that while teachers' level of education, workload, ICT competence and technical support were found to be inhibiting integration of CAL, computer anxiety and leadership support were promoting the process.

The last aim of the study was to highlight the challenges that integration of CAL could be facing. Broadly speaking, issues raised included inadequacy of CAL teaching and learning resources, inadequate leadership support as well as inadequate technical support. The study specifically established that the single laboratory in schools visited with its facilities could not adequately cater for the CAL integration needs of all subjects and classes since most schools were either double or triple streamed. With regard to technical support, most schools did not have a trained computer technician and the ICT champion though

available did not have the technical expertise that could answer to some of the needs required. Though respective administrations were generally supportive of teachers' venture to integrate CAL in classroom practice, the supports given were indicated not to be commensurate with the dynamic technological needs of teachers for CAL integration.

On the whole the study established that CAL as a teaching strategy is a better method of instruction of organic chemistry in particular and for subjects such as chemistry in which a majority of students have persistently posted poor achievement. The strategy was found to improve students' achievement across age, gender, ability and attitude by providing them with opportunities to explore and manipulate abstract concepts that not only enables them improve in their achievement levels but also motivates them thus enabling a change in their attitude towards the subject. The study also ascertained that the process of integration of CAL is gaining popularity amongst teachers in public secondary schools within the county propelled by a number of teacher and institutional factors. However, a number of factors including inadequate access to ICT facilities, limited leadership support and limited technical support among others were found to still be posing challenges to the process.

## **5.4 Recommendations**

### **5.4.1 Policy Recommendations**

Specific recommendations emanating from this study include:

- i. Since the study established that integration of CAL promotes students learning outcome, role out of the program to all schools should be fasttracked by equipping all schools with ICT facilities and support programs. Sub county and county schools which are populated with low ability students whom the study has shown to benefit most from CAL should be given priority in this regard.
- ii. The study while inquiring on the impact of CAL on students' learning outcome established that a majority of them had poor computer skills which was found to be hampering the use of this teaching strategy. Teachers complained of being forced to use little time available for instructing students on basic manipulation practices which wastes much of the valuable time. To aid the process of integration of CAL in teaching and learning process, it is recommended that introductory computer studies be taught to all students in secondary schools to equip them with basic computer skills thus ease the process of integration of CAL in teaching and learning of individual subjects.
- iii. The study also illustrated that the process of integration of CAL is being hampered by a number of teacher related factors including inadequate technical skills and heavy workload. It is recommended that a twin approach be adopted by stakeholders to put to check these

challenges. To help ameliorate heavy workload which was found to be hampering the process, the government in collaboration with other stakeholders should employ and post more teachers to schools. In the process, special consideration could be given to more female teachers to help bridge the gender gap which was found to be apparent in the county. Additionally, teachers already in practice should be inserviced to enable them acquire more computer skills which would not only enable them to better implement the CAL programs but also enhance their computer attitude, lower their computer anxiety and enhance their self concept.

- iv. The study at the same time established that integration of CAL is facing a number of institutional related challenges. Broadly, these include challenges due to access, leadership support and technical support. Though schools under study had fully equipped computer laboratory with requisite ICT infrastructure for integration of CAL, the infrastructure was not adequate for the large population of students in most of these schools as well as for concurrent use in all subjects. It is therefore recommended that more ICT hardware be provided to ease the burden placed on the existing infrastructure. Additionally, more funds need to be availed for acquisition of more softwares and reliable internet connectivity. Likewise, stakeholders need to factor in employment of an ICT technician in each school to assist in technical cases including teaching basic computer skills to students and teachers.

Further to this, school administration should give more support to their teachers by integrating them into IT resource acquisition decision making process to help motivate them.

- v. Lastly, in addition to allocating more funds for CAL resource acquisition, the school administration should enhance supervision of CAL integration process to ensure that the ICT infrastructure in place are appropriately utilised.

