UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF COMPUTER-ASSISTED INSTRUCTIONS ON NON-SCIENCE STUDENTS' ACHIEVEMENT IN SELECTED TOPICS IN ORGANIC CHEMISTRY

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DECLARATION

STUDENT'S DECLARATION

I, Peter Ayisi Asare, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and that it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ……………………………………......

DATE: ……………………….....................................

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: Professor John K. Eminah

SIGNATURE: …………………………………......

DATE: ………………………………....................

DEDICATION

I dedicate this research to God Almighty who owns my life, and to my beloved wife Barbara Ayisi Asare for her tremendous support and encouragement towards my education. I also dedicate it to my lovely Mother Mary Asare and my late Father Mr. Samuel K. Asare.

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My sincere gratitude goes to Almighty God for His tender mercies, guidance and protection throughout my entire life and education up to this level. I also express profound gratitude to my supervisor Professor John K. Eminah for his assistance, guidance and encouragement towards the successful completion of this research work. I would also like to extend my profound gratitude to all my siblings and to the Staff of Juaboso Senior High School for their immense support and advice. I am also grateful to Mr. Alfred Boateng Forson and all my friends for their support and prayers. May the Almighty God bless them all.

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ABSTRACT

The study investigated the effect of computer-assisted instructions on non-science students' academic achievement and retention in some selected topics in organic chemistry. The research design employed for the study was a Quasi-Experimental specifically non-equivalent control group pre-test – post-test design. The total sample size was sixty-nine (69) non-science students from Juaboso and Nana Ntaadu II Senior High Schools. Two intact classes were purposively selected and used as the experimental and control groups for the study. Data were obtained using students' questionnaires and tests. The two groups were pre-tested, treatment (CAI for experimental and traditional for control) administered for six weeks and post-tested. A retention test was also administered to both groups six (6) weeks after the post-test. Descriptive statistics such as mean and standard deviation, and inferential statistics such as independent samples t-test, and dependent samples t-test were used in analysing the collected data to answer four research questions and three null hypotheses, which were tested at 0.05 level of significance. The t-test results for control and experimental groups indicated that there was a statistically significant difference between students Post-test scores of both control and Experimental groups. Findings of the study also revealed that students taught organic chemistry using CAI achieved significantly higher and retained knowledge better than those taught using traditional teaching method. Conversely, there was no significant difference in the mean achievements of the male and female students after using CAI. Based on the findings of the study, it was concluded that CAI has positive effect on students' academic achievement and retention ability in organic chemistry. It was therefore recommended that CAI be integrated into Senior High School integrated science instruction as this can result in significantly higher students' cognitive achievement in chemistry concepts than the traditional learning approaches.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter discusses the fundamental elements of the study in integrating Information Communication and Technology (ICT) into the teaching of science. It begins with the background to the study which formed the basis of the study and the researcher's motivation for conducting the study. Other key elements discussed in this chapter include statement of the problem, purpose of the study, research objectives, research questions, null hypotheses, significance of the study, limitation and delimitation of the study and organisation of the work.

1.1 Background to the Study

Science appears to be one of the academic subjects which most students dislike. This apparent dislike of science is either due to one or more combination of factors like teacher's ineffective pedagogical skills, learners' background in science or misconceptions of students about the subject (Shulman, 1987).

The major problem facing science education is the identification of the most effective and efficient pedagogical strategies for improving science literacy (Bennett, 2011). Students appear to respond to information differently. Therefore, it is necessary for teachers to use many different formats and modes to teach the subject matter of a lesson. According to Kyei-Baffour (1991), it is a known fact that most science teachers in various schools depend so much on theoretical approach of teaching science. Also, quite a good number of science teachers have insufficient knowledge in the effective use of teaching aids hence they teach science in an abstract manner. Without the effective use of teaching and learning aids, learners are compelled to memorise concepts that are difficult to understand and this usually results in the poor performance in examinations. Teaching and learning materials when used appropriately facilitates easy learning and understanding of concept and the knowledge gained becomes part and parcel of the learner (Bruner, 1973).

The common teaching methods used in teaching integrated science in Senior High Schools have been found to be lecturing, questioning and answering, explanation of concepts and note giving (Twoli, 2006). A number of strategies however, have been recommended for use in the teaching of science. Among these are cooperative learning, discussion methods, peer tutoring, role playing, and the use of Information Communication and Technology (ICT). According to Isman et al. (2007), the use of technology in education provides students with a more suitable environment to learn, serves to create interest and a learning-centered atmosphere, and helps increase students' motivation.

Naming and drawing the structures of organic compounds, like all other chemical concepts at the symbolic level are associated with some degree of difficulty in learning with respect to their structures, equations, and chemical reactions. The structure and naming of hydrocarbons serve as the foundation for moving to similar tasks for organic compounds containing other functional groups (Fessenden & Fessenden, 1990). The act of naming a compound is not necessarily giving the compound an IUPAC name but the name should be unambiguous with respect to the structure of the compound (Komza et al., 2000). Ege (as cited in Komza et al., 2000) stated emphatically that scientists cannot talk about organic chemistry relegating structural diagrams to the background, that is chemical scientists in the area of Organic chemistry always draw molecular structures for the reactions they talk about.

This is because molecular structures of compounds help to identify the constituent atoms, their spatial arrangements, and the chemical bonding between the atoms.

Computer-assisted instruction (CAI) is a program of instructional material presented by means of a computer or computer systems. Computer-assisted instruction (CAI) can serve as a powerful tool to supplement teacher's instruction in the classroom. It allows the incorporation of animation, moving pictures, and sound into lessons which extend the teachers' abilities to present materials that encourages students' interaction with the subject matter. It allows students to take a more active role in learning. The integration of technology in education enhances learning environment by providing opportunity to learners to be constructively engaged with instruction (Delannoy, 2000). It is evident that the children we teach at the senior high school level are becoming more conversant in the use of technology.

The literature notes that computer-assisted instruction (CAI) is one such area lauded for its capacity to improve the teaching of difficult and abstract science concepts, simulate dangerous experiments and stimulate interest in science learning (Allessi & Trollip, 1991). The use of Computer may also be effective in other areas as a general pedagogical aid that complements regular teaching methods (Kiboss, 2004). Most of the research done on effect of CAI, focused on its effects on elective science students.

It is against this background that this research sought to investigate the effect of computer-assisted instructions on non-science students' achievement in the nomenclature and reactions of some organic compounds in integrated science and its effect on non-science students' retention in organic chemistry.

1.2 Statement of Problem

Over the years, non-science students in Juaboso senior high school perceived organic organic compounds as difficult and frustrating concept to learn. From the researcher's experience in teaching integrated science at Juaboso senior high school, he observed that most non-science students found it very difficult using the IUPAC nomenclature system to name and write molecular and structural formulae of some organic compounds. It has been that most non-science students' interest in organic chemistry was very low.

Assessment of non-science students' work books and examination scripts over the years revealed that most students avoided answering questions involving the naming and the writing of structures of organic compounds and those who attempted mostly got it wrong. Indeed, most students could not name the first ten straight and branched chains organic compounds correctly.

Moreover, the Chief Examiner report in 2017 listed organic chemistry as one of the topics in science that students performed woefully in. It stated that most students ignored the few organic chemistry questions in integrated science and those who attempted did not answer them well. In the report, the chief examiners for the science subjects generally recommended that the students should be taken through enough practical lessons to improve their performances.

An empirical study by Adu-Gyamfi et al. (2012) exposed the weaknesses of senior high school (SHS) students in using the IUPAC nomenclature system to name and write formulae of organic compounds. The identified weakness were common for both hydrocarbons and non-hydrocarbons such as alkanols, alkanoic acids, and alkyl alkanoates. The students' difficulties in using IUPAC nomenclature in drawing structural formulae of organic compounds stemmed from the fact that they could not identify the correct number of carbons in a continuous chain as well as any substituent group and its point of attachment from the IUPAC name when drawing the structures (Adu-Gyamfi et al., 2012). This unsatisfactory situation require redress.

For this reason, the study was designed to investigate the effect of computer-assisted instructions on non-science students achievement in the nomenclature and reactions of some organic compounds in integrated science.

1.3 Purpose of the study

The purpose of the study was to investigate the effect of computer-assisted instructions on senior high school non-science students' achievement in selected topics in organic chemistry. The study was to use computer-assisted instructions (CAI) to aid the teacher to explain the structures of the various functional groups of organic compounds and the names associated with each group. Also the study was to investigate the effect of CAI of the retention of non-science students in selected topics in organic chemistry.

1.4 Objectives of the Study

The objectives of the study were to determine the

1 Effect of computer-assisted instructions on the achievement of non-science students' in organic chemistry as compared to those taught using the traditional method

2 Differences in achievement of male and female non-science students when taught organic chemistry using computer-assisted instructions.

3 Effect of computer-assisted instruction on retention of non-science students' in organic chemistry as compared to those taught using the traditional method.

4 Views of students on the use of CAI as an instructional strategy in teaching organic chemistry.

1.5 Research Questions

The following research questions were addressed in the study

1 What is the effect of computer-assisted instruction on the achievement of non-science students in organic chemistry as compared to those taught using the traditional method?

2 What is the difference in the achievements of male and female non-science students in organic chemistry when taught using CAI?

3 What is the effect of computer-assisted instructions on the retention of non-science students in organic chemistry compared to those taught using the traditional method?

4 What are the views of the students on the use of CAI as an instructional strategy in organic chemistry?

1.6 Null Hypotheses

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

- H_{01}: There is no significant difference in the achievements of non-science students' taught organic chemistry using computer-assisted instructions and those taught using the traditional method.

- H_{02}: There is no significant difference in the achievements of male and female non-science students in organic chemistry when taught using CAI

- H_{03}: There is no significant difference in the retention of non-science students in organic chemistry when taught using computer-assisted instruction compared to those taught using the traditional method

1.7 Significance of the Study

Based on the research findings, recommendations would be made to the Ghana Education Service, school administrators, science teachers and other stakeholders of education to help improve achievement of non-students in organic chemistry**.** The outcomes of this study would be helpful to science teachers and educators to realise the need to integrate CAI in the teaching of complex scientific concepts such as organic chemistry.

It may also be useful in the in-service training for teachers at Senior High Schools and training institutions to integrate C.A.I in the classroom.

Finally, the report will serve as a reference material for stakeholders of science education within the Western North Region and the country at large.

1.8 Limitations and Delimitations of the Study

1.8.1 Limitations of the study

According to Best and Kahn (2006), limitations are conditions beyond the control of the researcher that places restrictions on the validity of the research. The following factors were likely to affect the results of the research;

Students who fall sick, being punished or deliberately absent themselves during the treatment period were likely not to understand the concepts taught very well. Students who may not pay attention to the content of the computer-assisted instructions but rather focused on the few animations were likely not to understand the concepts very well. Also, Covid-19 restrictions may affect the planned activities.

Ideally, the study was supposed to cover all senior high schools in Western North Region but time constraint was accounted for this limitation.

1.8.2 Delimitations of the study

The study was restricted to the use of computer-assisted instructions and traditional method in the teaching of nomenclature and chemical properties of aliphatic hydrocarbons, alcohols, alkanoic acids, and alkyl alkanoates in integrated science.

The study was also restricted to third year non-science students only because organic chemistry is usually taught in this year.

The study was conducted in Juaboso Senior High School and Nana Ntaadu II Senior High School.

1.9.1 Definition of Terms

Achievement: The academic outcomes that indicate the extent to which students have accomplished specific goals that were the focus of activities in classroom instruction.

Computer-assisted instructions: refers to a program of instructional materials presented by means of a computer or computer systems

Control Group: Refers to the group of students who will be taught with the traditional method during the treatment period.

Experimental Group: Refers to the group of students who will be exposed to the CAI in the learning of the hydrocarbons

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

Non-science students: These are senior high school students who are not offering science, general agric, home economics or technical as their programme.

Organic chemistry: A branch of chemistry that entails the study of carbon compounds.

Technological Literacy: Competence in the use of information and communication technology

Traditional method: This method (Chalk-Talk method) involves the use of excessive words to explain concepts to students.

1.9.3 Abbreviations/Acronyms:

CAL : Computer Assisted Learning

CAI : Computer-Assisted Instructions

GES : Ghana Education Service

IUPAC: International Union of Pure and Applied Chemistry

OCAT: Organic Chemistry Achievement Test

SHS : Senior High School

SDT : Social Development Theory

TAM : Technology Acceptance Model

TIM : Traditional Instructional Methods

WAEC: West African Examinations Council

WASSSCE: West African Senior Secondary School Certificate Examination

1.9.3 Organisation of the Study Report

This write-up is divided into five chapters. Chapter one deals with the introduction under which the background of the study, statement of the problem, purpose of the study, research questions, significance of the study, limitations and delimitations. In chapter two, literature that is relevant to the research was reviewed. Chapter three indicates the research methodologies that were used to gather the necessary information about the issues raised in the study and these are the research design, population, sample and the sampling technique, the research instrument for collecting the data, reliability and validity of instruments, pilot testing of instruments, the method of data collection, data analysis and treatment procedures. Chapter Four, deals with presentation of results and discussions. Chapter Five discusses the findings conclusions, recommendations and suggestions for further research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter discusses some literature that relate to this study. It begins with the theoretical framework that underpins the study. It is continued with the conceptual framework and discussions on concepts on computer-assisted instruction, and its impact on chemistry education. The literature was reviewed under the following headings

- Theoretical framework
- Conceptual framework
- Use of Modern Technology in Science Education in Ghana
- The Relevance of Teaching Methods in Science Education
- Concept of CAI
- Traditional methods of instruction versus CAI Methods.
- CAI and teaching of organic compounds
- CAI and students’ gender
- CAI and Retention of Knowledge
- Empirical studies on the use of CAI in chemistry
- Nomenclature and Reactions of Some Organic Compounds
- Causes of poor performance of students in naming and writing the structure of some organic compounds
- Students’ perception on the use of CAI during teaching and Learning of science
- Challenges of the use of C.A.I in science teaching

2.1 Theoretical framework of the study

The study was premised on Social Constructivist theory of learning developed by Lev Vygotsky (1978) and Technology Acceptance Model developed by Davis (1989).

The Technology Acceptance Model (TAM), which was developed by Davis (1989), assumes that when users perceive that a type of technology is useful and also easy to use, they will be willing to use it. Davis developed the Technology Acceptance Model which deals more specifically with the prediction of the acceptability of an information system. The purpose of this model is to predict the acceptability of a tool and to identify the modifications which must be brought to the system in order to make it acceptable to users. This model suggests that the acceptability of an information system is determined by two main factors: perceived usefulness and perceived ease of use. Perceived usefulness is defined as being the degree to which a person believes that the use of a system will improve his performance. Perceived ease of use refers to the degree to which a person believes that the use of a system will be effortless. Several factorial analyses demonstrated that perceived usefulness and perceived ease of use can be considered as two different dimensions (Davis, 1989).

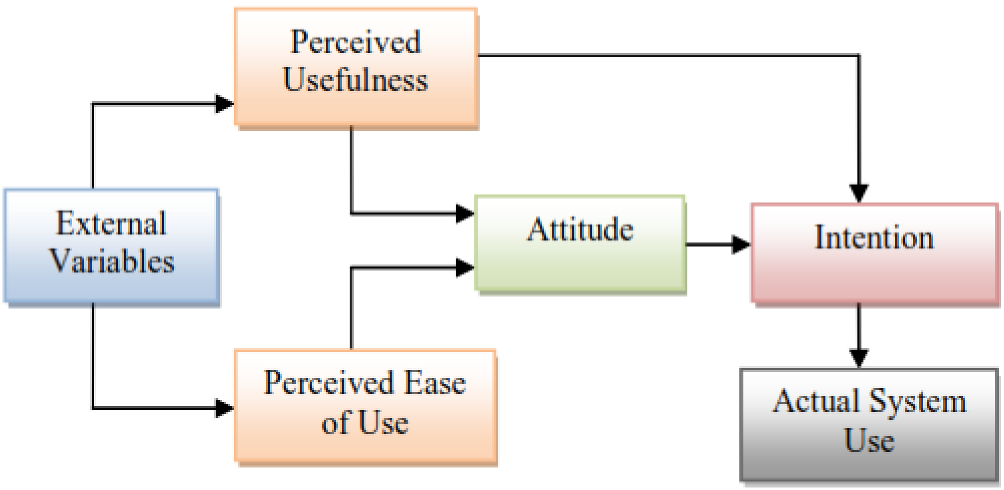

Figure 1: Technology Acceptance Model propounded by Davis (1989)

According to technology acceptance model, for CAI technology to be effective it needs to make the learners and teachers experience a feeling of the technology's usefulness and ease of its use. The more successful the CAI technology is in generating positive attitudes in learners towards using the CAI in learning, the better their learning experiences and outcomes. Thus, technology acceptance model proved to form an appropriate framework for use of CAI technology by learners in this study.

Moreover, Bandura (1982) noted the importance of perceived usefulness and perceived ease of use of technology, in predicting a person's self-efficacy. According to Bandura, self-efficacy which is similar to perceived use consists of self-judgment of how well one can perform specific tasks required to accomplish specific goals, while the learning outcome judgment is similar to perceived usefulness. The value of learning outcomes, which are academic achievement, student's self-efficacy and students' collaborative skills in this study is therefore linked to perceived usefulness of CAI.

Constructivism in science education is underpinned by a philosophy that all learning is constructed and that new knowledge is built upon the prior experiences of the learner (Naylor, 1999; Kruckeberg, 2006). The fundamental insight of constructivist theory is that knowledge is actively constructed and not simply acquired by the learner. According to Jonassen (1996), constructivist learning is described by four principles: the principle of knowledge construction; the principle of active learning; the principle of social interaction; and the principle of situated learning. Constructivists view learning as an active process (principle of active learning) in which learners construct new ideas or concepts based on the current or past knowledge and not simply acquiring the knowledge. Active learning of students may serve as a driving force to hard work that eventually translates to improved learning outcomes. The construction of knowledge is an active process that happens through individual or social engagement. This implies that trainers should provide learners opportunities to socially and individually engage in the process of making meaning by using participatory methods. Learners are not passive receptors; they should be engaged in active learning and supported in the construction of meaning, beyond the classic repertoire of listening, reading and memorising. Social interaction principle explains that knowledge is rightly developed through interactions that include; learner-learner and learner- teacher interactions (Jonassen, 1996).