#### **5.4.2 Recommendations for Further Research**

It is suggested that further research be undertaken in the following areas:

- i. Longitudinal study of the effects of CAL on teaching and learning of organic chemistry in public secondary schools in Kwale county, Kenya.
- ii. Comparative study of the effects of CAL on the teaching and learning of organic chemistry in public and private schools in Kwale county, Kenya.
- iii. Comparative study of the effects of CAL on the teaching and learning of organic chemistry in rural and urban based counties in Kenya.
- iv. A study of the effects of CAL on the teaching and learning of other areas of chemistry e.g inorganic chemistry.

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**APPENDICES****Appendix A: Students' Questionnaire (SQ)****Introduction**

The statements below are intended to gather information on your experiences during the teaching and learning process of Chemistry. Suggest to the best of your ability your opinion against each of the statements. Thanks for accepting to take part in this program.

**Section A: Background characteristics.**

1. What is the name of your school? \_\_\_\_\_
2. What is your gender? (tick one) Boy ( ) Girl ( )
3. What is the category of your school? Girls Only ( ) Boys Only ( )  
Mixed ( )
4. What is your age? Below 16 ( ) 16 – 18( ) Above 18 ( )
5. What is the average number of students in your present class [stream]?  
[Choose one]  
Below 40 ( ) 40 – 45 ( ) Above 45 ( )
6. What is your residential status as a student? Boarder ( ) Day scholar ( )

### Section B

For **MOST** statements in this section, the abbreviations **SA- Strongly Agree**, **A- Agree**, **NS- Not sure**, **D- Disagree**, and **SD- Strongly Disagree** appear. Please respond to all the statements by ticking the one you consider most appropriate.

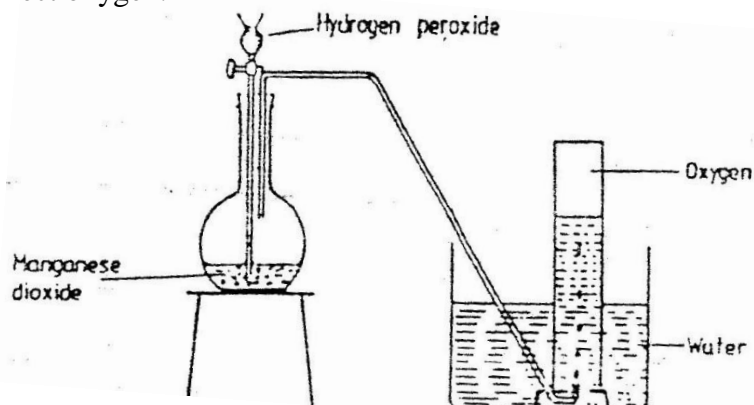
7. What is your opinion about each of the following statements? (Choose one option in each case)

Statement	SD	D	N	A	SA
Chemistry lessons are funny.					
Chemistry is necessary to solve daily life problems.					
I hate chemistry.					
I would like to work with people who make discoveries for chemistry after finishing school.					
I'm not good at chemistry.					
I don't want to work in a laboratory after finishing school.					
Chemistry lessons bore me.					
It may be interesting to work in a laboratory to earn money.					
Chemistry is one of the most interesting lessons.					
Chemistry is easy for me to learn.					
To make career about chemistry is boring.					
To be a scientist is boring.					
I'm looking forward to chemistry lessons.					
Although I work hard, I don't understand chemistry lessons.					
I want to become a scientist after high school.					
Chemistry knowledge is important to find a good job.					
I like chemistry projects.					
I don't like chemistry.					
I have positive attitude towards chemistry.					
Chemistry does not interest me.					

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

Answer all questions in the spaces provided.

1. The diagram below represents a set – up that can be used to prepare and collect oxygen.



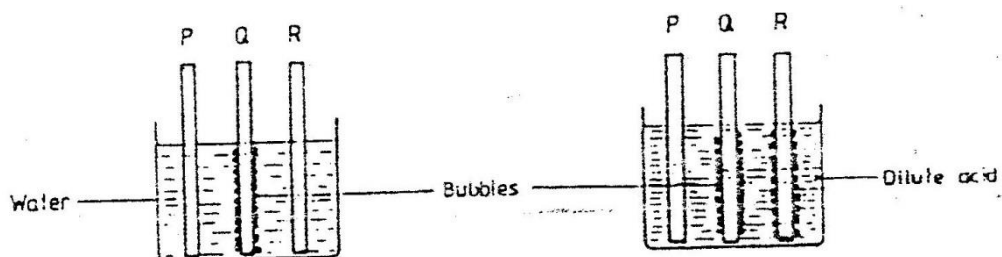
- a) Write an equation for the reaction that takes place [1mk]
- b) What property of oxygen makes it possible for its collection as indicated by the diagram [1mk]
- c) Explain why it is important not to collect any gas for the first few seconds of the experiment. [1mk]
2. The electron arrangement ions  $X^{3-}$  and  $Y^{2-}$  are 2, 8, and 2, 8, 8 respectively.
- (a) Write the electronic arrangement of the elements X and Y. [2mk]
- (b) Write the formula of the compound that would be formed between X and Y. [1mk]
3. The table below gives some properties of gases D and E.

Gas	Density	Effects of $H_2SO_4(aq)$	Effects of $NaOH(aq)$
D	Lighter than air	Reacts to form a salt	Dissolves without reacting
E	Heavier than air	Not affected	Not affected.

a) Describe how you would obtain a sample of E from a mixture of gases D and E. [2mks]

b) Suggest a possible identity of gas D. Give a reason for your answer. [1mk]

4. In an experiment, rods of metals P, Q and R were cleaned with sand paper and placed in a beaker containing water. Another set of rods was also cleaned and placed in a beaker containing dilute acid. After placing the rods in the two liquids bubbles of gas were seen around some of the rods as shown in the diagrams below.



a) Why is it necessary to clean the rods with sand paper before dipping them into the liquids? [1mk]

b) Arrange the three metals in order of their reactivity starting with the most reactive. [2mks]

5. The table below gives the atomic numbers of elements W, X, Y, and Z. The letters do not represent the actual symbols of the elements.

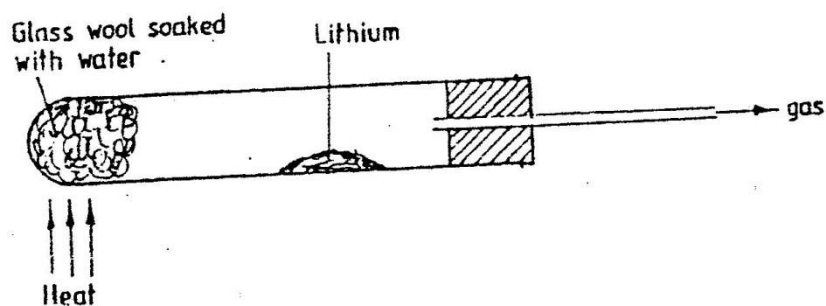
Element	W	X	Y	Z
Atomic Number	9	10	11	12

a) Which one of the elements is least reactive? Explain [1mk]

b) i) Which two elements would react most vigorously with each other? [1mk]

ii) Give the formula of the compound formed when the elements in b (i) react  
[1mk]

6. The diagram below represents a set-up that was used to react lithium with water study it and answer the questions that follow:



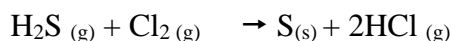
a) Write an equation for the reaction that takes place; given that the atomic number of lithium is 3.  
[1mk]

b) Why would it not be advisable to use potassium in place of lithium in the above set-up?  
[1mk]

c) Which other element could be used in the above set up instead of lithium?  
[1mk]

7. Explain how you would obtain solid carbonate from a mixture of lead carbonate and sodium carbonate powders.  
[3mks]

8. In an experiment, 2.4g of sulphur was obtained by reacting hydrogen sulphide and chlorine as shown by the equation below:



a) Which of the reactants acts as a reducing agent in the above reaction? Explain.  
[1mk]