Social Constructivists argue that human beings construct knowledge through interactions with others (McKinley, 2015). In social constructivist classrooms, collaborative learning is a process of student-student interaction mediated and structured by the teacher. The foundation of constructivism is attributed to the work of Dewey, Piaget and Vygotsky who maintain that how students respond to new learning situations is influenced by their prior knowledge (Hyslop-Margison & Strobel, 2011). Vygotsky observed that humans are inherently social; therefore, learning and development originate from experiences relating to others. Adults serve as a critical source of children's cognitive development by demonstrating and transferring methods of intellectual processing that children internalise.

This study views student learning through Vygotsky's Social Development Theory (SDT) (1978) in which social interaction is fundamental for cognitive development and learning is a product of society and socialisation. Vygotsky identified three main tenets of Social Development Theory: social interaction, more knowledgeable other, and zone of proximal development. The connections between people and their sociocultural environment are foundational to Social Development Theory. A more knowledgeable person is a person or program that contains greater ability than the student around a given concept. The zone of proximal development exists in the space between what a student can do on their own and what they can do with assistance.

This aligns with Bandura's Social Cognitive Theory (1986) in that learning is socially manifested, and students gain and process information from social interaction. Through this lens, we observe that student-teacher, student-student, student-technology relationships are necessary for effective learning. As such, students learn with the teacher as the primary facilitator within the social classroom environment (Arievitch & Haenen, 2005). Vygotsky's social constructivism also supports the use of tools, which scaffolding and providing directed pointers can "enrich and broaden both the scope of activity and the scope of thinking of the child". With the introduction of CAI, the learning environment is positioned to shift, leading to a transformation in student-teacher, student-student, and student-technology interactions. This theory supports learners to construct their own knowledge in a way that leads to more efficient learning, provides motivation and facilitates innovation.

According to Bodner (1986), constructivist learning theory holds that knowledge is constructed in the minds of the learner. According to the constructivist theory, knowledge is being actively constructed by the individual and knowing is an adaptive process which organises the individual's experiential world. In this philosophy learners construct knowledge themselves and the learning process is characterised by placing a high responsibility into the hands of the learner instead of the teacher. Computers are extremely suited for this type of learning since they encourage independent, individualised, experimental and discovery learning.

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. In simple terms, the theory holds that learning is an active process and knowledge is constructed from experience (Christie, 2005).

Thus, applied to senior high school chemistry instruction, constructivist approach emphasises student's cognitive creation of chemical concepts through daily active practical involvement with a number of chemical concepts. The theory emphasises hands-on, real-world experiences which seeks and values students' points of view. The theory posits that learning is a personal interpretation of the world and emphasises problem solving and understanding of phenomenon through use of authentic tasks, experiences, settings and assessments of content presented holistically – not in separate smaller parts. In short, the theory postulates that learning is best achieved in social context of content (Christie, 2005; Honebein, 1996).

According to Gray (1997), a constructivist classroom is distinguished from a conventional classroom by a number identifiable characteristics; learners are actively involved in learning, the environment is democratic, the activities are interactive and student-centered and the teacher facilitates a process of learning in which students are encouraged to be responsible and autonomous. This is in contrast with conventional teaching methods in which teachers directly transfer information to the passive learners. Gray recognises that learning should not be seen as some sort of conceptual implanting process but as interplay between students existing ideas and knowledge or experiences they are exposed to in the classroom. The constructivist learning environments are intended to provide various paths for learners to explore large amount of information with the teacher providing the role of a facilitator.

Basically, CAI is an effective constructivist pedagogy that incorporate various technological techniques such as computer tutorials, simulations and drill and practice programs in the teaching and learning to actively support the learning process. In the use of CAI students are at the center of the learning process and that are actively involved in constructing knowledge rather than being passive recipients of instruction. CAI is an appropriate medium to support active, interactive and self-directed learning. It allows students to work out their own learning strategies and develop different styles of learning. CAI also facilitate constructivist practice by providing a medium of discovery and exploring larger information and giving students autonomy in using knowledge as opposed to conventional methods. Learning with CAI provides positive interactions between student-student and student-teacher. These interaction plays a vital role during the learning process.

In terms of constructivist theory; student-student and student-teacher interaction is important in the class environment. CAI resources requires creation of constructivist programs like tutorials, simulations, animations and practice exercises which students can access and use on their own. These CAI programs allow students to control, pace and sequence their learning. When creating constructivist learning in CAI environments, teaching experience and training of the teacher is important in determining how effectively the teacher makes proper use of CAI resources. According to Comber and Keeves (1993), teaching experience cause higher learning outcomes in science as knowledgeable teachers are more confident in imparting information and are able to present a wider range of examples which helps the students to understand concepts more easily. Teaching and Learning that is meaningful to students is developed through discoveries that occur during exploration motivated by curiosity (Bruner, 1961).

In this study therefore, the constructivist theory provides the appropriate framework for viewing the computer-assisted instruction as an approach for teaching chemistry in attempting to improving the students' achievement, self-efficacy and collaborative skills of students in Chemistry. Teachers applying this theory would use instructional methods that support active, interactive and self-directed learning. This theory was found fit for the study because CAI programs are interactive and thus can enable students to control the pace and sequence of their learning (Silverman & Casazza, 2000).

2.10 Conceptual Framework

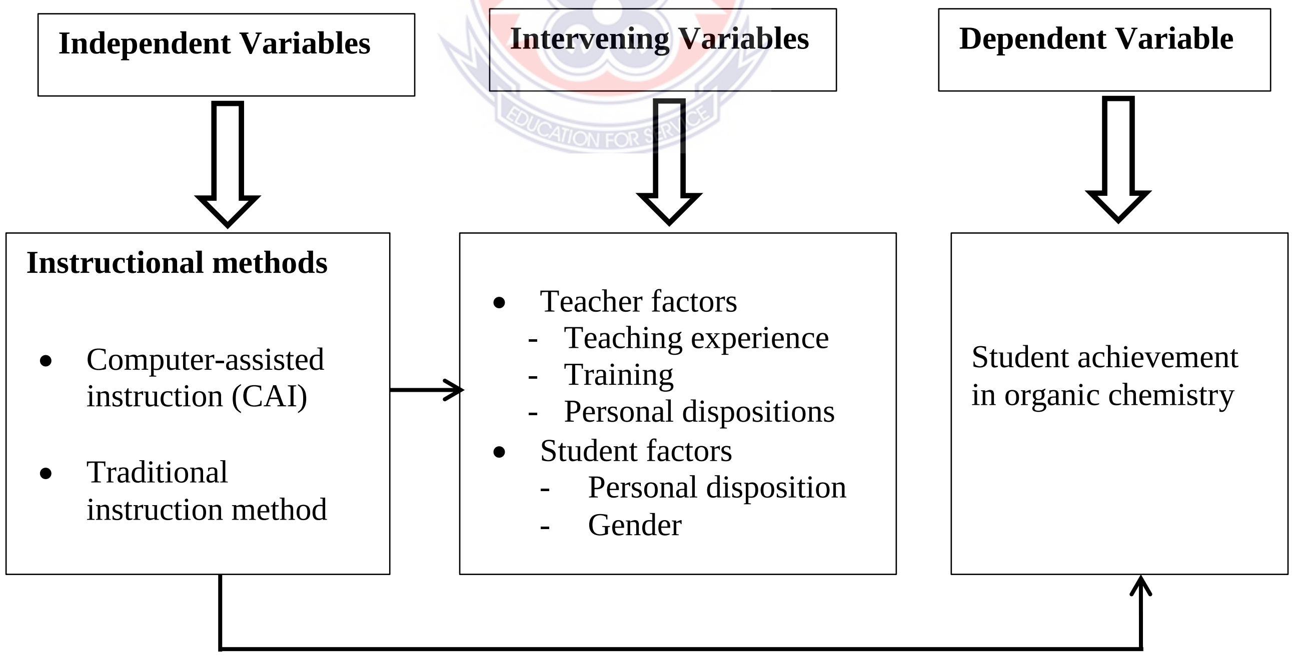

Figure 2: Conceptual Framework for the use of CAI and TIM in Learning Organic Chemistry

The study intended to compare the impact of use of CAI and conventional methods of instruction in organic chemistry. It was hypothesised that achievement of students in organic chemistry is influenced by the teaching strategy employed and controlled for by student, teacher related factors. The conceptual framework shows how the independent variable interact with both intervening variables and the dependent variables to bring about the students' outcomes in teaching and learning of organic chemistry. The independent variables (instructional methods) for this study were the computer-assisted instruction (CAI) and traditional instructional methods while the dependent variables were students' achievements in organic chemistry. The intervening variables included the students related factors and teacher related factors.

The researcher is of the view that for improved students' learning outcomes to be realised, the instructional methods used by the teachers have to succeed positively in impacting on students' achievement. In Chemistry teaching, the instructional methods play a major role in determining the students' learning outcomes. In this study, Chemistry instructional methods were categorised in two major main groups that is, the traditional instructional methods (TIM) and Computer-assisted instruction (CAI). It is indicated that CAI packages can transform the way students understand and learn concepts (Anderson, 2002). The researcher insists that CAI 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.

There are a number of factors that may influence the instructional process as well as the learning outcomes. These factors are the intervening variables. These intervening variables include; teacher related factors and students related factors. Teacher related factors involve teachers' experience and training, and their personal dispositions. The experience and training that the teacher has determines how effectively the teacher will use the teaching approach. Some researchers agree that teaching experience during the first few years of teaching is positively correlated with students' achievement (Kosgei, Mise, Odere & Ayugi, 2013; Standford, 2014). Students' related factors involve students' personal dispositions and gender. Students' personal dispositions and gender of the students may have an influence on learning outcomes. Gender was inbuilt in this study in order to statistically control for its variation (Fraenkel & Wallen, 2003).

2.2 Use of Modern Technology in Science Education in Ghana

As a result of the rapid development of the information and communication technology, the use of modern technology in education has become inevitable. Advancement in science and technology has recently changed the education systems in societies. The increasing importance of skilled persons not only as users of knowledge but producers of knowledge puts additional responsibilities on the educators of science. According to Ozmen (2008), the use of computer technology in education enables learners be active in the learning process, to construct knowledge, to develop problem solving skills and to discover alternative solutions.

According to Miller (2001), the use of technology in the classroom increases knowledge and expands the understanding of learners. Technology also link learners to their real and true world of information that can make them understand concepts and apply them. It can also make learners interested in a particular topic that they dislike (Cohen & Riel, 1989). This is so because it helps learners to perform better and that results in motivating them intrinsically. Cohen and Riel, (1989) concluded that technology can increase performance of learners and broaden the knowledge base of learners if they are well directed by someone knowledgeable in it. According to Roblyer (2002), effective use of any form of technology in the teaching and learning process can result into effective learning, hence produce classic performance in academic work. Ormrod (2001), says that, the use of computer and overhead projectors in teaching and learning can capture learners' attention and inevitably remember what they have learnt. The use of well-organised computer modules in the teaching of abstract concepts in science can make learning effective and teaching very easy with marvelous output of work (Gagné, 1985).

One of the aims of the science and technology course is to train individuals capable of keeping up the fast developing and changing science world and capable of utilising the recent technological discoveries in every field. The use of technology in education provides the students with a more suitable environment to learn, serves to create interest and a learning centered-atmosphere, and helps increase the students' motivation (İşman, Baytekin, Balkan, Horzum, & Kiyici, 2002). With the use computers in education, a lot of terms have come into and gone out of use in education (Owusu, Monney, Appiah, & Wilmot, 2010). The overlapping terms related to the uses of computer and associated technologies in science education are categorised into three by Bybee, Powell, and Trowbridge (2008) as follows: learning about computers, learning with computers and learning through computers. Big impact is placed on the computer-based science and education as well as ordinary science laboratories in the educational curricula in the world.

2.3 The Relevance of Teaching Method in Science Education

The problem of poor performance of students at the senior high school in integrated science chemistry is a great concern to science educators and relevant stake-holders in education. According to Wachanga and Mwangi (2004), successful teaching and learning of Chemistry depends partly on methods whose activities target most learning senses. This may imply that there is the need for teachers to vary the teaching technique in their day to day teaching activity. As accepted throughout the world the idea of using student centered constructivist based instructional methods is widely accepted, since teacher centered, traditional instructional methods have given insufficient opportunities for student to construct their own learning. Eliciting students' individual capabilities, intelligence and creative thinking can only be achieved through student centered instructional methods.

Teachers can use various teaching methods to achieve instructional objectives in science, which are broadly categorised as teacher-centered or conventional and student-centered methods. According to Cangelosi (1997), conventional instructional methods of teaching refers to instructional methods in which the teacher controls the entire lessons and learner-learner interaction is minimal or entirely lacking. Conventional methods are specifically teacher centered methods and lecture method. Twoli (2006) identified various teaching methods including the lecture, demonstration, practical or laboratory experiments, project work and field trips for teaching secondary schools chemistry. Berry (2008) argued that traditional method like lecture approach lacks the effectiveness of an active learning approach. In this era of instant and global information access, it has become increasingly important for science teachers to help students develop science process skills instead of focusing solely on the memorisation of a body of facts. It is therefore incumbent on science teachers to use innovative teaching methods rather than relying on traditional methods which only results in rote memorisation of scientific concepts.

A number of strategies however, have been recommended for use in the teaching of science. Among these are cooperative learning, discussion methods, peer tutoring, role playing, and the use of Information Communication and Technology (ICT). According to Isman et al. (2002), the use of technology in education provides students with a more suitable environment to learn, serves to create interest and a learning-centered atmosphere, and helps increase students' motivation. Science education is vital to the pace of the social, political and economic development of any nation, so effective teaching is very essential. Effective teaching of science concepts is important because teaching is based on helping children progress from one level to another in a more sociable interactive environment and to get the approach right to get students to be independent learners (Muijs & Reynolds, 2017). The teaching of science requires clear goals and non-traditional models that use the inquiry processes exploration, based on the natural curiosity of human beings to promote the development of skills associated with scientific culture. The learning of science should be the one that will generate conceptual understanding as students develop the ability to adequately recognise, interpret, explain, and illustrate the connections among the subordinate concepts of a macro concept and among these with other related concepts. Science teachers need to recognise the nature of the scientific endeavour and how it relates to science teaching if they are to help students completely understand the content and underlying philosophy of science.

2.4.1 Concept of CAI

Jonassen (2000) describes computer-assisted instructions (CAI) as an ICT tool that support learning by allowing students to construct knowledge, explore and assess information with other students. It allows the incorporation of animation, moving pictures and sound into lessons which extend the teachers' abilities to present materials that encourage students' interaction with the subject matter (Song & Keller, 2001). Computer-assisted instruction (CAI) is one such area lauded for its capacity to improve the teaching of difficult and abstract science concepts and to simulate dangerous experiments and to stimulate interest in science learning (Allessi & Trollip, 1991). Computer-assisted instructions may also be effective in other areas as a general pedagogical aid that complements regular teaching methods (Kiboss, 2004). CAI serves one main purpose of complementing the teaching and learning of concepts and skills as well as providing practical instruction through interactive programs that teach effectively. It uses a combination of text, graphics, sound and video and are available in various modes such as tutorials, simulations and drill and practice, to present content and provide immediate feedback for students' responses (Patel, 2013). CAI is a common technology in today's educational setup and that it can be utilised to help a student learn in all areas of curriculum (Patel, 2013).

Computer-assisted instruction has been confirmed as a tool which can be used to increase academic achievement of students in schools. It has been proved empirically that CAI is an excellent approach of teaching that strengthen students' achievement, stimulate their interest and decrease their exhausting and abstract nature (Gambari and Adeghenro, 2008). The advantages of CAI method according to Ozmen (2008) include, ensuring the application of proven teaching methods to students; offering equal educational opportunities for students by using the same programme; changing the role of the teacher from teaching capacity to that of a guide; also when properly handled, removing fright and embarrassment on students and bringing about meaningful learning and academic achievement. Research has discovered that learners who utilise computers have extensive self-assurance, confidence and are more efficacious and propelled to learn than those learners who are subjected to learn in traditional learning environment (Wishart, 2002). CAI helps to enable learners to focus on the physical meaning of the abstract concepts, subsequently, to get a detailed understanding of the theory (Azar & Şengüleç, 2011).

Generally, the use of CAI in education is premised on its potential to revolutionise 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 CAI can greatly improve student achievement (Cotton, 1991; Brumbaugh & Rock, 2001; Ku, Harter, Liu, Yang, Cheng, 2005).

Similarly, CAI 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. Other benefits of use of CAI 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.

According to Adeyemi (2012), CAI programs use drill and practice, problem solving, tutorials and simulation approaches to present topics that best test the students" understanding. It is learner-centered and activity-oriented. CAI creates a learner-centered environment which facilitates a more collaborative way for students to learn. In a learner centered environment, the teacher models instructions and acts as a facilitator, providing feedback and answering questions when needed. It is the student that chooses how they want to learn, why they want to learn that way and with who. Students answer each other's questions and give each other feedback, using the instructor as a resource when needed. This process allows students to become owner of their knowledge. The major objective of CAI is to enable all learners maximise their learning achievement, characterised by adaptability of instruction to the learner needs They further opined that CAI instruction is learner centered provides self-pacing, has multiple user approach with random access facilities for revision and updating. It is indeed a medium of instruction (Okoli & Onyeagba, 2016).

Several classifications of CAI packages are available on the market. Five (5) specific types by Spiro and Jehng (1990) seem to be most often utilised for educational purposes.

Drill and Practice instructional programs simply assist the student in remembering and utilising information that the teacher has already presented, reinforcing previous learning through repetition. It is most important to improving knowledge level.

Tutorials are designed to introduce unfamiliar subject matter. The format of a computer tutorial often emulates a dialogue between the computer and the student, i.e. information is presented, questions are asked of the student and on the basis of the response given, a decision is made to move on to new material or review what has already been presented.

Instructional Games present course content in a competitive and entertaining manner, in an effort to maintain a high level of student interest. Though most frequently used to reinforce factual knowledge at the lower levels of the taxonomy, it is quite possible to create instructional games that demand application skills from all levels.

Computer Simulations require the student to apply acquired knowledge to a novel situation. As a result, the student must analyse a presented scenario, make decisions based on the information given and determine a course of action. The simulated environment must change based on the course of action taken, presenting a significant challenge to the programmer.

Problem-solving software requires the student to use high level cognitive abilities in the process of considering the problem at hand, analysing the problem situation and its various solutions, predicting respective outcomes, determining which specific plan to attempt, and enacting the appropriate action(s) (Shute, 1993).

Evaluative ability can be tested throughout programs representing any of these five types of CAI by prompting the student at significant times during the session and providing appropriate feedback or explanation.