- b) Given that the yield of sulphur in the above reaction is 75%, calculate the number of moles of  $\text{H}_2\text{S}_{(g)}$  used in the reaction ( $S=32.0$ ) [2mks]
9. 10gm of sodium hydrogen carbonate were dissolved in  $20\text{cm}^3$  of water in a boiling tube. Lemon juice was then added drop wise with shaking until there was no further observable change.
- a) Explain the observation, which was made in the boiling tube when the reaction was in progress [2mks]
- b) What observation would have been made if the lemon juice had been added to copper turnings in a boiling tube? Give reason? [1mk]
10. a. The melting point of phosphorous dichloride is  $-91^\circ\text{C}$ . While that of magnesium chloride is  $715^\circ\text{C}$ . In terms of structure and bonding, explain the difference in their melting points. [2mks]
- b. Give a reason why phosphorus is stored under water [1mk]

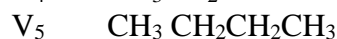
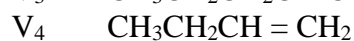
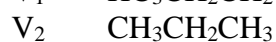
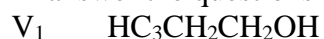
**The End**

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

Answer all the questions in the spaces provided

1. a. What is a hydrocarbon? [1mk]

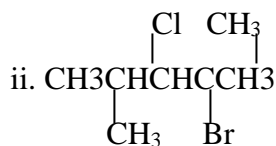
b. The list below shows the formulae of some organic compounds. Use it to answer the questions that follow.



- (i) Select two compounds which
- I Are not hydrocarbons ( 1mk)
- II Belong to the same homologous series ( 1 mk)
- (ii) Identify the compound that is likely to undergo polymerization. Give a reason for your answer. ( 2 mks)

c. Give the IUPAC names of the following compounds [5mks]

i. CH=CHCH<sub>3</sub>



iii. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH

i. CH<sub>3</sub>CH<sub>2</sub>COOH

ii. CH<sub>3</sub>C-O-CH<sub>2</sub>CH<sub>3</sub>

d. Draw the structures of the following compounds: [3mks]

i. 2, 3 – dibromo – 2 – methylbutane

ii. Ethanol

iii. Propanoic acid

e. In which homologous series do the following compounds belong [2mks]

i)  $\text{CH}_3\text{CCH}$

ii)  $\text{CH}_3\text{CH}_2\text{COO}$

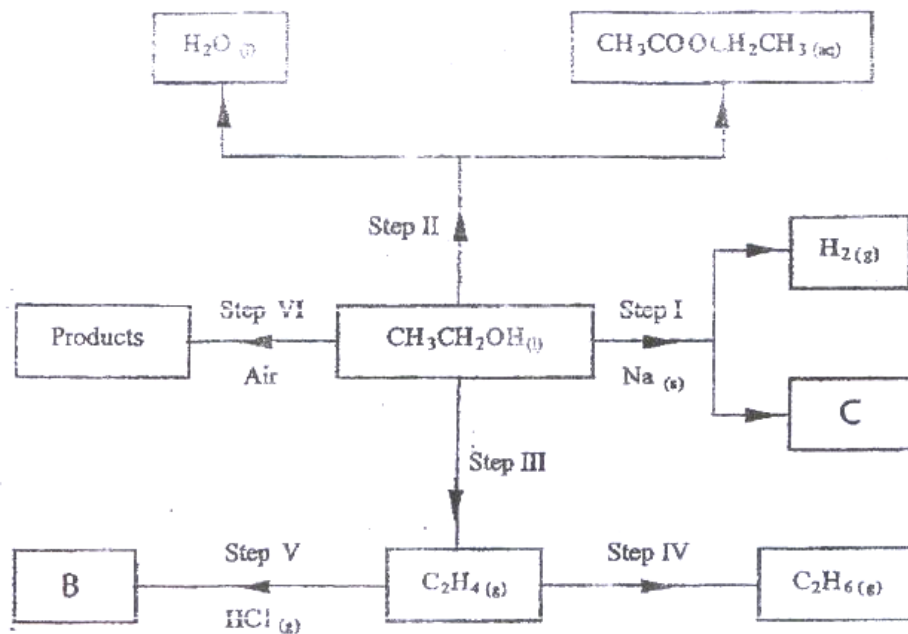
2. a). Study the information in the table below and answer the questions that follow.

Alcohol	Heat of combustion on KJ mol <sup>-1</sup>
Methanol	715
Ethanol	1371
Propanol	2010
Butanol	2673

i. Give a reason why the difference in the molar heats of combustion between successive alcohols is close. (3mks)

ii. Describe a physical test that can be used to distinguish between methanol and hexanol. (2 mks)

b). Use the flow chart below to answer the questions that follow.



i) Name:

(I) the type of reaction that occurs in step II; (1 mk)

(II) Substance B. (1 mk)

ii) Give the formula of substance C. (1 mk)

iii) Give the reagent and the conditions necessary for the reaction in step (IV) (3mks)

d. The empirical formula of a hydrocarbon is  $\text{CH}_2$ . The hydrocarbon has a relative molecular mass of 56. [H=1.0; C=12.0].

i. To which homologous series does the hydrocarbon belong?  
[2mks]

ii. Draw the structural formula of two positional isomers of the compound and give their names  
[2mks]

## Appendix D: Chemistry Teachers Questionnaire [CTQ]

### Introduction

The following statements are intended to gather information on your experiences during the teaching and learning process of chemistry. The statements in section A are open-ended. Statements from section B onwards are both open-ended and closed. Please respond to all of them accordingly. All the information given is confidential and will be used for the purposes of this study only. Thanks in advance for accepting to participate in this study. Your cooperation is highly appreciated.

### Section A: Background characteristics.

1. What is your gender? (*Tick the most appropriate*) Male ( ) Female ( )
2. Level of education? (*Tick one*) Certificate ( ) Diploma ( ) Dip. In Education ( )  
Untrained Graduate ( ) Trained Graduate ( ) Trained Post Graduate ( )
3. Besides academic qualifications, are there any refresher courses you have attended?  
Yes ( ) No ( )  
If yes, please specify \_\_\_\_\_
4. Term of service. (*Tick one*) Temporary ( ) Contract ( ) Permanent ( )
5. Teaching experience: .Below 5 yrs ( ) 5-10 yrs ( ) 11-15 yrs ( ) Over 15yrs ( )
6. Length of service in the current station. (*Tick one*)  
Below 5 yrs ( ) 5-10 yrs ( ) 11-15 yrs ( ) Over 15yrs ( )

7. Work load in terms of number of lessons per week

Below 25 ( ) 25 – 28 ( ) Above 28 ( )

8. Apart from teaching, do you have any administrative responsibilities? (**Tick one**)

Yes ( ) No ( )

If yes, please specify \_\_\_\_\_

9. What is the total number of students in your present form three Chemistry classes/streams? [**Choose one**]. Less than 40( ) 41 – 45( ) Above 45 ( )

10. Do you have any formal training in IT? Yes ( ) No ( )

11. If yes, please indicate level

Basics in IT ( ) Certificate ( ) Diploma ( )

12. Who sponsored you for the training? Self ( ) School ( ) Others ( )

If others please specify \_\_\_\_\_

**Section B**

13. Which of the following CAL materials are available for your use for teaching of Chemistry in your school? (Choose one option in each case)

CAL materials/services	Available	Not available
LCD projector		
Data projector		
Laptop		
Desktop computers		
Scanner		
Photocopier		
Digital camera		
Video camera		
Printer		
Chemistry educational software		
CD – ROM		
Chemistry internet sites		
Chemistry chat rooms		
Chemistry video games		
Global chemistry websites and materials		
List of chemistry websites for topic areas		
E-magazine		
E-library		

14. Indicate the frequency with which you use the following ICT materials in learning of Chemistry. (Choose one option in each case)

CAL materials/services	Weekly frequency of use				
	None	Rarely	Once	Twice	Always
LCD projector					
Data projector					
Laptop					
Desktop computers					
Scanner					
Photocopier					
Digital camera					
Video camera					
Printer					
Chemistry educational software					
CD – ROM					
Chemistry internet sites					
Chemistry chat rooms					
Chemistry video games					
Global chemistry websites and materials					
List of chemistry websites for topic areas					
E-magazine					
E-library					

15. Indicate which of the following CAL programs/practices you involve yourself in to support learning of Chemistry. (Choose one option in each case)