2.4.2 Traditional methods of instruction versus CAI methods

Various methods of teaching chemistry are known, such include guided discovery problem-solving, discussion, and expository individualistic methods. These methods depend on various forms of teacher–student-activities though some methods are more activity oriented than others. Conventional (Traditional) method of teaching refers to teaching using chalk and board for teachers and pen and paper for students. This method usually does not promote skill acquisition, objectivity and critical thinking ability among learners. There is the need for more activity oriented, students centered and innovative method that can develop in the students' science process skills, which include Computer Assisted Learning approach. Computer Assisted Learning approach is a student-centered method where the teacher and students play equal active role in teaching and learning process. The teachers' primary role is to coach and facilitates student learning and overall comprehension of material while the students construct new ideas and concept based on their past knowledge. In order to solve chemistry problems in an acceptable manner, the problem solver must have both conceptual scientific and procedural knowledge (Festus & Ekpete, 2012).

Integrated Science teachers need to choose different styles and strategies for helping students learn some abstract science concepts (like organic chemistry) and skills. Science teachers can use various teaching methods to achieve instructional objectives in chemistry. These methods are broadly categorised as teacher-centered or traditional instructional and student-centered methods.

According to Cangelosi (1997), traditional (conventional) instructional methods of teaching refers to instructional methods in which the teacher controls the entire lessons and learner-learner interaction is minimal or entirely lacking. Traditional instructional method is characterised by direct instruction. Direct instruction usually includes the presentation of materials, talking aloud by the teacher, guided practice, correction and feedback and modelling by the teacher (Kinney & Robbertson, 2003 in Antwi, Anderson & Sakyi-Hagan, 2014). The teacher plays the role of the expert impacting knowledge and decides what, when and how students should learn with all students studying the same topic at the same time (Brown, 2003). This approach to learning assumes that all students have similar levels of knowledge in the subject being taught and they absorb new material in a similar space (Marbach-Ad, Seal & Sokolove, 2001). Students are rarely given much choice about what they are to learn (Atwi, Anderson & Sakyi-Hagan, 2014).

Twoli (2006) identified various teaching methods including the lecture, demonstration, practical or laboratory experiments, project work and field trips for teaching secondary chemistry.

According to Twoli (2006), the lecture mode of instruction has been considered appropriate for achieving low-level objectives in the learning of chemistry. Menon (2015) posited that the traditional approach of lecture and note taking has lost its effectiveness in this modern day. This method of instruction has very low yield on students' outcomes and this gives a strong argument for using it sparingly and for very brief spans in secondary chemistry (Twoli, 2006). In efforts to grow academically, it must be considered that differentiated modalities of teaching and learning are necessary to implement deeper levels of growth and conceptual development. Topics such as structure of the atom, periodic table and organic compounds which are of higher-level objectives may not be appropriately taught using the lecture method.

Teacher demonstration is a very common method used in teaching chemistry. When teaching chemistry through demonstration, students are set up to potentially conceptualise class material more effectively (Erik, Williamson & Ruebush, 2007). Demonstrations can also be used to explain an experimental set up before the students begin to set up their apparatus for individual or group activities. Demonstration is especially useful when the apparatus or materials to be used are not enough for the whole class. It is also useful when the materials are too dangerous or the equipment are too delicate to be entrusted to the students (Twoli, 2006). Experiments whose compounds and products involve emission of poisonous gases in their experiments can only be demonstrated by the teacher implying that the students cannot perform such experiments on their own. On the other hand, CAI simulations usually are based on interactive graphics which gives the learner the ability to visualise a process or an activity.

Practical work involves teaching/learning activities conducted by the students under guidance of the teacher. The teacher provides either singly or in groups with the materials and apparatus as well as the instructions to be followed in performing the activities. Practical work gives students an opportunity to acquire process skills and manipulative skills. However, this method is expensive in terms of materials and apparatus as well as time consuming. Kim and Chin (2011) argue that practical work is not sufficient to develop students 'habits of mind' because they involve simply doing but do not require thinking through doing. CAI simulations however provides a computer model of an experiment (Trowbridge, Bybee & Powell, 2004), which engages students' critical thinking, save the burden of acquiring materials and apparatus required for real experiments.

Project work is viewed as very important in the learning of chemistry because students are exposed to a wider range of skills such as process, manipulative and scientific skills. It also helps the students to improve their communication skills, especially when writing the reports, one is required to use suitable technical terms (Twoli, 2006).

The International Society for Technology in Education (2005) suggests that teachers who move away from traditional learning environment to new learning environment promote active learning, higher level thinking, collaborative and multisensory stimulation. These environments support multiple intelligence, constructivism and cooperative learning. In teaching and learning process, traditional education and the existing educational materials neither helped to solve the existing problems nor assisted in the development of conceptual learning. In order to manage effective learning in Science, there should be a learning environment where the level of the students' prior knowledge is known, real life events are discussed, students are both mentally and physically ready and cognitive change is provided. At the same time, these learning environments should provide opportunities to students to consolidate the recently-learned notions.

To develop the students' cognitive learning and their performance in solving problems, there is a need to teach Science concepts by using different student-centered education methods instead of the traditional methods (Ergun, 2010). The potential benefits of CAI cannot be underestimated in the contemporary world. There are numerous of established findings on the instructional value of the computer, particularly in advanced countries. The current trend in research all over the world is the use of computer facilities and resources to enhance students' learning. This is because, students learn instructional contents faster, and retain what they have learned better with CAI than with conventional lecture method. Computer-assisted instructional materials are more successful in building an ideal and desirable attitude, and in capturing enthusiasm towards learning physics (Azar & Sengüleç, 2011).

Many researches have been carried out on the effectiveness of computer-assisted instruction (CAI) and have revealed that the students' achievements increase when the CAI technique is provided as a supplement to the classroom education. Studies carried out by Kausar, Chudhry and Gujjar (2008); Tabasu and Harrison in Owusu (2009) revealed that students that were instructed through CAI performed better than those who were instructed through conventional teaching strategy such as lecture method. Agrahari, and Singh (2013) reported that the achievement of students exposed to CAI either individual or cooperatively was better than those exposed to conventional teaching method. This could be as a result of utilisation of computers which strengthen their cognitive mechanism. CAI is more effective on less successful children because it helps the children to progress at their own pace and provides them with appropriate alternative ways of learning by individualising the learning process (Senemoglu, 2003 in Abimbade et al., 2018). Senteni (2004) also found out that CAI enabled the students to increase their motivation and achievements and to develop positive attitudes towards learning.

According to some studies there is no significant difference between the academic achievement of students who used CAI and their counterparts who made use of the traditional teaching methods (Alacapinar, 2003; Çetin, 2007; Onasanya, Daramola & Asuquo, 2006). Other researchers such as Delafuente, Araujo and Legg (1998), and Owusu (2009) affirmed that CAI has little or no effect on students' academic achievement.

According to Morrell (1992), there seems to be the major complaint of students when CAI is used alone without the presence of a teacher. Students are particularly not happy with the lack of opportunity to ask questions when they encountered any difficulty. According to him, students wish a teacher is around for them to ask questions. This therefore seems to agree with Cotton (1991) and Ornstein and Levine (1993, p. 551) that the best use of CAI is when it is used as a supplement to teacher-directed instruction. It also agrees with Brophy, (1999); Gance, (2002); Jenks and Springer, (2005); who asserted that how CAI is delivered can affect its effectiveness, and that new studies are needed to clarify the effect of CAI in contemporary student environment.

2.4.3 CAI and teaching of organic compounds

In science subjects including physics, biology and chemistry, CAI is applicable in collecting information and interacting with resources such as images and videos, and to encourage communication and collaboration (Ghani et al., 2014) resulting in improved student achievement in the subjects. From the research findings, the researcher concluded that integrating CAI in teaching of sciences can lead to increased students' learning competencies and increased opportunities for communication.

In chemistry, the use of CAI 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 CAI tools, concepts which could otherwise be difficult to comprehend without the tools can be visualised by the learners. This is because according to the researchers, CAI 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 visualisation, exploring patterns and drawing generalisations. 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.

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 CAI 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.

2.4.4 CAI and Gender

"Gender simply means the character or characteristics of being male or female, man or woman, boy or girl (male or female) "(Ukala, 2018). Gender issues have been linked with performance of students in academic tasks in several studies but without any definite conclusion. Researchers have revealed that gender influences students" academic achievement in CAI. For example, Ismail (2010) observed that males and females respond differently to computer aided instruction. Idowu (2018) argued against the findings of Ismail and stressed that computer programme lack specific gender attributes so it would be very unlikely that male and female learners will vary in their response to computer aided instructions.

There is a general imbalance in achievement of male and female students in the sciences. Some studies revealed that male students perform better than the females in physics, chemistry, and biology (Danmole, 1998; Novak & Mosunda, 1991; Okeke & Ochuba, 1986). While others revealed that female students are better off than males (Kelly, 1978; Wonzencreaft, 1963). Some studies such as those of Bello (1990), did not find any form of influence being exerted by gender on students' academic performance in the science after using CAI.

What appears not to be very clear is whether these performances vary with method of instruction. With the advancement in technology, computerisation and digitalisation, various methods of instruction have been devised and used in teaching and learning to solve most instructional problems. Thus, there may be need to try use of the CAI so as to be well informed of the achievement of male and female students. The CAI package, if effectively applied, could revolutionise the classroom teaching and learning process. It will make it more collaborative, active and interactive manner and enhance students' academic achievement in difference trades.

2.4.5 CAI and Retention of Knowledge

According to Eze, Ezenwafor and Molokwu (2015), retention is the ability to retain the knowledge of what is learnt and to be able to recall it when it is required. Kundu and Totoo (2007) defined retention as the preservative factor of the mind. The authors posited that whatever touches consciousness leaves trace or impression and is retained in the mind in the form of images. This implies that for one to talk about retention, one must have been exposed to certain experiences or activities such as teaching. Retention is usually measured in collaboration with academic achievement. It is therefore seen as the achievement on a subject after a certain period of time. Retention helps in knowledge development. Knowledge development can be guaranteed when effective teaching methods are used in the teaching and learning process (Eze, Ezenwafor & Molokwu, 2015).

CAI has a significant better effect on retention of the students (Cotton, 2001). Ozden and Gultekin, (2008) contented that the use of appropriate instructional methods could enhance students' retention, which could in turn improve the students' academic achievement. The assumption is that when an effective method is employed for instruction, it aids students to internalise what they have been taught in order to correctly and successfully remember and apply it on a later date. Cotton (1991) found out that with regard to learning rate, CAI students 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. CAI can encourage the advancement of students' decision-making and critical thinking aptitudes, data processing skills and communication abilities. It is therefore pertinent that science teachers use teaching strategy, which could improve academic achievement and knowledge retention among science students. Currently, from the available empirical studies, the use of demonstration teaching method has not really addressed the low retention rate of students in technical colleges.

2.5 Empirical studies on the use of CAI in Chemistry

Many researchers have affirmed successful implementation of computer-assisted instruction in the classroom. Henriques (2002) as well as Dori and Barak (2000) as reported in Kargiban and Siraj (2009), maintained that the use of CAI 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 CAI in instruction in chemistry leads to achievement results superior to those obtained when traditional methods of instruction are used. According to Oloyede and Adenkunle (2009), 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 CAI 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.

Nduati (2015) found a statistically significant mean difference in achievement of students taught carbon compounds using CAI relative to those taught through conventional methods. Garanga et al. (2012) specifically observed that CAI positively impacts students' achievement in structure and bonding. Similarly, Akcay et al.

(2006) in a study of the effect of CAI 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 CAI 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.

Studies on gender differences in Chemistry achievement with respect to CAI have continued to yield inconsistent results while some other studies reveal no significant difference in the achievement of the two genders.

Nduati (2015), 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. He 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 CAI, there appeared to be a greater positive effect on boys than girls. These researchers based the difference in achievement 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.

Volman and Van Eck (2001) findings identified that boys' have greater access to computers in schools as well as boys' dominate 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. The report however noted that girls tended to lack confidence in computing and most often underestimated their computer-related competence. 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 CAI be made more available to girls and women (Hafkin & Taggart, 2001; Rathgeber, 2001).

Eshiwani (1982) noted that girls under-achieve in science and mathematics. This underperformance of girls is partly due to teachers' bias in the teaching and learning process. Teachers tend to pay more attention to boys who appear to be more troublesome to control than girls who appear to be well disciplined. As a result, girls receive less attention, less help and fewer challenging learning activities from their teachers

Spence (2004) found no significant influence of gender on the achievement of college students in mathematics when they were exposed to mathematics courseware in online and traditional learning environment. However, female online learners were significantly less likely to complete the course compared to their traditional female counterpart or male online counterparts. In a review of studies on access, use, attitude, and achievement with computer, Kirkpatrick and Cuban (1998) concluded that when female and male students at all levels of education had the same amount and types of experiences on computers, female achievement scores and attitudes are similar to that of males in computer classes and classes using computer. Similar findings showed insignificant effect of use of CAI on achievement of students based on gender implying that use of CAI affects achievement of boys and girls equally. Barnea and Dori (1999) who in a study of high-school chemistry students' performance and gender differences in a computerised molecular modeling learning environment, illustrated that in achievement and spatial ability tests no significant differences between the genders existed.

2.6 Nomenclature and Reactions of Some Organic Compounds

In chemistry, organic compounds are generally any chemical compounds that contain carbon hydrogen bonds. Due to carbon's ability to catenate (form chains with other carbon atoms), millions of organic compounds are known. The study of the properties, reactions, and syntheses of organic compounds comprise the discipline known as organic chemistry.

Organic compound	Functional group	General formula
Alkanes	$-\overset{\vert}{\underset{\vert}{C}}-$	C_nH_{2n+2}
Alkenes	$>C=C<$	C_nH_{2n}
Alkynes	$-C\equiv C-$	C_nH_{2n-2}
Alkanols	$-OH$	$R-OH$
Alkanoic acids	$-COOH$	$R-COOH$
Alkyl alkanoates	$-CO\text{-}O-$	$-CO\text{-}OR$

Figure 3: Organic Compounds and their Functional Groups

2.6.1 Hydrocarbons

Hydrocarbons are organic compounds having only carbon and hydrogen. For example, CH_4, CH_3CH_3, $CH_2{=}CH_2$, $CH{\equiv}CH$ etc. Hydrocarbons can either be alkanes, which contain carbon-carbon single bonds; alkenes, which contain at least one carbon-carbon double bond; or alkynes, which contain a carbon-carbon triple bond (Fessenden & Fessenden, 1990). There are two groups of hydrocarbons; namely saturated and unsaturated hydrocarbons, however, each carbon atom has to maintain tetravalency that is having four covalent bonds attached to the carbon atom in a molecule. In the saturated hydrocarbons or alkanes, all the four bonds around any carbon atom in the molecules are single bonds and in the unsaturated hydrocarbons (alkenes and alkynes), there is always a carbon-carbon multiple bonds in the molecule. The structure and naming of hydrocarbons serve as the foundation for moving to similar tasks for organic compounds containing other functional groups (Fessenden & Fessenden, 1990).

Hydrocarbons depend on a systematic naming system developed and used to name them. Each distinct compound has a unique molecular structure which is represented by a structural formula. Each compound is given a characteristic and unique name to distinguish it from the others. The International Union of Pure and Applied Chemistry (IUPAC) developed a naming system and ways of writing the structure, which students at the Colleges of Education are expected to use in their study. The IUPAC system has replaced the common names which had their origins in the history of science and the natural sources of specific compounds.

The IUPAC naming system is a set of logical rules devised and used by organic chemists to avoid problems posed by arbitrary naming system. The use of the rules helped students to write the structural formula, and to write a unique name for every distinct compound. An IUPAC name has three essential features: a root or base indicating a major chain or ring of carbon atoms found in the molecular structure; a suffix or other element(s) designating functional groups that may be present in the compound; and names of substituent groups, other than hydrogen, that completes the molecular structure. (Daley & Daley, 2005; Zumdahl, 2000 & Vallhardt, 1987).

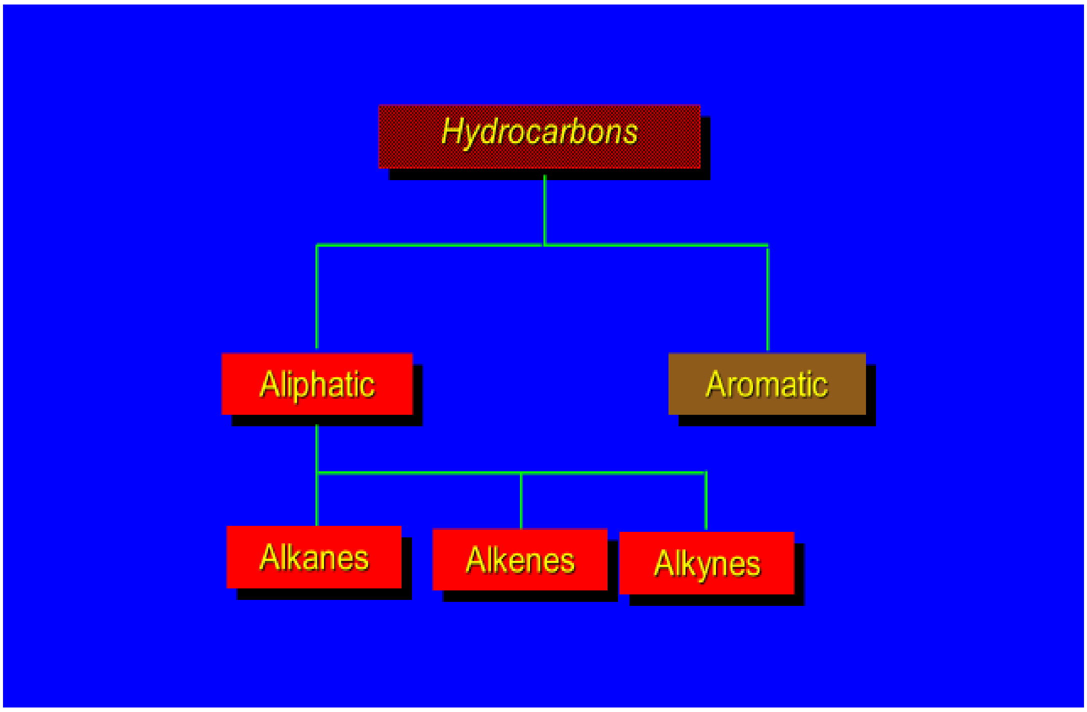

Figure 4: A Screenshot Indicating types of Hydrocarbons

Guidelines for Naming Alkanes

The names of alkanes form the basis of naming most of the other groups of hydrocarbons. The longest carbon chain is worked out to form the root name to which -ane is added. The carbon atoms in the longest chain are numbered such that the most heavily substituted carbon takes the least number. The various substituents (if any) are then identified with their location on the longest chain. The numbers of similar substituent groups are indicated using prefixes (di-, tri-, and so on.) to show how many there are. Write out the final name by arranging the substituent in alphabetical order and with no spaces, with commas between numbers, and with hyphens between numbers and letters.