ICT programs/practices	Are you involved	
	Yes	No
Storing and sharing information		
Typing		
Emailing		
Surfing the internet		
Photocopying		
Taking pictures		
Designing		
Word processing		
Data generation from CD		
Programming		
Facsimile		
Video conference		
Data management with computer		
Downloading software		
Downloading vital info from internet		
Desktop publishing		
E-conference		
Training on Web		
Using educational material		
Drawing, painting or graphics		
Spreadsheets (e.g., MS-Excel)		

16. Indicate which of the following CAL programs/practices you involve your students in to support learning of Chemistry. (Choose one option in each case)

ICT programs/practices	Are you involved	
	Yes	No
Storing and sharing information		
Typing		
Emailing		
Surfing the internet		
Playing video games		
Photocopying		
Taking pictures		
Charting in the chart rooms		
Doing assignments		
Designing		
Word processing		
Data generation from CD		
Programming		
Facsimile		
Video conference		
Data management with computer		
Downloading vital info from internet		
Desktop publishing		
E-conference		
Using educational material		
Drawing, painting or graphics		
Spreadsheets (e.g., MS-Excel)		

### Section C

17. Against some statements in this section are abbreviations **SA –Strongly Agree**, **A – Agree**, **NS – Not sure**, **D- Disagree**, and **SD –Strongly Disagree**. Please respond to all of the statement by ticking against the box you feel is the most suitable as per your opinion.

**a. Access**

Statement	SD	D	N	A	SA
We have adequate access to CAL resources for Chemistry					
I can readily access Internet on my own					
There is adequately equipped computer laboratory in the school.					
There are sufficient computers for students and teachers					
Each chemistry teacher has an access to a computer connected to the internet for their own personal use					
The computer laboratory is readily available whenever I need it					
Classrooms, lighting, air condition and arrangement are suitable for computer aided instruction in chemistry					
Internet speed is sufficient in our school					
Computers are fast enough to use for instructional activities					
There are sufficient licensed software programs for chemistry					

**b. Teaching and Learning Using CAL**

Statement	SD	D	N	A	SA
There is widespread use of CAL to support learning of Chemistry in our school					
There is widespread CAL use as a traditional classroom tool for teaching and learning					
The widespread CAL use is parallel with traditional learning methods					
The widespread CAL use enables flexible learning					
Widespread CAL use facilitate communication between teachers and students					
The CAL resources are used to disseminate academic information					
Substantial learning material are made accessible online to the students using CAL					
I give assignments that lead students to use Internet resources					
Is use Internet resources for teaching – learning endeavors.					

**c. Institutional Support**

Statement	SD	D	N	A	SA
There is CAL skills development for students in our school					
There is CAL skills development for teachers					
There is adequate support for CAL development in teaching-learning of Chemistry in our school					
There are sufficient opportunities to improve my technology knowledge					
Sufficient technology training is provided					
The computer training offered by the school system has helped me to use computers in my teaching					
Administrators ask our opinions for their innovative applications					
We are informed about the administration's prospective technological endeavors.					
My principal is supportive of use of computers in the classroom					
The School Board is supportive of use of computers in the classroom.					
Parents are supportive of use of computers in the classroom.					

**d. Technical support.**

Statement	SD	D	N	A	SA
There are user manuals for technological devices I use					
Whenever I have problems with technological devices, there are warnings and user manuals to help me with what to do					
Whenever I have a problem in laboratories or technology classrooms, I get quick and efficient technical assistance.					
The school system has a computer technician I can call with computer-related questions and problems					
There is a person in my building with enough computer expertise to answer my computer-related questions					

**e. Attitude towards CAL Integration**

Statement	SD	D	N	A	SA
Use of instructional technology is complex					
Use of instructional technology is intimidating					
Use of instructional technology makes teaching more systematic					
Use of instructional technology makes teaching more creative					
Use of instructional technology lacks personal touch					
Use of instructional technology requires high administrative support					
Use of instructional technology is less time consuming					
Use of instructional technology leads to greater student involvement					
Use of instructional technology ensures greater instructor availability round the clock					
Use of instructional technology leads to easier student assessment					
Use of instructional technology gives a global orientation to students					
Use of instructional technology leads to intellectual enhancement of the department					