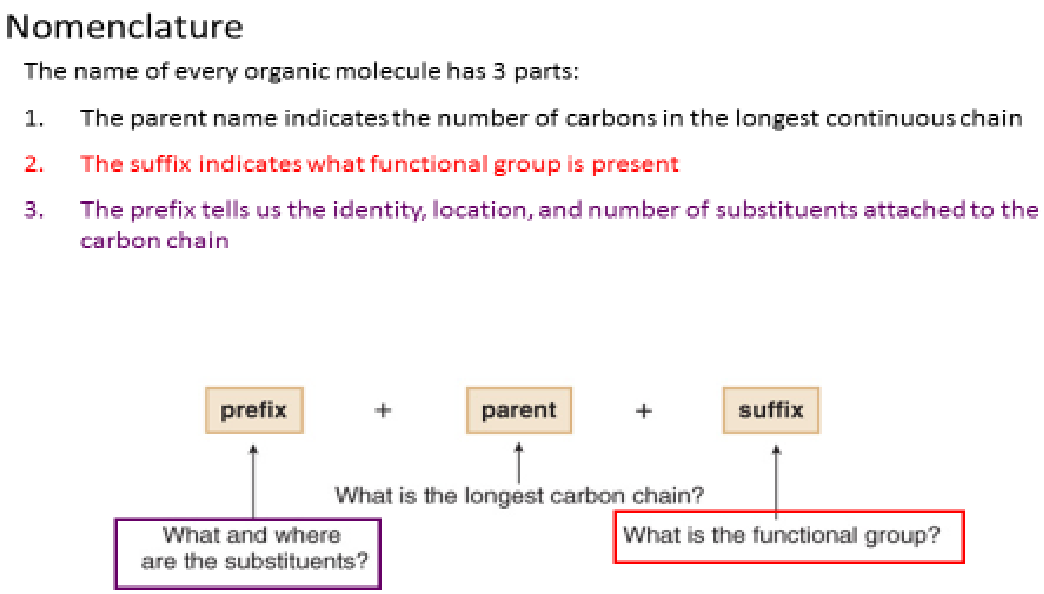

Figure 5: A Screenshot Indicating Nomenclature of Organic Compounds

Guidelines for Naming Alkenes

The root is determined by the longest chain in which the, C=C, is found. The numbering of the carbon atoms is done from the end that would give the carbon atom on which the double bond begins the least number. For symmetrical alkenes, the nearest substituent rule is used to determine the end where numbering starts. If more than one double bond is present the compound is named as a diene, triene or equivalent prefix indicating the number of double bonds and each double bond is assigned a locator number. The final name is written out with no spaces, with commas between numbers, and with hyphens between numbers and letters

Guidelines for Naming Alkynes

Just like alkanes and alkene, alkynes are named based on the corresponding number of carbon atoms in the molecule, with the suffix **-yne**, as in ethyne (**C_2H_2**), which is the first member of the alkyne group. The naming of akynes follows similar pattern like the alkenes. Here the root name ends with –**yne** and if double bonds are present, double bonds precede triple bonds in the IUPAC name. The final name is written out like that of the alkenes.

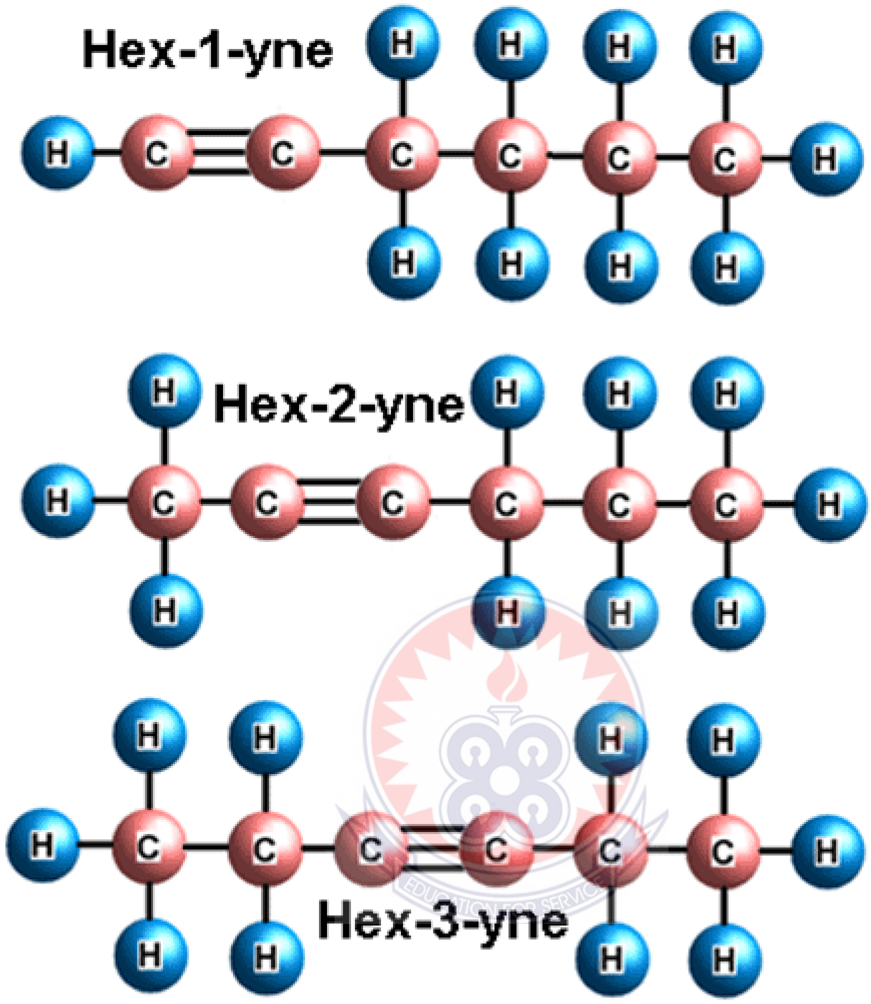

Figure 6: A Screenshot Indicating ball and Stick Model

Reactions of Hydrocarbons

Alkanes undergo substitution reactions with halogens. They react with halogens in the presence of sunlight or U.V light to give haloalkanes and the corresponding hydrogen halide. Alkanes also undergo combustion reactions in the presence of excess air (oxygen) to give carbon dioxide and water. In limited supply of oxygen, combustion is incomplete, hence carbon monoxide and soot are produced.

Alkenes generally undergo addition reactions with hydrogens, halogens, water and bromine water. Hydrogenation reaction (addition of hydrogen) of alkenes in the presence of catalyst (Pt, Pd or Ni) produces corresponding alkanes. Alkenes react with halogen to give corresponding dihaloalkanes. Alkenes react with water in the presence of concentrated Sulphuric Acid to give the corresponding alcohol. They also undergo bromination reaction to decolourise the bromine water. Alkenes burn in air if ignited. Finally, Alkenes can polymerise to form large molecules under high temperature and pressure. Alkynes undergo reactions similar to alkenes.

2.6.2 Alcohols

An alcohol is an organic compound with a hydroxyl (OH) functional group on an aliphatic carbon atom. Because OH is the functional group of all alcohols, we often represent alcohols by the general formula ROH, where R is an alkyl group. Alcohols are common in nature. Most people are familiar with ethyl alcohol (ethanol), the active ingredient in alcoholic beverages, but this compound is only one of a family of organic compounds known as alcohols. The family also includes such familiar substances as cholesterol and the carbohydrates. Methanol (CH_3OH) and ethanol (CH_3CH_2OH) are the first two members of the homologous series of alcohols.

Nomenclature of Alcohols

Alcohols with one to four carbon atoms are frequently called by common names, in which the name of the alkyl group is followed by the word *alcohol*:

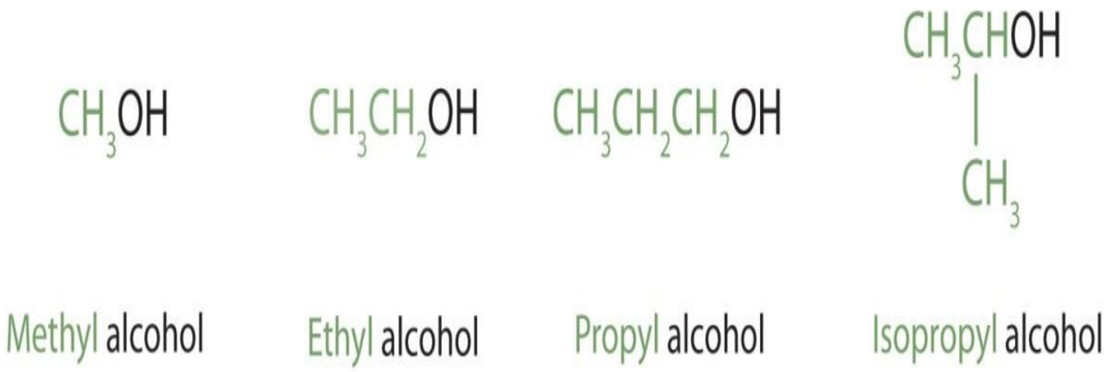

Figure 7: A Screenshot indicating examples of alcohols

According to the International Union of Pure and Applied Chemistry (IUPAC), alcohols are named by changing the ending of the parent alkane name to *-ol*. Here are some basic IUPAC rules for naming alcohols:

1. The longest continuous chain (LCC) of carbon atoms containing the OH group is taken as the parent compound—an alkane with the same number of carbon atoms. The chain is numbered from the end nearest the OH group.
2. The number that indicates the position of the OH group is prefixed to the name of the parent hydrocarbon, and the *-e* ending of the parent alkane is replaced by the suffix *-ol*. (In cyclic alcohols, the carbon atom bearing the OH group is designated C1, but the 1 is not used in the name). Substituents are named and numbered as in alkanes.
3. If more than one OH group appears in the same molecule (polyhydroxy alcohols), suffixes such as *-diol* and *-triol* are used. In these cases, the *-e* ending of the parent alkane is retained.

Reactions of Alcohols

The most common reactions of alcohols can be classified as oxidation, dehydration, substitution and esterification.

Oxidation

Alcohols may be oxidised to give ketones, aldehydes, and carboxylic acids. These functional groups are useful for further reactions; for example, ketones and aldehydes can be used in subsequent Grignard reactions, and carboxylic acids can be used for esterification. Oxidation of organic compounds generally increases the number of bonds from carbon to oxygen and it may decrease the number of bonds to hydrogen

Esterification

Alcohols can combine with many kinds of acids to form esters. When no type of acid is specified, the word *ester* is assumed to mean a carboxylic ester, the ester of an alcohol and a carboxylic acid. The reaction, called Fischer esterification, is characterised by the combining of an alcohol and an acid (with acid catalysis) to yield an ester plus water.

Dehydration of Alcohols to alkenes

Converting an alcohol to an alkene requires removal of the hydroxyl group and a hydrogen atom on the neighbouring carbon atom. Because the elements of water are removed, this reaction is called a dehydration. Dehydrations are most commonly carried out by warming the alcohol in the presence of a strong dehydrating acid, such as concentrated sulfuric acid.

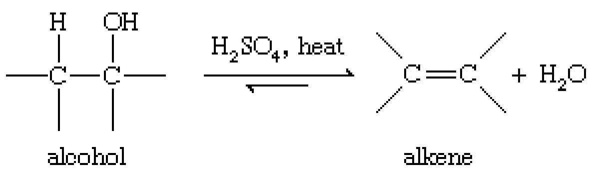

Figure 8: Dehydration of ethanol to form ethane

Substitution to form alkyl halides

Alkyl halides are often synthesised from alcohols, in effect substituting a halogen atom for the hydroxyl group. Hydrochloric (HCl), hydrobromic (HBr), and hydroiodic (HI) acids are useful reagents for this substitution, giving their best yields with tertiary alcohols. Thionyl chloride ($SOCl_2$), phosphorus tribromide (PBr_3), and phosphorus triiodide (generated from phosphorus, P, and molecular iodine, I_2) are also useful for making alkyl chlorides, bromides, and iodides, respectively.

2.7 Factors that affect student's achievement in organic chemistry lessons

Attitude of the student influences his or her performance (Keeves & Morgenstern, 1992). This was also upheld by Anderson (2006) who explained that attitude and achievement are related and that a positive attitude towards science lesson results in a good performance. Most non-science students developed some negative attitude towards science lessons. This negative attitude manifested in the form of lack of interest, satisfaction and motivation (Gardner & Gauld, 1990).

Also, the pedagogical content knowledge (P.C.K) of a teacher is a very significant factor in instructing and learning of concepts in chemistry. Geddis (1993) stated that Pedagogical content knowledge has been viewed as a set of special attributes that helped someone transfer the knowledge of content to others. It deals with the most useful forms of representation of ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations which are the ways of presenting and formulating a subject/topic that makes it comprehensible to others (Shulman, 1987). Shulman (1987) stated that pedagogical content knowledge includes those special attributes a teacher possessed that helped him or her guide a student to understand content in a manner that was personally meaningful. Shulman further clarified that pedagogical content knowledge includes "an understanding of how some particular topics, problems, or issues are organised, presented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (pp 12-14). He likewise recommended that pedagogical content knowledge was the best knowledge base of teaching: The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background that students have.

Different factors that influence students' performance in organic chemistry lesson are: past experiences of the learners, material availability (Murphy, 1990), presentation of concepts and topics in an abstract (Ornstein, 2006). Also truancy, lack of motivation, time available for teaching and learning, learning strategies of students and self-efficacy are also identifying factors affecting student performance (Bandura, 1997; Nisbet & Shucksmith, 1986).

Finally, according to Hesse and Anderson (1992), and Phelps (1996), many general chemistry topics, at the high school and university levels, are taught and assessed in terms of facts, set of rules and procedural knowledge without emphasising conceptual understanding. This mode of assessment may likely result in poor learning as it encourages rote learning.

2.8 Students' perception on the use of CAI during Teaching and Learning of Science

Students' perceptions on CAI mean the understanding, knowledge, and skills that influence the constructions of their reality as to whether CAIs are useful tools for learning organic compounds or not. Successful application of Computer-Aided Instruction in the learning of science is strongly influenced by students' perceptions of CAI.

Globally, the literature on students' perception of CAI has been and will continue to produce varied results. For instance, Adekunle (2016) conducted a survey involving 7500 secondary school students in Nigeria to determine their perception of computer education in Abuja. The results show that students had a positive attitude towards the use of computers in education. Male students were found to have a positive attitude towards the use of ICT in education than female students.

Tolbert (2015) carried out Quasi-Experimental research to assess the impact of Computer-Aided Instruction on students' performance, and students' perception of CAI. In all, 56 students were sampled and were placed into two categories of equal numbers (n=28). The control group was taught with traditional methods of instruction and 20 minutes daily remedial traditional instruction. The treatment group was taught with a traditional method of instruction and 20 minutes daily remedial traditional instruction. The findings revealed no statistically significant difference between the two methods of instruction.

In Ghana, Atta (2015) conducted a Quasi-Experimental study involving 40 students in the Central Region to explore the impact of computer-assisted instruction on basic school students' performance in Mathematics. The findings revealed that students had a positive attitude towards CAI, and students who were taught with CAI scored higher marks than those taught with the traditional methods of instruction.

2.9 Challenges in the use of CAI in Science Teaching

Use of CAI in teaching and learning may encounter many Challenges. Several studies have divided these Challenges into two categories, Extrinsic and intrinsic barriers. Herdren (2000, as cited in Al-Alwani, 2005) saw extrinsic barriers as pertaining to organisation, rather than individuals and intrinsic barriers as pertaining to teacher's administrators and learners. The Challenges can also be classified into resource, teacher level, and school level and management barriers.

Resource barriers include, lack of adequate computer assisted learning resources like computers, internet connectivity and content in digital form, devices that support teaching and learning like the projectors, speakers and optical disk readers and players.

Teacher level barriers include, lack of teacher confidence; some studies have investigated the reason for lack of teacher confidence of using computer assisted learning in teaching and learning. For example Beggs (2000, as cited in Balanskat *et al.*, 2006) asserted that teachers "fear to failure" caused lack of confidence, and limitation in ICT knowledge makes them feel anxious about using computers in teaching where some of the learners could be having more skills than them.

There are school level barriers like lack of time; some researchers have indicated that though some teachers have some basic knowledge of using computers in the classrooms, they still make little use of technologies because they do not have enough time. This is attributed by the fact the schools do not have enough time scheduled for computer classes, the research time to explore sites to gather information, connecting devices and preparing the lesson in PowerPoint presentation form or in other digital form, like photos and images. Ford (2007), indicated that many teachers lack training in the proficiency of using computer assisted learning in that they cannot be able to use basic devices like a computer and a projector to display or deliver a lesson.

School administration becomes a barrier if the school head is ICT compliant or has less interest in learning the skills, less support to purchase and implement ICT related resources. All these literature point to the fact that in order to implement an efficient working ICT infrastructure some of these barriers must be removed.

2.10 Summary of Literature Review

Numerous studies from reviewed literature have reported that Computer-assisted Instructional method is successful in raising students' achievement scores (Kiboss, 2004; Wanjala, 2005; Olga, 2008; Serin, 2011; Mwei, Too & Wando, 2011; Jesse, Twoli & Maundu, 2014). From the literature reviewed, it was realised that the earlier studies that were conducted on how the use of computer aided instruction affect students' achievement mainly considered the study of Mathematics, Biology and Science subjects in general, which employed two-group quasi experimental pretest-posttest design. Moreover, the few studies have focused on impact of use of computer-assited instruction on students' achievement in Elective Chemistry (Jesse, 2012), but have not fully concentrated on non-science students' achievement in integrated science chemistry. Due to this gap, the present study sought to investigate the influence of computer-assisted instruction on non-science students' achievement as well as gender achievement in organic chemistry.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter deals with the research design, location of the study area, population, sampling technique, instrument for data collection, procedure for data collection, validity and reliability of research instrument, data analysis and ethical considerations.

3.1 Research Design

The study employed a quasi-experimental research design since the subjects were not assigned randomly to the experimental and control groups (Creswell, 1994, pp. 127–139). The aim was to evaluate the effects of CAI on senior high school (SHS) non-science students' academic achievement in organic chemistry after they were taught the topic in the West African Secondary School Certificate Examinations (WASSCE) Integrated Science syllabus with the CAI.

The specific design used was a pre-test post-test non-equivalent control group design. Intact classes were used hence no random assignment of subjects. This design was chosen because it is very prevalent and useful in education. It provides reasonable control over most of the variables affecting internal and external validity. Furthermore, the samples within the groups involved may be different prior to the study (Mertens, 1998). One (1) experimental group and one (1) control group were purposively selected. The treatment for the experimental group was the computer-assisted instructional approach whiles the control group was taught by traditional approach of teaching. The content to be taught and learnt was the same for the two groups; it was the modes of delivery that were different. The development of the treatment went through phases. This design is represented diagrammatically in Table 1 below

Table 1. Non-equivalent Groups Pre-test and Post-test Design

Groups	Pretest	Treatment	Post test
A →	Q_1 →	X_+ →	Q_2
B →	Q_1 →	X_- →	Q_2

Time →

KEY A=Experimental Group B=Control Group Q_1= Pre-test Q_2=Post-test

X_+=CAI treatment Package X_=Traditional Teaching method.

Table 1 illustrates the Non-equivalent Groups of Pretest-Posttest. Two comparable groups were used in the order of A and B respectively. The two groups were initially given a Pre-test (Q_1), afterwards, two different treatments (X_+) and (X_) were administered to group A and B. Finally, Post-test (Q_2) was conducted. The duration from the Pre-test treatment to the Posttest of the experiment happened within a specified time.

The treatment package (CAI) was developed with the assistance of a computer programmer based on the content that was used for the development of the lesson plan of the traditional approach. It was ensured that the content conformed to what has been prescribed by the senior high school Integrated Science syllabus. The CAI was developed in the Microsoft Office 2016 and its associated packages. The software included graphics, text and hyperlinks. There was an animation of the concepts presented at the end of the lesson. The format of this CAI tutorial was such that concepts were presented, questions asked and students were encouraged to progress.

A lesson plan was developed for the traditional approach of teaching. This lesson plan used three instructional strategies comprising lecture, discussion and intermittent questions and answers to present the content material to the students. The experimental group was taught for six (6) weeks and the control group was also taught for six (6) weeks simultaneously by the researcher. After this, a post-test was administered to both groups. The pretest-posttest non-equivalent group design was used to collect data to find out whether there was any significant difference between the academic achievements of students taught by CAI and those taught by the traditional approach.

3.2 Location of the Study Area

The study was carried out in Juaboso Senior High School and Nana Ntaadu II senior High school in the Juaboso District in the Western North Region of Ghana. The Juaboso District is one of the nine districts in the Western North Region of Ghana. The district lies between latitude 6^{o} 6'N and 7^{o} N, and longitude 2^{o} 40'W and 3^{o}15'W. The district has Bia East, Bia West and Asunafo Municipal districts as its northern neighbours. Its eastern neighbours are the Asunafo South, Sefwi Bodi and Sefwi Wiawso Municipal districts. The Suaman District lies south and the La Cote d'Ivoire is to the West.

3.3 Population

Kanne (2004) defined population as the entire group of individuals from which a sample may be selected for statistical measurement. There are two types of population in any study, the target population, and the population from which the researcher can realistically select subjects, which is known as the accessible population.

3.3.1 Target Population

According to Amedahe (2001), the target population of a study is the aggregate of cases about which the researcher would like to make generalisations and it is the units from which the information is required and actually studied. The target population for this study was all Senior High school students in the Western North Region.

3.3.2 Accessible Population

Amedahe (2001) defined the accessible population as the designated criteria that are accessible to the researcher as a pool of subjects for a study. According to Amedahe, researchers usually sample from an accessible population and hope to generalise to a target population. The accessible population for this study was third year non-science students of Juaboso Senior High School and Nana Ntaadu II Senior High School.

3.4 Sampling Procedure

A sample is a carefully selected representative group from the population for a study. One experimental group (EG) and one control group (CG) was purposively selected from the accessible population. The nature of the study required that the research sample was purposively selected. This is because a research on CAI must necessarily be conducted in schools where computers are available for students' use and where the students are computer literate. This was why Juaboso Senior High School, where the researcher teaches, was purposively sampled as the experimental group for the study. A Second school, Nana Ntaadu II Senior High School, was also sampled as the control group, as the school is believed to be more or less equivalent in standard to the school used for the experimental group.

3.5 Sample Size

An intact class of 39 non-science students in Juaboso Senior High School (General Art 1) class was used as the experimental group and an intact class of 30 non-science students in Nana Ntaadu II Senior High School (General Art 1) class was used as the control group for the study. A total sample size of 69 non-science students was used for this study. Thirty-five (35) students out of the 69 entire student participants were males and 34 students were females.

3.6 Research Instruments

A research instrument is a device used to collect data to answer a research question. The research instruments used for the study were:

i. Pre-treatment, post-treatment and retention Organic Chemistry Achievement Tests (OCAT)

ii. Questionnaire

3.6.1 Test Instrument

A test is a formal, systematic, usually paper-and-pencil procedure for gathering information about pupil's behaviour (Airasian, 1991). The test instrument used in this study was an Organic Chemistry Students' Achievement Test (OCAT). The OCAT consisted of 20-item objective type questions which could assess student's knowledge of the selected section of organic chemistry. The test items were selected from the past papers for the last eight years West African Senior High School Examinations (WASSCE) set by West African Examinations Council (WAEC). The test items were three sets of twenty (20) each, one for pre-test, one for post-test and the last one for retention test. Each group (control and experimental) was given a pre-test (Appendix

A) before the treatment and a post-test (Appendix B) after the treatment. The two groups were then given the retention test (Appendix C) 6 weeks after their post-test.

The multiple-choice items of the objective test consisted of one correct answer and three distracters which reflect students' alternative conceptions. The test also had columns for students to provide short answers to questions. These were noticed at questions where students were asked to provide IUPAC names or write structures of organic compounds

The content of the test was validated by the research supervisor and four senior high school chemistry teachers. To ensure safety of test items, the questions for the pre-test, post-test and retention test were set, typed, and copies run by the researcher.

Table 2: Question Items per each Content Area in the Tests.

Content area	**Number of items**
Writing of I.U.P.A.C. names.	5
Writing of structural formulae.	5
Determination of longest chain	2
Reactions of organic compounds	5
Determination of functional groups	3
Total	**20**

3.6.2 Questionnaire

Questionnaire for Students (SQ) was used to collect data from students about their views on the use of CAI as an instructional strategy. A self-developed student Questionnaire (SQ) was designed and used based on the purpose of the research and the research questions. It contained 10 statements. Each of the statements was of the Likert type ranked Strongly disagree with a value of 1 to Strongly agree with a value of 5. According to Mcleod (2008), Likert Scale is a point scale type which is used to allow the individual to express how much they agree or disagree with a particular statement of an attitude, belief or judgement. For easy interpretation of the results, strongly agree (SA) and agree (A) were identified as agree; and disagree (D) and strongly disagree (SD) as disagree. This gave a midpoint score of 3 which is the same as undecided or neutral position. The reliability of this instrument was then estimated using the Cronbach's alpha coefficient SPSS. The student's questionnaire (SQ) which had 10 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 0.72 in the study.

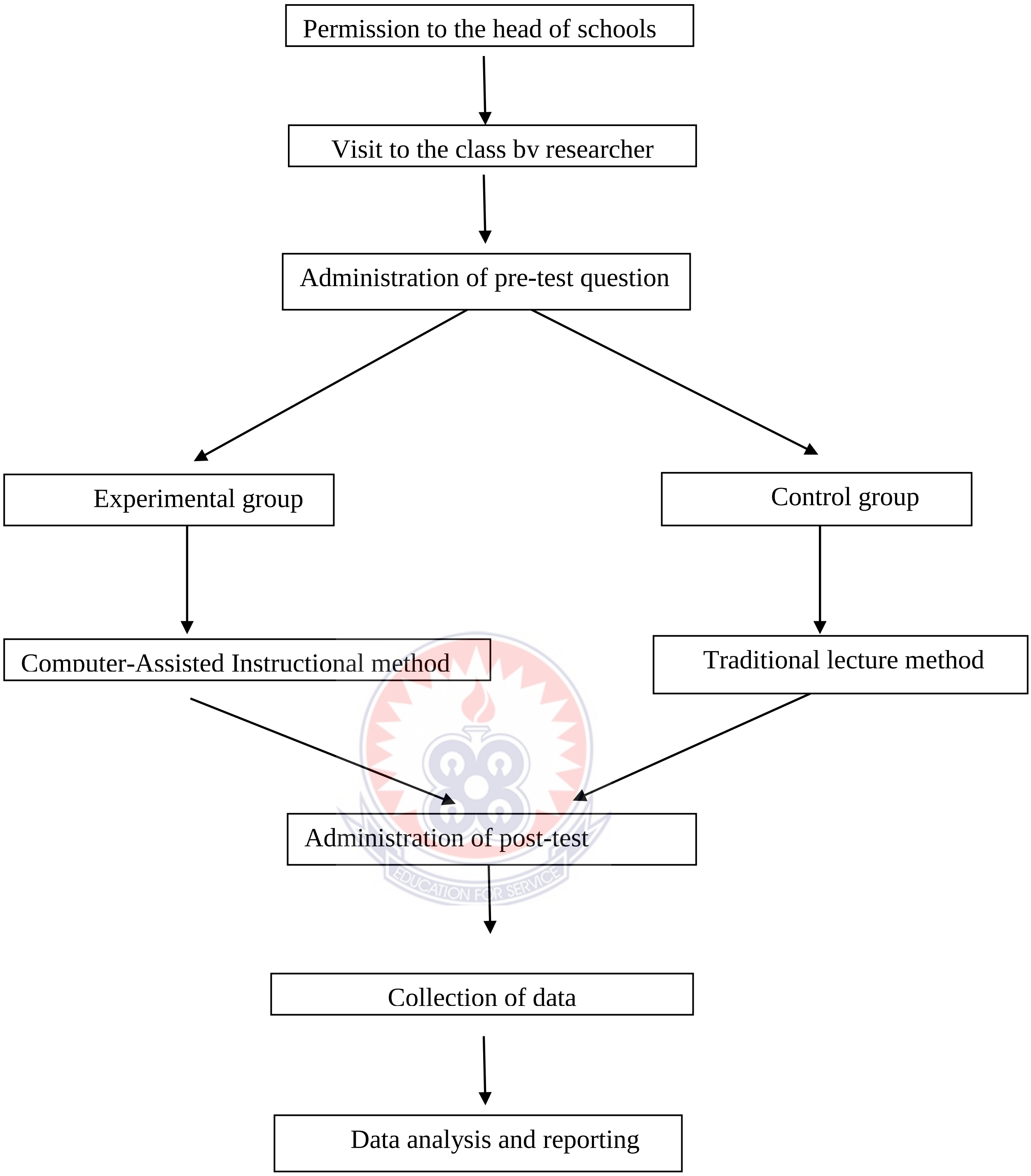

Figure 9: A summary and diagrammatic representation of the research design

3.7 Validity of the Main Instrument

According to Alhassan (2006), Validity of a research instrument is concerned with how well it measures the concept(s) it is intended to measure. To ensure content validity of the instrument, the research instrument was given to colleague senior teachers to ascertain its validity. The research instrument was also given to the supervisor who examined it to make sure that it sampled the behaviour it was expected to measure. Based on the criticism that was made by colleague senior teachers and more importantly the supervisor, a final set of questions was obtained for the research.

3.8 Reliability of the Main Instrument

Fraenkel and Wallen (2003), defines reliability as the consistency of scores or answers from one administration of an instrument to another and from one set of items to another. It concerns with the extent to which a test, questionnaire or any measurable procedure produces the same results on a repeated trial. To ensure reliability of the instruments, the instruments were tested using test-retest reliability method. The instruments were first administered and then re-administered on the same respondents after one week. The results of the first test and second test outcomes were compared to ascertain the reliability of the instruments. The reliability of the test using croncbach alpha reliability coefficient was calculated to be 0.72.

3.9 Trial-testing of the Instrument

Gall, Borg and Gall (2007), noted that it was essential to thoroughly trial-test your instrument before using it in your study. A pilot study was conducted at Bodi Senior High School (a school different from the study schools but located within the target population) with 35 students in 3 Art 1 class. The OCAT for the pre-test, post-test and retention test were pilot tested in this school. A questionnaire was also administered to the students after taking the treatment in order to establish the views of students on the use of CAI as an instructional strategy for teaching organic compounds. The result of the analysis was used in modifying the package before being deployed in the main study. This helped to establish the reliability of the test instrument, and the acceptability and usability level of the treatment instrument. Also, the reliability coefficient of the OCAT was found to be 0.72. From the feedback obtained after piloting, the study instruments were refined. The pilot study helped the researcher to draw a base-line for the validity and reliability of the instrument.

3.10 Data Collection Procedure

The study was carried out in 3 phases. Phase 1 (pre-treatment phase); phase 2 (treatment phase); and phase 3 (post-treatment phase).

Phase 1 (Pre-treatment phase): The researcher introduced himself to school authorities and students. The pre-treatment process involved the administration of the pre-test (See Appendix A). The pre-test assessment instrument made up of 20 test items on the selected organic chemistry topics was administered to the two groups, at their various schools to obtain a pre-test data. The test was conducted to draw a baseline on the performance of students in the experimental group and students in the control group. It helped to determine the prior knowledge of the non-science students on organic chemistry. All the answered test scripts were marked, recorded and the scores were collated for further processing.

Phase 2 (Treatment Phase): Different instructional strategies were adopted in treating aspects of organic chemistry in the 2 schools for six weeks. The treatment for experimental group involved the use of CAI in teaching the selected organic chemistry topics namely Nomenclature and reactions of Aliphatic hydrocarbons, Nomenclature and reactions of Alkanols (Alcohols), Nomenclature and reactions of Alkanoic Acids, Nomenclature of Alkyl Alkanoates (Esters).

The Control group benefited from the Traditional method of teaching the same topics listed, of which the researcher personally delivered using well prepared lesson notes.

The CAI was first used to teach the drawing of hydrocarbon structures when their names are given. This was followed by teaching the naming of hydrocarbon opened structures and teaching of the writing of hydrocarbon condensed structures. The structure and naming were limited to compounds having not more than ten carbon atoms. The IUPAC naming and the writing of structural and condensed formulae were carefully integrated into the teaching and learning process to facilitate the students' understanding. The CAI was also used to teach reactions of organic compounds where the researcher gave some simulations to show how some of the reactions occur and the products formed from the reactions

The CAI was developed using Microsoft Office Power Point 2007. In developing the CAI, provision was made for introduction of the program, presentation of information, and ending the program. The CAI was developed jointly by two experienced Chemistry teachers and a computer expert reflecting relevant contents of Nomenclature of organic compounds and chemical reactions of organic compounds. It was made interactive such that the learners could be engaged in dialogue and feedback provided immediately to enable learners proceed.

A computer system installed in the school (of the experimental group) by the Centre for National Distance Learning and Open Schooling (CENDLOS) called the intelligent Box (iBox) was also used as part of the CAI treatment package. The iBox system is an offline technology, designed and deployed for students to access quality educational content without internet connectivity and its associated cost. The iBox has a compatible software and e-Content in four formats (text, audio-visual, interactive practices and questions and answers) for offline classroom without internet cost.

To make sure that the CAI is free from problem before it is implemented, it was pilot tested in order to correct any unforeseen error before the start of the study. Pilot testing of the CAI was conducted at Bodi Senior High School.

Phase 3 (Post-treatment phase): At the end of the treatment, the researcher conducted an assessment instrument on the selected organic chemistry topics to the schools in one day. This was done to find the effects of the two treatments on the participants.

Scores obtained from the two schools constituted the final post-test data. Students' Questionnaire were also administered to the non-science students in the experimental group after the treatment to collect data from students about their views on the use of CAI as an instructional strategy. The post-treatment process also involved administering a retention test given to the experimental and control groups six (6) weeks after the post-test to determine the effect of both treatments on students' retention. The data obtained were analysed statistically and the results were presented and discussed.

3.11 Data Analysis

Data analysis is the ordering and breaking down of data into constituent parts and the performing of statistical calculations with the raw data to provide answers to the questions guiding the research (Osuala, 1993). It is the process of systematically applying statistical and/or logical techniques to describe, illustrate and evaluate data. The purpose of analysing data is to obtain usable and useful information. The analysis, irrespective of whether the data is qualitative or quantitative, may describe and summarise the data, identify relationships between variables, compare variables, identify the difference between variables and forecast outcomes.

The statistical analysis of the tests (pretest, post-test and retention test) were carried out first using the quantitative approach. The descriptive statistics such as means, mean difference and standard deviation of both experimental and control groups were computed by Microsoft Excel 2016 programme. These descriptive statistics were used to summarise the general trends in students' performance. The purpose of descriptive statistics was not only to describe the data from a study but also to help find pattern within the data described and to inform inferential statistics as well. Study of central tendency indicated the overall performance of students in the groups; different groups and different academic performance levels. Inferential statistics was used to identify significant difference within the quantitative data for the purpose of answering the research questions. Inferential statistics such as students' t-test was performed at the 0.50 level. The inferential statistics used in this study was used for answering the quantitative aspect of the research questions as well as testing the study's hypotheses.

The t-test for dependent samples was used to analyse the pretest and the post-test scores of the experimental and the control groups to determine whether the groups achieved better on the post-test with respect to their pre-test scores.

The experimental and the control groups' mean scores from the pre-test and post-test was analysed using the t-test for independent samples. The t-test was more effective since it evaluated the difference between the mean scores of the groups.

The researcher used quantitative approach of data analysis for research question one (1) where he sought to determine the effect of computer-assisted instruction on the achievement of non-science students in organic chemistry as compared to those taught using traditional method. Data used for this analysis were obtained from the pretest and post test scores. The pre-test and post-test scores were analysed using descriptive analysis of quantitative approach which sought to organise and describe the data by investigating how the scores obtained are related to each other. Furthermore , the pre-test and post-test scores were further analysed using inferential approach for quantitative data analysis where the researcher used a t-test statistics to determine if the treatment had effects on the groups. In this method of analysis, data obtained from participants in both experimental and control groups were analysed statistically using independent and dependent sample *t*- test. The difference between the mean scores of both groups on the pre-test post - test scores were tested at a 0.05 significant level. The independent and dependent sample *t*-test was used to investigate whether any differences existed between experimental and control groups' mean scores on the OCAT. This was done to answer the research question one (1) and either to reject or fail to reject the null hypotheses "There is no significant difference in the performance of non-science students taught organic chemistry using CAI and those taught using traditional method”.

Research question two (2) which sought to determine the differential impact of the CAI as a teaching strategy on male and female students’ cognitive achievement in the selected topics in organic chemistry also adopted descriptive and inferential statistics. The descriptive statistics employed helped in determining the relationship between the male and female students in the experimental group scores in the pre-test and post-test. Pre-test and post-test scores were further analysed using inferential statistics for quantitative data where the researcher used t-test statistics to determine if the treatment had any differential impact on the performance of male and female students exposed to computer-assisted instructions.