**f. Computer Anxiety**

Statement	SD	D	NS	A	SA
Computers do not scare me a tall.					
Working with a computer makes me nervous					
I do not feel threatened when others talk about computers					
It wouldn't bother me to take computer courses.					
Computers make me feel uncomfortable.					
I feel at ease in a computer class.					
I get a sinking feeling when I think of trying to use a computer					
I feel comfortable working with a computer.					
Computers make me feel uneasy.					
Working with computers is addictive					
Makes us dependent on computers					
Can be used to invade our privacy					
Inhibit human critical thinking					

**g. Self-concept**

Statement	SD	D	NS	A	SA
My colleagues think I'm unfriendly;					
Colleagues treat me well;					
When I have a problem, I ask;					
I prefer to be on my own rather than with others;					
I think my colleagues like me;					
I'm nearly always unfriendly with others;					
After arguing with someone, I talk to them;					
Others want to work with me;					
I'm bad at lots of things;					
I'm happy the way I am;					

**h. Challenges**

Statement	SD	D	N	A	SA
Lack of control over inappropriate materials					
Lack of class time for use					
Lack of technical/administrative/social support					
Incompatible with current assessment practices					
Incompatible with pedagogical belief					
Lack of training					

**Thank you**

**End**

**Appendix E: Chemistry Teachers Interview Schedule [TIS]**

This interview aims at obtaining information on your experiences in the use of CAL in the teaching and learning of chemistry. The information you provide will be highly confidential and will only be used for the purposes of this study. Your cooperation is highly appreciated.

1. In your opinion, how do you rate the performance of sciences in your school? [Probe: Chemistry]
2. What is the nature of students in your school i.e. based on entry behaviour, societal background, and peer influence e.t.c.?
3. Do you think this has an impact on their performance in chemistry?
4. What is your comment about the conditions under which students learn in your school? [Probe: Availability and use of CAL hardware and software]
5. What is the most predominant method that you prefer to use? [Probe for traditions vs CAL in chemistry].
6. What are some of the reasons why the method you have stated above is most preferred?
7. What are some of the specific ICT tools that you use in teaching and learning of chemistry?
8. What are some of the challenges that you encounter in teaching chemistry using CAL in your school?
9. In your opinion, what do you think should be done to improve the use of CAL in teaching and learning of chemistry?

**The End**

**Thank You**

**Appendix F: Observation Checklist**

Date \_\_\_\_\_

**Type of School**      Boys            [ ]      Girls            [ ] Coeducational  
[ ]

**Type of Group**      Experimental [ ]      Control            [ ]

**PART A: GENERAL INFORMATION**

1. Does the school have a ICT technician? Yes [ ] No [ ]
2. If yes, what is his/her level of training?
3. If no, why?
4. Against each item are the words: Availability (Available, Unavailable); Adequacy (Adequate, Inadequate); and Usage (Used, Not used) for section. The researcher will tick the most appropriate column with the help of the most relevant personnel.

Availability	Adequacy		Usage			
	A	B	C	D	E	F
Resources/Facility						
Computer laboratory						
Computer lab timetable						
Chemistry allocated time in timetable						
Desktop computers for teachers						
Laptop for teachers						
Internet access						
LCD projector						
Scanner						
Photocopier						
Digital camera						
Video camera						
Printer						
Chemistry educational software						
CD-ROM						
Chemistry internet sites						
Chemistry chat rooms						
Chemistry video games						
Global chemistry websites and materials						
List of chemistry websites for topic areas						
E-magazine						
E-library						

**PART B: CHEMISTRY TEACHER**

1. Does the teacher have a lesson plan?    Yes    [   ]                      No    [   ]

2. List the teaching strategy/method indicated in the lesson plan

a) \_\_\_\_\_

b) \_\_\_\_\_

c) \_\_\_\_\_

3. Classify the teaching strategy/method as;

Teacher centered [   ]    Interaction    [   ]    Learner Centered    [   ]