The difference between the mean scores of both groups on the pre-test and post-test scores were tested at a 0.05 significant level. The independent t-test was used to investigate whether any differences existed between experimental group male and female students’ mean scores on the OCAT. This was done to answer the research question two (2) and either to reject or fail to reject the null hypothesis two (2) which states that “There is no significant difference in the performance of male and female non-science students in organic chemistry when taught using CAI’’.

Research question 3 which sought to determine if there were any significant difference in achievement of non-science students on retention test in organic chemistry when taught using computer-assisted instruction as compared to those taught using traditional method. Retention test scores of students were used as data which was analysed using inferential approach for quantitative data analysis where the researcher used a t-test statistics to determine if there was a significant difference between the groups. In this method of analysis, data obtained from participants in both experimental and control groups were analysed statistically using independent sample *t*- test. The difference between the mean scores of both groups on the retention test scores were tested at a 0.05 significant level. The independent *t*-test was used to investigate whether any differences existed between experimental and control groups' mean scores on the retention test.

Research question four (4) sought to determine the views of students when exposed to CAI. With this, the researcher used a researcher made questionnaire and collected data on students' views in the experimental group when they were exposed to CAI. An in-depth qualitative analysis such as the constant comparison method was used to answer the research question on the students' perception about the use computer-assisted instructional approaches. Descriptive statistics such as frequency tables and percentages were employed to compute the results for analysis. This qualitative data analysis contributed to both descriptive and inferential interpretations from the quantitative data. Together, the results or the study provided the basis for the significance and implications of the study as well as possible future research

3.12 Ethical Considerations

Permission from the participating school authorities was obtained first. The researcher needed to protect the identity of the students and the institutions, develop a trust with them and promote the integrity of the research. The researcher ensured that the dignity and wellbeing of the students were protected. During data collection, subjects were informed about the purpose for the research.

During the process of data collection all the students in the classes were assured of confidentiality. The researcher respected the research site by not allowing the treatments to interfere with the institution's programmes and disturb them after the study. For data analysis and interpretation, the researcher ensured the anonymity of individual students. The researcher also provided accurate account of the information from the data collected.

3.13 Chapter Summary

The chapter discussed the research design, study population, the study location, sampling techniques, sampling size, research instruments and pilot study used have been described. How the data obtained from experimental and control groups through the organic chemistry achievement test (OCAT) and questionnaires were organised and summarised to obtain a general sense of information and overall meaning were also discussed. Appropriate methods were used to ensure validity and reliability of research instruments used were also explained. Lastly the chapter considered data collection procedure, data analysis procedure and the ethical considerations for the research.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Overview

This chapter presents research findings, their interpretations and discussion of findings as per the objectives of the study. Both descriptive and inferential analysis technique were employed in analysing the collected data. The order of presentation and discussion of the results obtained in this study were discussed in accordance with the research questions formulated for the study. Therefore, the following research questions were addressed:

1 What is the effect of computer-assisted instruction on the achievement of non-science students in organic chemistry as compared to those taught using traditional method?

2 What is the difference in the achievement of male and female non-science students in organic chemistry when taught using CAI?

3 What is the effect of computer-assisted instructions on retention of a non-science students in organic chemistry as compared to those taught using traditional method?

4 What are the views of students on the use of CAI as an instructional strategy in organic chemistry?

4.1 Biographic Data of Students

The biographic data were not pivotal to the study but they helped to present information on the characteristics and entry behaviour of the participants used for the research and also the interpretations of the findings. The biographic data considered in this study were: gender of students and class size.

With regards to gender, 35 students out of the 69 entire student participants representing 50.72% were males and 34 students representing 49.28% were females. The experimental group had 20 female students representing 51.28% and 19 male students representing 48.72%. The control group had 16 male students representing 53.33% and 14 female students representing 46.67%. The data showed that the total number of male students that participated in the study were slightly more than their female counterparts.

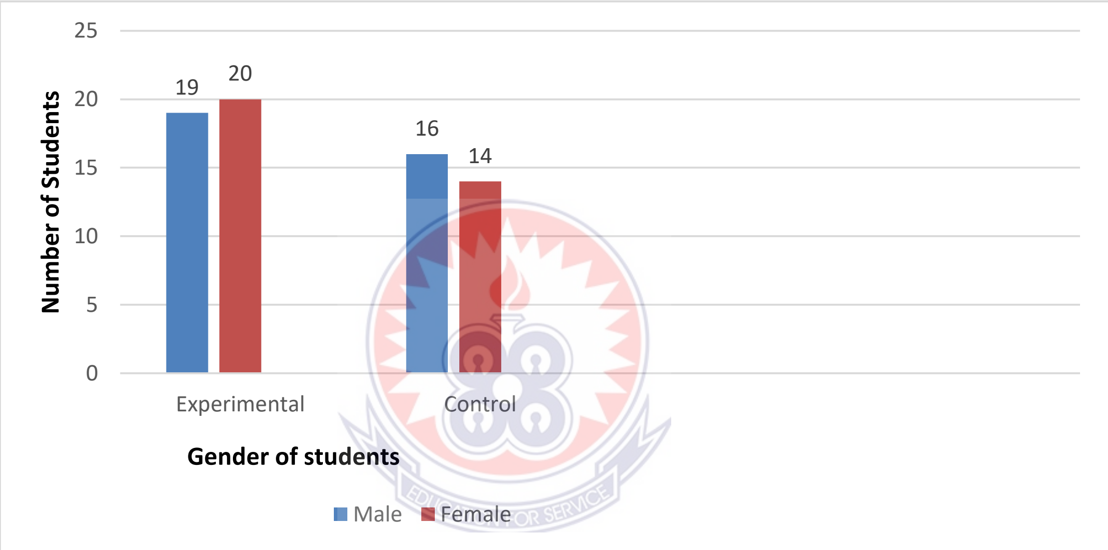

Figure 10: A graphical representation of the gender of students in the experimental and control group

4.1.2 Class Size

A large class size can be a confounding variable to the implementation of a CAI approach in the science classroom as the science teacher does not get the opportunity to consider the learning needs of each of the students. A manageable class size makes teaching and learning easier for the science teacher, taking into consideration the learning needs of every learner. The total number of students used in the study was 69 non- science students of Juaboso and Nana Ntaadu II Senior High Schools. Out of this Number, 39 students representing 56% of the total students involved in the study was assigned to the experimental group. Also 30 students representing 43.47 % of the total students involved in the study was assigned to the control group.

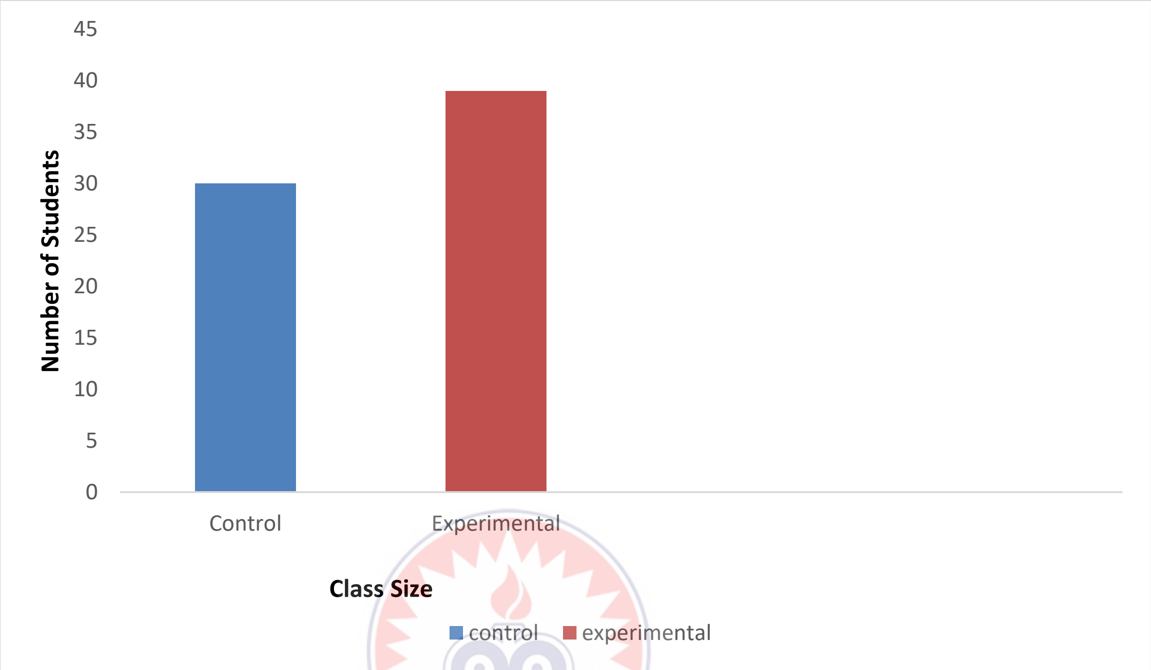

Figure 11: A graphical representation of the class size of students in the control and experimental groups

4.2 Results for Research Question One

What is the effect of computer-assisted instruction on the achievement of non-science students in organic chemistry as compared to those taught using the traditional method? The null hypothesis formulated and tested based on the research question is stated as follows:

H_{01}: There is no significant difference in the achievement of non-science students' taught organic chemistry using CAI and those taught using traditional method.

Research Question One sought to determine the effect of computer-assisted instruction on the achievement of non-science students in organic chemistry as compared to those taught using traditional method. To answer the research question posed by the null hypothesis stated above, a baseline on the performance of students in the experimental group and students in the control group was drawn by conducting a pre- treatment test to determine the prior knowledge of the non-science students on organic chemistry. Preliminary analysis was done by comparing the two groups' scores from the pre-test using t-test for independent samples.

The statistical analysis results of the pre-test of the experimental and the control groups illustrated in Table 3 shows that there was no statistically significant difference ($P=0.84$, $p>0.05$) in the performance of the two groups at the beginning of the study. The result revealed that there was no significant difference ($p>0.05$) between the mean scores of students in the experimental group and the control group in terms of students' understanding of organic compounds before the instruction was given. The experimental group had a mean score of 3.67 which was similar to the control group mean score of 3.6.

Table 3: Independent samples t-test of Pre-test scores of Organic Chemistry Achievement Test (OCAT)

Group	**N**	**Mean**	**SD**	**DF**	**T-Value**	**P-Value**
Experimental	39	3.67	1.56			
				67	**0.2**	**0.84**
Control	30	3.6	1.19			

Key: N=number of scores, SD=standard deviation, DF=degrees of freedom**.**

To determine whether the experimental group performed better on the post-test than the pre-test, the dependent samples t-test was used. The results are illustrated in Table 4.

From Table 4, the results showed that there was a mean difference of 12.69 between the post-test scores and the pre-test scores of the experimental group. Also the computed p-value of 1.898×10^{-26} was significant at $p < 0.05$ level indicating that there was a statistically significant difference between the pre-test and post-test scores of students in the experimental group.

Table 4: Dependent t- test of Pre-test and Post-test scores of the Experimental Group Organic Chemistry Achievement Test (OCAT)

Group		**N**	**DF**	**Mean**	**SD**	**t- value**	**P-value**
	PRE-TEST			3.67	1.56		
EXPERIMENTAL		**39**	**38**			**-26.56**	**1.898E-26**
	POST-TEST			16.36	2.96		

Key: N=number of scores, SD=standard deviation, DF=degrees of freedom.

To determine whether the control group achieved better on the post-test than the pre-test, the dependent samples t-test was used. The results obtained were analysed and illustrated in table 5. From Table 5, the results show that there was a mean difference of 9.03 between the post-test scores and the pre-test scores of the control group. The computed p-value of 9.399×10^{-15} was significant at $p < 0.05$ level indicating that there was a statistically significant difference between the pre-test and post-test scores of students in the control group.

Table 5: Dependent t- test of Pre-test and Post-test Scores of the Control Group Organic Chemistry Achievement Test (OCAT)

Group		N	DF	Mean	SD	t- value	P-value
	PRE-TEST			3.6	1.19		
CONTROL		**30**	**29**			**-14.024**	**9.399E-15**
	POST-TEST			12.63	3.12		

Key: N=number of scores, SD=standard deviation, DF=degrees of freedom.

The results in Table 4 and table 5 show that both groups improved on their performance in the post-test as compared to the pre-test. However, the mean difference of 12.69 between the post-test scores and the pre-test scores of the experimental group as compared to that the control group of 9.03, indicated that the experimental group had much gain on the treatment than the control group.

To determine whether there was a significant difference in the effect of the treatment on students' achievement, Independent samples t-test of Post-test scores of Organic Chemistry Achievement Test were conducted to compare the effectiveness of the treatments on the students' achievement. The results as shown in Table 6 portrays that there is a significant difference ($p<0.05$) between the achievement of experimental and control groups on post-test scores. The computed p-value of 5.0×10^{-6} was significant at $p < 0.05$ level indicating that there was a statistically significant difference between the post-test scores of students in the experimental and control groups. As a result, the first null hypothesis, which states that 'there is no significant difference in the achievements of non-science students' taught organic chemistry using computer-assisted instructions and those taught using the traditional method', was rejected.

Table 6: Independent Samples t-test of POST-test scores of Organic Chemistry Achievement Test (OCAT)

Group	N	Mean	SD	DF	T-Value	P-Value
Experimental	39	16.36	2.96			
				67	**5.024**	**5.0E-6**
Control	30	12.63	3.12			

Key: N=number of scores, SD=standard deviation, DF=degrees of freedom.

4.3 Discussion of Results for Research Question One

The main aim of the research was to compare the effect of CAI and traditional teaching methods on non-science students' achievement in organic chemistry. The difference in means between the pre-test and post-test scores of the experimental group was 12.69 which indicated that they performed better after the CAI was used to teach organic chemistry. Also, the t-test results for the difference in means in the experimental group pre-test and post-test gave a p-value of 1.898×10^{26} which was considered to be significant at $p < 0.05$ level. This indicated that the experimental group performance in organic chemistry on the post-test was significantly better than their performance in. the pre-test. This shows that the achievement of students in experimental group was significantly higher after going through the instruction using CAI.

Analysis of Data from Table 6 showed that the mean values for the control group pre-test and post-test scores were 3.6 and 12.63 respectively. The mean difference between the pre-test and post-test scores of the control group was 9.03 which indicated that the students performed better in the post-test than the pre-test. The t-test results for the difference of means in the experimental group pre-test and post-test gave a p-value of 9.399×10^{-15} which was considered to be significant at the $p < 0.05$

level. This indicated that the control group performance in organic chemistry on the post-test was significantly better than their performance in. the pre-test.

Analysis of the post-test and the pre-test scores using the dependent samples t-test indicated that in both groups there were significant difference between their pre-test scores and their post-test scores. That is in both groups students improved on their performances on the post-test as compared to the pre-test. This agrees with the study by Onasanya, Daramola and Asuquo (2006), who maintained that both CAI and traditional methods have significant impact on students achievement. However, the mean difference value of 12.69 by the experimental group, compared to that of 9.03 by the control group, indicated that, the experimental group had much gain on the treatment than the control group.

From Table 6 the computed data analysis on the post-test scores of the experimental and control group revealed that the mean for the experimental group and control group post-test scores were 16.36 and 12.63 respectively. The mean difference between the post-test scores of the experimental and control groups was 3.73 which indicated that there was difference in the performance of the experimental group mean from the control group mean. Also the t-test results for the difference of means in the experimental and control group post-test scores gave a p-value of 5×10^{-6} which was considered to be significant at $p < 0.05$ level. This therefore indicated that there was a significant difference in the performance of the experimental and control group post-test scores. This mean that the CAI treatment helped to improve the experimental group performance in organic chemistry.

The descriptive analysis of the post-test results which showed that the mean achievement of students from experimental group was higher than that of students from control groups implied that CAI 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.

The independent t-test analysis indicated significant effect of CAI 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 agrees with 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, 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.

It was noted from the finding that use of CAI in teaching of organic chemistry is a better teaching strategy which yields better students' achievement. This agrees with findings of Ozman (2007) who postulates that teaching-learning of topics in chemistry can be improved by the use of computer-assisted teaching materials. The researchers indicated 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.

Even though the experimental group performed better than the control group, the control group also had their performance raised after teaching them without the use of the CAI. The performance of the experimental group after the treatment indicated that the treatment strategy was very effective hence such classic performance. Since there was a significant difference ($p<0.05$) in the performance of the experimental group exposed to CAI and the control group exposed to traditional approach, it could be concluded that CAI is one of the innovative approaches to enhance the teaching and learning of organic chemistry lessons in the senior high schools.

4.4 Results for Research Question Two

Research Question 2. What is the difference in the achievement of male and female non-science students in organic chemistry when taught using CAI? The null hypothesis formulated and tested based on the research question is stated below:

H_{02}: There is no significant difference in the achievement of male and female non-science students in organic chemistry when taught using CAI.

Research question 2 sought to determine if there was any significant difference in the achievements of the male and female students in the experimental group after the use of CAI. To answer the question posed by hypothesis 2 which stated that "there is no significant difference (p<0.05) in the achievements of male and female non-science students in organic chemistry when taught using CAI", an independent t-test was conducted on the male and female students' scores in the pre-test and post-test.

From Table 7 the computed p value of 0.8929 was greater than 0.05 indicating that there was no statistically significant difference (p<0.05) between the mean organic chemistry achievement pre-test scores of the male and female students in the experimental group. The result in Table 7 revealed that there was no significant difference between the mean scores of male and female non-science students in the experimental group in terms of students' understanding of organic compounds before the treatment was given. The male Students had a mean score of 3.63 as compared to the female mean score of 3.7. However, the mean difference 0.07 between the two groups was not statistically significant.

Table 7: Independent T- test for Pre-test scores of Male and Female Students' in the Experimental Group

Experimental Group	N	Mean	SD	DF	t- value	P- value
Males	19	3.63	1.46	**37**	**2.026**	**0.8929**
Females	20	3.7	1.69			

Key: N=number of scores, SD=standard deviation, DF=degrees of freedom.

An independent sample t-test for the post-test scores of males and females in the experimental group is represented in Table 8. From Table 8, the computed p value 0.381 was greater than 0.05 indicating that there was no statistically significant difference (p<0.05) between the mean organic chemistry achievement post-test scores of male and female students' in the experimental group. Therefore, the null hypothesis

2 which states that there is no significant difference in the achievements of male and female non-science students in organic chemistry when taught using CAI, is valid, hence failed to be rejected.