4. How does the teacher prepare the students before using the strategy/method?

\_\_\_\_\_  
\_\_\_\_\_

5. How does the teacher report or reinforce key points in the presentation?

a) Immediate                                      [   ]    At appropriate breaks                      [   ]

b) Later after presentation                      [   ]    Withheld key points                      [   ]

6. Teacher's competence on the use of the strategy/method.

a) Very good [   ]    Good [   ]    Average [   ]    Poor [   ]    Very poor [   ]

7. Note any other relevant observations made during the lesson

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**PART C: THE STUDENT**

8. Indicate the rating by placing a tick (✓) in the appropriate box using the scale below;

- |                      |   |               |   |
|----------------------|---|---------------|---|
| a) Not at all        | 1 | b) A little   | 2 |
| c) Fairly adequately | 3 | d) Adequately | 4 |
| e) A great deal      | 5 |               |   |

<b>Students' roles</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
How is the learners' participation in the lesson?					
Students' interaction with the teaching resource					
Students' interaction with each other					
Students asking questions/seeking guidance					
Students interaction with the teacher					

9. Note any other relevant observations made during the lesson

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## Appendix G: Kwale County Public Secondary Schools with ICT

### Infrastructure

1. Diani Secondary	2. Franz Joseph Secondary
3. Mwavumbo Secondary	4. Kaya Tiwi Secondary
5. KichakaSimba Secondary	6. Waa High
7. Kinango Secondary	8. Kingwede Secondary
9. Kinondo Secondary	10. Kwale Girls
11. Kwale High	12. Lukore Secondary
13. Lungalunga Secondary	14. Matuga Girls
15. Mazeras Girls	16. Mazeras High
17. Mivumoni Secondary	18. Taru Secondary
19. Waa Girls	20. Msambweni Secondary
21. Samburu Secondary	22. Ngozi Girls



## Appendix I: Research Authorization Letter



### NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,  
2241349, 310571, 2219420  
Fax: +254-20-318245, 318249  
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Website: www.nacosti.go.ke  
When replying please quote

9<sup>th</sup> Floor, Utalii House  
Uhuru Highway  
P.O. Box 30623-00100  
NAIROBI-KENYA

Ref: No.

Date:

NACOSTI/P/15/1499/4629

9<sup>th</sup> March, 2015

John Otieno Ogembo  
Kenyatta University  
P.O. Box 43844-00100  
NAIROBI.

*Reported on 16/03/2015*  
*Reported on 16/03/2015 and authorized to carry out research in Kwale County*

COUNTY DIRECTOR OF EDUCATION  
KWALE COUNTY  
P.O. BOX 25-20003 KWALE  
DATE.....SIGN.....

#### RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on *"Effect of computer assisted learning on teaching and learning of organic chemistry in public secondary schools of Kwale County, Kenya,"* I am pleased to inform you that you have been authorized to undertake research in **Kwale County** for a period ending **30<sup>th</sup> May, 2015**.

You are advised to report to **the County Commissioner and the County Director of Education, Kwale County** before embarking on the research project.

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

*DR. S. K. LANGAT*  
**DR. S. K. LANGAT, OGW**  
**FOR: DIRECTOR GENERAL/CEO**

Copy to:

The County Commissioner  
Kwale County.

The County Director of Education  
Kwale County.


### Appendix J: Research Permit

**THIS IS TO CERTIFY THAT:**  
**MR. JOHN OTIENO OGEMBO**  
**of KENYATTA UNIVERSITY, 0-80400**  
**UKUNDA, has been permitted to conduct**  
**research in Kwale County**  
**on the topic: EFFECT OF COMPUTER**  
**ASSISTED LEARNING ON TEACHING AND**  
**LEARNING OF ORGANIC CHEMISTRY IN**  
**PUBLIC SECONDARY SCHOOLS OF**  
**KWALE COUNTY, KENYA**  
**for the period ending:**  
**30th May, 2015**

*[Signature]*  
**Applicant's Signature**

*[Signature]*  
**for Director General**  
**National Commission for Science,**  
**Technology & Innovation**


**Permit No : NACOSTI/P/15/1499/4629**  
**Date Of Issue : 9th March, 2015**  
**Fee Received :Ksh 2,000**



**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 4375**

**CONDITIONS: see back page**