Table 8: Independent T- test for Post-test scores of Male and Female Students' in the Experimental Group

Experimental Group	N	Mean	SD	DF	t- value	P- value
Male	19	16.79	2.637			
				37	**2.028**	**0.381**
Female	20	15.95	3.252			

Key: N=number of scores, SD=standard deviation, DF=degrees of freedom.

4.5 Discussion of Results for Research Question Two

The study revealed that CAI has no significant differential effect on the achievements of male and female students in organic chemistry. This finding on gender agrees with the earlier findings of Mudasiru and Adedeji (2010); Husaini and Mohammed (2004), on effect of CAI on gender. Thus, it can be said that the use of CAI method enhanced the achievements of both male and female students similarly in organic chemistry. Barnea and Dori (1999), illustrated that no significant differences between the genders existed in chemistry students' performance and gender differences in a computerised molecular modeling learning environment, achievement and spatial ability tests

The implication of this finding could be that what matters in teaching and learning is the effectiveness of the instructional strategy. Accordingly, once an instructional strategy is motivating and engages students' attention, it does not discriminate in the performance of males and females.

However, the findings of the study contradict 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. 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

4.6 Results for Research Question Three

Research Question 3. What is the effect of computer-assisted instructions on retention of a non-science students in organic chemistry as compared to those taught using traditional method? The null hypothesis formulated and tested based on the research question is stated below:

H_{03}: There is no significant difference in retention of non-science students in organic chemistry when taught using computer-assisted instruction as compared to those taught using traditional method

Research question 3 sought to determine if there were any significant difference in achievement of non-science students on retention test in organic chemistry when taught using computer-assisted instruction as compared to those taught using traditional method. To answer the question posed by hypothesis 3 which stated that

"There is no significant difference in retention of non-science students in organic chemistry when taught using computer-assisted instruction as compared to those taught using traditional method", an independent t-test was conducted on the experimental and control group retention test scores and the results were presented in Table 9 below.

The outcome of the results as shown in Table 9 indicates that there is a significant difference between the achievement of experimental and control groups based on retention test scores. The computed p-value of 0.0027 was significant at $p < 0.05$ level indicating that there was a statistically significant difference ($p<0.05$) between the post-test scores of students in the experimental and control groups. Furthermore, the mean values clearly show that students showed better performance on retention test of the experimental group (mean=15.05, SD=3.8) than retention test of the control group (mean=11.9, SD=4.39). As a result, the null hypothesis was rejected and an alternate hypothesis was formulated that there is "statistically significant difference ($p<0.05$) in students' academic achievement on retention test in organic chemistry when taught using computer-assisted instruction as compared to those taught using traditional method.

Table 9: Independent Samples t-test Analysis of the Achievement of Experimental and Control Groups on Retention Test

Group	**N**	**Mean**	**SD**	**DF**	**T-Value**	**P-Value**
Experimental	39	15.051	3.80			
				67	**3.13**	**0.0027**
Control	30	11.9	4.39			

Key: N=number of scores, SD=standard deviation, DF=degrees of freedom.

4.7 Discussion of Results for Research Question Three

The findings of the study agree with that of Ezenwafor, Eze and Owunsa (2020) who reported that students taught with CAI had higher mean retention than those taught using conventional lecture method. This finding also agrees with earlier findings of Cotton (1991) who 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. The Currrent result also support that of the study conducted by Abdulahi, Yusuf and Mohammed (2019) who also stated that CAI has the ability to help students retain knowledge. Again, this finding of the current study also supports the findings of Okoye (2018) who found that CAI was significantly more viable than conventional teaching in learners' retention achievement. Furthermore, the findings also agree with that of Anyamene, et al. (2012) which reported that students taught with CAI had higher mean retention than those taught using demonstration method.

Finally, it was observed that the mean score of students in the retention test was slightly less than that of the post-test (post-test mean score = 16.36; Retention test mean score= 15.051) which indicates that the achievement of students is declining with time. Students must therefore be advised to revise on the content over time in order to retain their achievement for much longer.

4.8 Results for Research Question Four

Research Question 4: What are the views of students on the use of CAI as an instructional strategy in organic chemistry? Results of the views of students on each item in the questionnaire were showed in Table 10.

With questionnaire item one "*CAI has improved my performance in organic chemistry concepts"* twenty-nine students representing (75%) of the total number of students in the experimental group agreed with the questionnaire item, four students representing (10%) disagreed while six students representing (15%) were undecided. The responses to the questionnaire item drew a dichotomy between the performance of students exposed to CAI approach of teaching concepts in organic chemistry and students exposed to traditional approach of teaching concepts in organic chemistry.

With Questionnaire item two, "*CAI motivated me in learning organic chemistry concepts",* twenty-nine representing (75%) of the total number of students in the experimental group agreed with the questionnaire item, six students representing (15%) of the total number of respondents in the experimental group disagreed with the questionnaire item, four students representing (10%) of the total number of respondents in the experimental group also were undecided about the questionnaire item. From the questionnaire item two it is evident that the CAI motivated the students in the experimental group to learn concepts in organic chemistry.

With questionnaire item three, *CAI approaches improved my ability to interpret concepts in organic chemistry,* thirty five students representing (89%) of the total number of respondents in the experimental group agreed with the questionnaire item, one student representing (3%) of the total number of students in the experimental group disagreed with the questionnaire item, three students representing (8%) of the total number of students in the experimental group were undecided about the questionnaire item. There was a high level of percentage from students in the experimental group on their agreement on how CAI has helped them to interpret difficult concepts in organic chemistry.

Questionnaire item four, *I like to be instructed by CAI approaches in the learning of organic chemistry*, thirty students representing (77%) of the respondents in the experimental group agreed with the questionnaire item, five students representing (13%) of the total number of respondents in the experimental group disagreed with the questionnaire item also four students representing (10%) of the total number of respondents in the experimental group were undecided about the questionnaire item. Students will always show up their best if they are taken through teaching approaches that arouse their interest, also students will always love to solve problems they understand and find interesting, the responses from questionnaire item four indicates that students developed interest for CAI and will always like to be instructed using CAI.

With questionnaire item five, *I learn concept better when teacher teaches with graphic and visual modes such as computer simulations, video, charts, diagrams, power point table and presentations*, thirty four students representing (87%) of the total number of respondents in the experimental agreed with the questionnaire item, three students representing (8%) of the total number of respondents in the experimental group disagreed with the questionnaire item, two students representing (5%) of the total number of students in the experimental group were undecided to the questionnaire item. The use of most of the senses in learning can be one catalyst to stimulate students' interest in lessons. It could be inferred that, the responses of the students in the experimental with questionnaire item five indicates how the use of visual modes by teachers in teaching can help them learn better and in alacrity. Questionnaire item six, *I will learn concept better when teachers teach by using only verbal modal instruction such as lecture* method, this item was negatively skewed to prevent the items been skewed only to the positive, thirty-one students representing (79%) of the total number of students in the experimental group disagreed with the idea of the teacher employing only verbal mode of instruction during lessons. Five students representing (13%) of the total number of respondents in the experimental group agreed to the fact of the teacher using verbal mode of instruction in teaching concepts in organic chemistry. Three students representing (8%) of the total number of respondents in the experimental group were undecided with the questionnaire item. The use of verbal mode of instruction by the teacher only disseminate firsthand information on the concept been taught but employing varying methods in conjunction with verbal mode help the student to get varying and diverse views about the concepts been taught. Students' response to questionnaire item six that was negatively skewed clearly indicates that verbal mode of instruction only does not arouse students' interest in learning concepts in chemistry.

With questionnaire item seven *CAI improves interest in learning concepts of organic chemistry,* thirty four students representing 87% of the total number of respondents in the experimental group agreed with the questionnaire item, three students representing 8% of the total number of respondents in the experimental group disagreed with the questionnaire item, also two students representing 5% of the total number of respondents in the experimental group were undecided about the questionnaire item. It is evident from questionnaire item seven that more than half of the students in the experimental group exposed to CAI have develop interest in solving organic chemistry concepts.

Questionnaire item eight, *CAI lessons encouraged interaction with other students* thirty-two students representing 82% of the total number of respondents in the experimental group agreed with the questionnaire item, three students representing 8% of the total number of respondents in the experimental group disagree with the questionnaire item, four students representing 10% of the total number of respondents in the experimental were undecided to the questionnaire item. Interaction is one of the means of helping students acquire new ideas from their peers, it is evident from questionnaire item eight that more than half of the students in the experimental group have agreed to the fact that the use CAI approach in teaching concepts in organic chemistry will not only help them to understand and develop interest in solving arduous concepts in chemistry but will also help them build a community where they can interact and share ideas.

With questionnaire item nine, *CAI lessons stimulates students than traditional methods of instruction*, with this questionnaire item, thirty three students representing 85% of the total number of students in the experimental group agreed with the questionnaire item, two students representing 5% of the total number of respondents in the experimental group disagree with the questionnaire item, four students representing 10% of the total number of respondents in the experimental group were undecided about the questionnaire item. Also with the questionnaire item nine, it could be inferred from students' response that the students in the experimental group have come to understand the need of using more interesting and stimulating teaching approaches to teaching concepts in organic chemistry than sticking to outmoded and archaic methods of teaching concepts in organic chemistry.

Lastly with questionnaire item ten, *I will want my teacher to use CAI in teaching other chemistry concepts, with this questionnaire item*, thirty five students representing 90% of the total number of respondents in the experimental group agreed, two students representing 5% of the total number of respondents in the experimental group disagreed with the questionnaire item, also two students representing 5% of the total number of respondents in the experimental group were undecided with the questionnaire item. This indicates that CAI has aroused the students in the experimental group interest in the use of CAI in teaching concepts in chemistry as this will help them understand other complex concepts in chemistry.

Table 10: Views of students about CAI

ITEM	SA	A	N	D	SD
1. CAI has improved my performance in organic chemistry concepts	19(49%)	10(26%)	6(15%)	2(5%)	2(5%)
2. CAI motivated me in learning organic chemistry Concepts	22(56%)	7(18%)	4(10%)	5(13%)	1(3%)
3. CAI approaches improved my ability to interpret concepts in organic chemistry	25(64%)	10(26%)	3(7%)	1(3%)	0(0%)
4. I like to be instructed by CAI approaches in the learning of organic chemistry	17(43%)	13(33%)	4(10%)	3(8%)	2(5%)
5. I learn concept better when teacher teaches with graphic and visual modes such as computer simulations, video, charts, diagrams, power point tables and presentations.	21(54%)	13(33%)	2(5%)	3(8%)	0(0%)
6. I will learn concept better when teachers teach by using only verbal modal instruction.	2(5%)	3(8%)	3(8%)	8(20%)	23(59 %)
7. CAI improves interest in learning concepts of organic Chemistry	23(59%)	11(28%)	2(5%)	2(5%)	1(3%)
8. CAI lessons encouraged interaction with other students	17(44%)	15(38%)	4(10%)	1(3%)	2(5%)
9. CAI lessons stimulates students thinking than traditional methods of instruction	25(64%)	8(21%)	4(5%)	2(5%)	0(0%)
10. I will want my teacher to use CAI in teaching other chemistry concepts	28(71%)	7(18%)	2(5%)	1(3%)	1(3%)

KEY 5= SA= Strongly Agree, 4 = A= Agree, 3 = N= Neutral, 2 = D = Disagree, 1 = SD = strongly Disagree

The views of experimental group about CAI approach questionnaire is represented in Figure 12 below

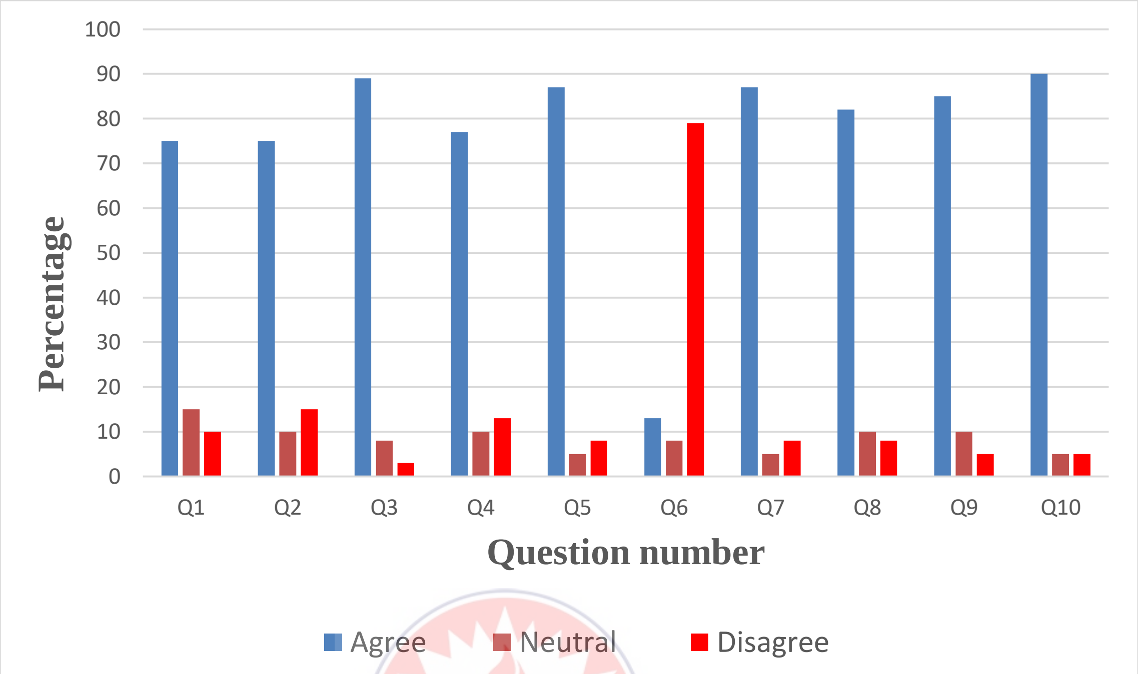

Figure 12: Experimental group views about CAI approach

4.9 Discussion of Results for Research Question 4

The research question 4 was posed to solicit the views of students in the experimental group about CAI. The general view of students in the experimental group about CAI was obtained by using the Likert items with scale ranging from strongly agree =5; Agree= 4; neutral=3; disagree=2; and strongly disagree=1. After collecting students' responses, the researcher analysed the students' responses qualitatively using frequency counts. The frequency was used as a speed bump in drawing a baseline between the experimental group general views on CAI.

The experimental group responses on their views towards CAI was first analysed descriptively using percentages and finally interpreted with the help of frequency. It could be inferred from Table 10 that all the questionnaire items had a greater gain for strongly agree with the exception of questionnaire item six that was negatively skewed. Even with questionnaire item six skewed negatively, most of the respondents in the experimental group disagreed with the item insisting on the teacher using verbal mode of instruction during chemistry lessons. A good and stimulating teaching and learning instruction arouse students' interest.

Although there are general views of students about teaching and learning approaches used by chemistry teachers in teaching chemistry concepts, one of the most stimulating and colossal approaches to make the teaching of chemistry concepts easier for the student is CAI. The general views students have about a teaching method can also be used as a mean of assessing how necessary it is to be applied in the classroom. It is evident from Table 10 that collated responses of students with the questionnaire items showed high level of agreement with all the questionnaire items indicating the good general views of the students about CAI.

The views of students exposed to CAI have always proved to be positive. This is evident from Adekunle (2016) who conducted a survey involving 7500 secondary school students in Nigeria to determine their perception about computer education in Abuja. The results from the research indicated that students have positive views concerning CAI. Students seem intrigued when they discover that the material they normally can only find in a book or class lectures is also available to them in a computer program they can quickly master.

From the collated students' response and results, it was obvious that students have positive views about CAI approach to teaching concepts in organic chemistry. Appropriate instructional approach influences many motivational variables of learners such as a tendency to think critically. Not every instructional strategy will be the perfect fit for every situation, so teachers must become adept at evaluating the best instructional approach in teaching concepts in chemistry. Instructional strategies provide a delivery mechanism for presenting great content. Instructional strategies are the how, and content is the what. In many cases, how you present the content is more important than what you present. Students latch onto content that is packaged in an interesting and engaging way. A lack of a great delivery system will fail to make connections with even the most interesting content. CAI therefore was agreed by the students in the experimental group to be more innovative and easier in learning concepts in organic chemistry. This agreed with the suggestions of Osborne and Collins (2000) that new technologies can be used to increase student motivation, facilitate clearer critical thinking and develop interpretational skills with data.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter summarised the research findings, makes conclusions from the study and outlines appropriate recommendations. The discussions, conclusions and recommendations were made in accordance with the purpose of the study and research objectives. Finally, the areas for further research are suggested for consideration in future studies.

5.1 Summary of the Main Findings

This section focused on the summary of the major findings of the study. The summary of findings was done in line with the research questions. The main findings of the study were summarised under the following captions; effect of computer-assisted instruction on non-science students' performance in organic chemistry; differences in the performance of male and female non-science students when taught organic chemistry using computer-assisted instruction; effect of computer-assisted instruction on non-science students' retention in organic chemistry as compared to those taught using traditional method; views of students on the use of CAI as an instructional strategy in teaching organic chemistry.

5.1.1. Effect of computer-assisted instruction on non-science Students' performance in organic chemistry

The main aim of the research was to determine the effect of CAI on non-science students' achievement in organic chemistry as compared to the traditional method. To achieve this, learners in experimental and control groups were pre-tested, treatment administered and subsequently post-tested. The data on students' achievement test in pre-test and post-test were analysed using independent and dependent t-test statistics.

For the pre-test, an unpaired t-test was done to show the significant difference between the experimental and the control groups before the treatment. It was premised on the notion that for any experimental research, the entry behaviour for control and experimental groups ought to be the same. The computed p-value of 0.84 was not significant ($p<0.05$). This implies that there was no significant difference ($p<0.05$) between the pre-test scores for the experimental groups and control groups. This reveals that the experimental and the control groups were comparable on their initial understanding of the organic chemistry concepts.

For the post-test, a paired and an unpaired t-test was used to analyse the scores. The paired t-test was also used to establish the significant difference between the pre-test and post test scores of the experimental group and control group. The unpaired t-test was used to establish the significant difference between the post-test scores of the experimental group and control group.

The paired t-test results of the experimental group gave a computed p-value of 1.898×10^{-26} which was significant ($p<0.05$), indicating that there was a statistically significant difference ($p<0.05$) between the pre-test and post-test scores of students in the experimental group. Also, the computed p-value of 9.399×10^{-15} from the paired t-test results of the control group was significant ($p<0.05$), indicating that there was a statistically significant difference ($p<0.05$) between the pre-test and post-test scores of students in the control group. The significant difference ($p<0.05$) between the pre-test and post-test scores of the experimental and control groups indicated that both treatments had significant effect on the achievement of students in organic chemistry.

Finally, an unpaired t-test was carried out to determine if there was significant difference between the post-test scores of the experimental group and the control groups. In the analysis of the results, the experimental group mean was found to be 16.36 whiles the control group mean was found to be 12.63 indicating a mean difference of 3.73 for the experimental and control group post-test scores. The computed t-test was 5.024 and a p-value of 5.0×10^{-6} which was considered to be statistically significant ($p < 0.05$).

The statistical analysis of the post-test of the experimental and control groups (Table 6) showed that there was statistically significant (0.05) difference in the performance between the experimental group and the control group. The collective performance of the experimental group outweighed the collective performance of the control group after the treatment. There was a significant improvement in the performance of students in the experimental group This means that non-science students who were taught by using CAI could interpret and comprehend more of the scientific organic chemistry concepts than those who were taught by the Traditional method.

5.1.2. Differences in the achievements of male and female non-science students when taught organic chemistry using computer-assisted instruction

An independent t-test was conducted for the pre-test and posttest scores of the male and female students in the experimental group to determine if the treatment had differential impacts on the students based on gender. The findings of pre-test mean scores between male and females as illustrated in Table 7 indicated that the computed p value of 0.8929 was greater than 0.05 (i.e. $p > 0.05$) indicating that there was no statistically significant difference between the mean organic chemistry achievement pre-test scores of the male and female students in the experimental group.

This meant that there was no significant mean difference between them with regards to their prior understanding of organic chemistry concepts before the treatment. The male Students had a pre-test mean score of 3.63 as compared to the female mean score of 3.7. However, the mean difference 0.07 between the two groups was not statistically significant. Also, the findings of post-test mean scores between both male and female students as illustrated in Table 8 revealed that computed p value of 0.381 was greater than 0.05 indicating that there was no statistically significant difference ($p<0.05$) between the mean organic chemistry achievement post-test scores of male and female students' in the experimental group.

5.1.3. Effect of computer-assisted instruction on non-science students' retention in organic chemistry as compared to those taught using traditional method

An independent t-test conducted on the experimental and control group retention test scores as illustrated in Table 9 indicated that there was a significant difference between the achievement of experimental and control groups based on retention test scores. The computed p-value of 0.0027 was significant at $p < 0.05$ level indicating that there was a statistically significant difference between the post-test scores of students in the experimental and control groups. Furthermore, the mean values clearly show that students showed better achievement on retention test of the experimental group (mean=15.05, SD=3.8) than retention test of the control group (mean=11.9, SD=4.39).

5.1.4. Views of students on the use of CAI as an instructional strategy in teaching organic chemistry

The effect of CAI was also confirmed from students' views about the approach of teaching. The descriptive analysis on all the questionnaires indicated that students have positive attitude towards CAI approach when properly applied in teaching and learning of organic chemistry. Students' perceptions of learning through computer-assisted instructional approaches indicated that the treatment improved their abilities and confidence to interpret and comprehend organic chemistry concepts and motivated them to learn the organic chemistry concept. Considering the results, it meant that students had positive attitudes towards the use of CAI instructional approaches. Students also indicated that they do not like to be instructed by only verbal mode of instruction.

5.2 Conclusions

Based on the findings of this study, it was concluded that CAI has a positive effect on students' academic achievement and retention ability in organic chemistry. The introduction of the CAI instructional approach produces a significant improvement in students' learning and understanding of concepts in organic chemistry as compared to the commonly traditionally instructional approach.

Also, based on the findings, no significant difference existed between the mean organic chemistry achievement pretest and posttest scores of male and female students in the experimental group. It was then concluded that, computer-assisted instruction has no significant differential effect on the achievements of male and female students in organic chemistry. It is therefore suitable for improving the cognitive achievement of both male and female students.

Again, the study concludes based on its findings that CAI has the ability to help students retain knowledge. CAI ability to help students retain knowledge in organic chemistry outweighs that of the traditional method of instruction.

Finally, the views of students expressed about the use of CAI as an instructional strategy connotes that students enjoy being instructed through CAI. Therefore, the study concludes that computer-assisted instructional approach if implemented effectively and efficiently has the potential of making learners perform better in solving chemistry problems as well as shaping students' attitude towards learning organic chemistry.

On the whole the study established that CAI as a teaching strategy is a better method of instruction in organic chemistry. The strategy was found to improve students' achievement across 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.

5.3 Recommendations

Based on the findings of this study, the following recommendations were made

1. Government agencies and professional associations, whose responsibilities are to design and revise the curriculum for secondary schools, should incorporate and emphasise the use of computer-assisted instruction strategies in senior high school science curriculum.
2. Through in-service training, teachers should as much as possible try to learn and use the CAI approach in their instruction since it exposes both students

and teachers to new ways of teaching and learning abstract science concepts like organic chemistry. The computer-assisted instructional approach should also be included in the curriculum of pre-service teachers.

3. The CAI approach which uses tutorials, drill and practice, simulation, and problem solving approaches should be encouraged in many Chemistry instructions, since it offers students more opportunities to explore, discuss, challenge and test their preexisting ideas about concepts.
4. Science teachers in senior high schools should be provided with appropriate CAI teaching and learning materials to enable them to fully implement the use of computer-assisted instructional approach in teaching chemistry content.

5.4 Suggestions for Further Research

From the outcome of the study, the following areas are suggested for further research.

1. The study should be replicated in some selected topics in other subject areas such as biology and physics and also in other chemistry topics such as the mole concept.
2. A study should be conducted to find out the positive effect of mobile phones, a tool for modern technology in the science classroom, on science students' academic performance in senior high schools.
3. Research should be carried out to determine the knowledge and perceptions of science teachers on the use of computer-assisted instructional teaching techniques.

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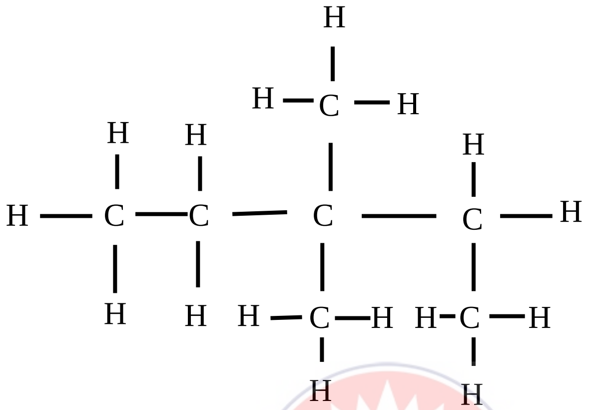
APPENDICES

APPENDIX A: PRE TEST

SEX: MALE FEMALE

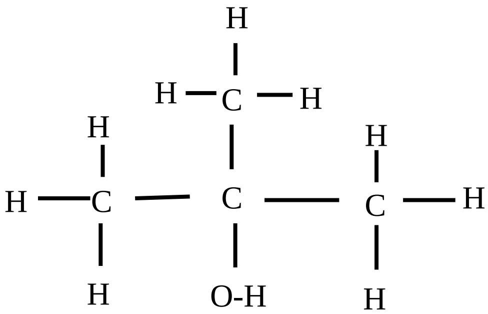
1. In the hydrocarbon structure below, how many carbon atoms are in the longest chain?



A. 5
B. 3
C. 4
D. 7

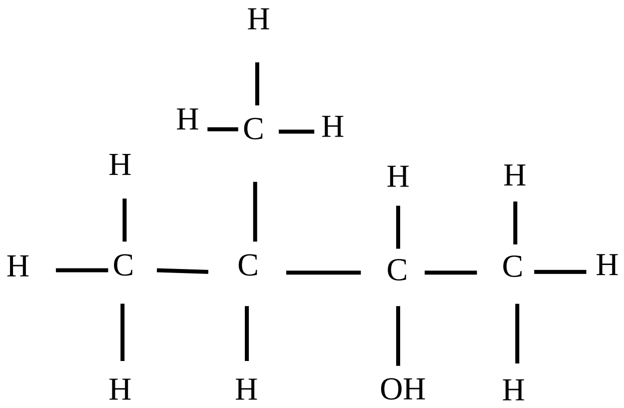
2. The structural representation of 3 – methylbutan -2- ol is

A.

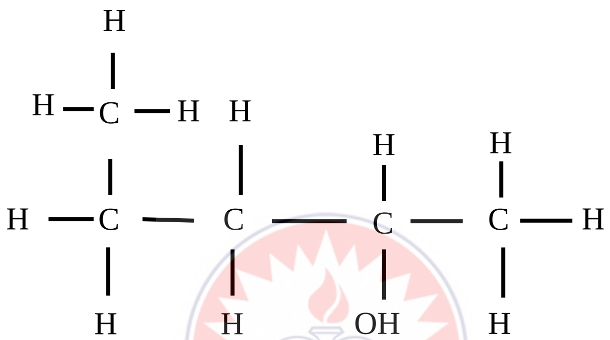


APPENDIX A CONTINUED

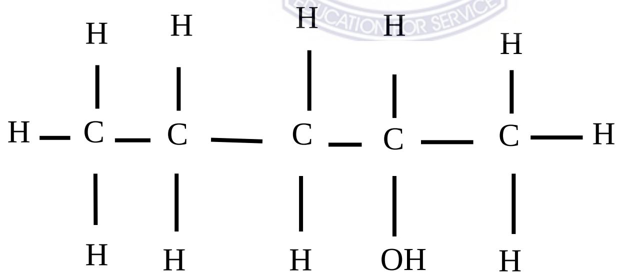
B



C



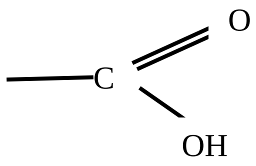
D



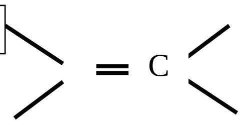
APPENDIX A CONTINUED

3. The functional group for alkyne is

(A

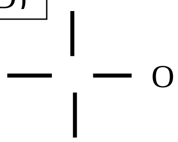


(B)



(C

(D)



4. The reaction

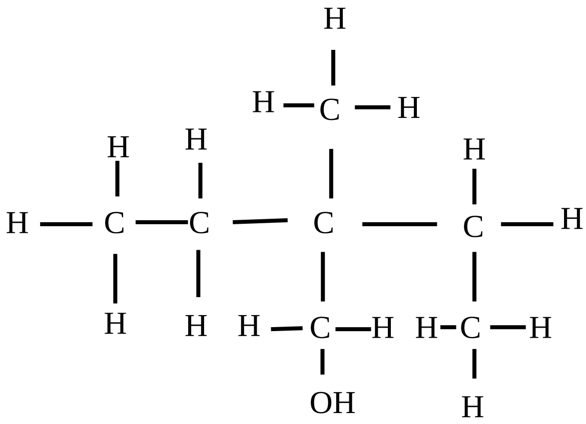
$$CH_3COOH + CH_3OH \xrightarrow[\Delta]{Conc.\, H_2SO_4} CH_3COOH \; + \; H_2O$$

is an example of

A. Esterification
B. Saponification
C. Hydrolysis
D. Fermentation

APPENDIX A CONTINUED

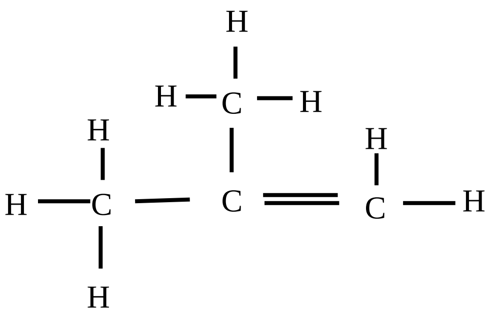
5 How many carbon atoms are in the longest chain in the organic compound below?



A. 3
B. 7
C. 5
D. 4

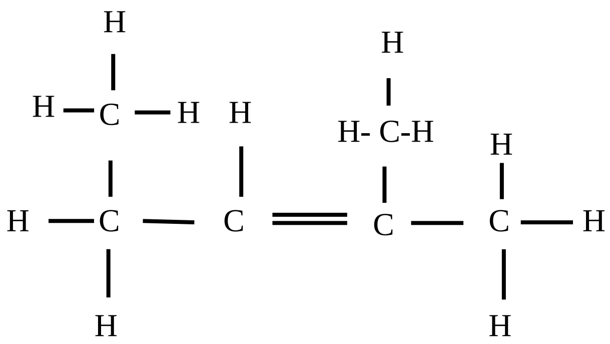
6. The structural representation of 3 – methylpent -2- ene is

A.

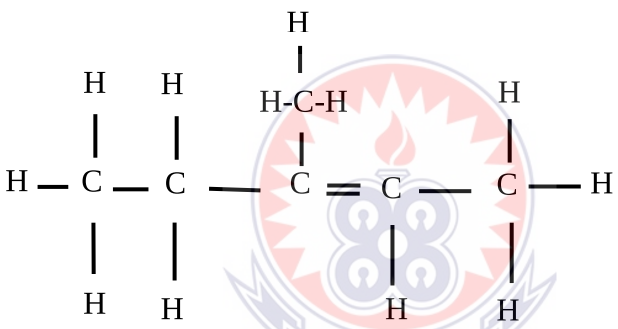


APPENDIX A CONTINUED

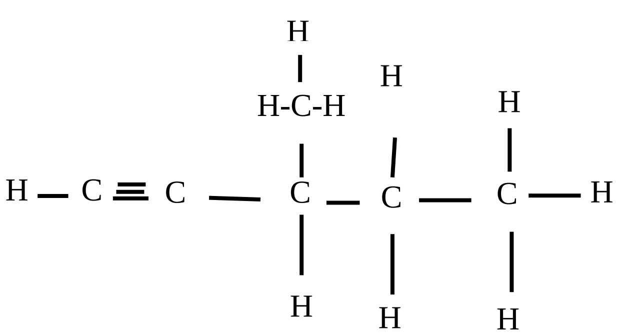
b



c



d



APPENDIX A CONTINUED

7. Which of the following pair of compounds will produce an ester when warmed with few drops of concentrated H_2SO_4

(a) Ethanol and ethane

(b) Ethanoic acid and ethane

(c) Ethane and ethanoic acid

(d) Ethanol and ethanoic acid

Write the structural formulae of the following organic compounds

8. heptane

9. 2-methylpropan-2-ol

10. 4,4-dimethylpent-3-ene

APPENDIX A CONTINUED

Consider the following compounds:

C_2H_4; C_2H_6; C_2H_5OH, C_2H_5COOH and CH_3COOCH_3.

State the one which:

11. will undergo polymerisation

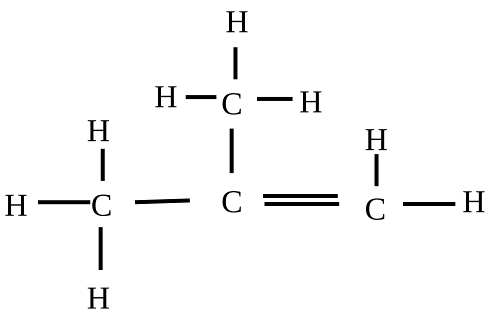
12. will liberate carbon dioxide with sodium hydrogen trioxocarconate (IV)

13. can decolourise bromine water

14. will produce CH_3COOH and CH_3OH

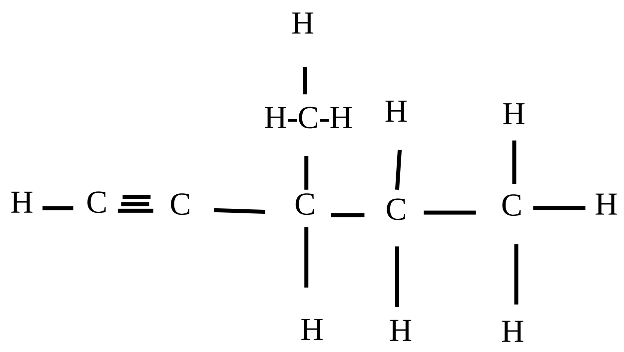
Give the IUPAC name of the compound represented by the structural formula

15.

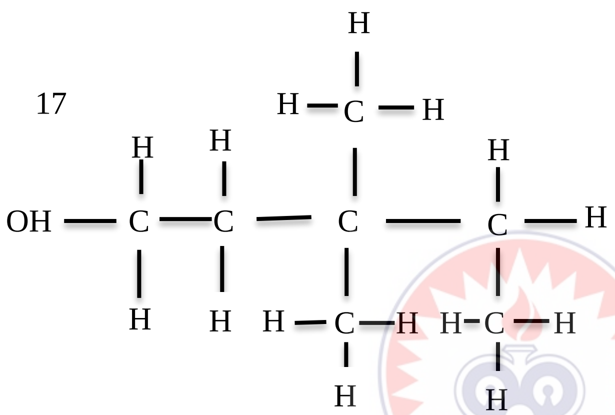


APPENDIX A CONTINUED

16



17



Give the functional groups of the following organic compounds

18. Alkenes

19. Esters

20. Alcohols

APPENDIX B (POST-TEST)

SEX: MALE FEMALE

Write out the structural formula of each of the following compounds in the spaces provided below them.

1. 3 – methylhex – 2 – yne

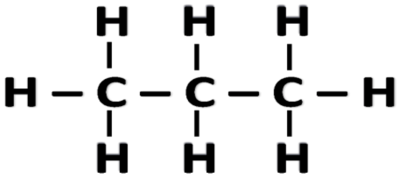
2. 2,3,3 - trimethyloctan-2-ol

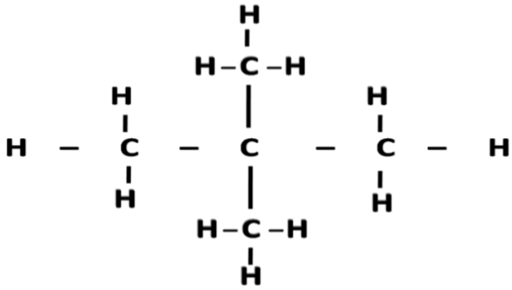
3. C_3H_6

4. 3– ethyl–4–methylhex–3–ene

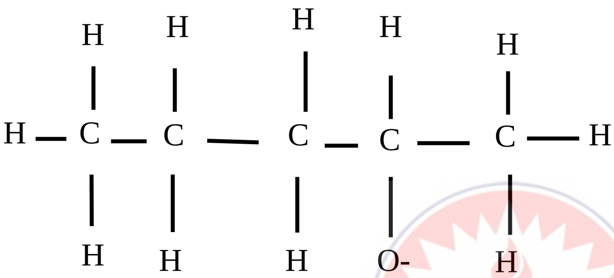
5. Hexanoic acid

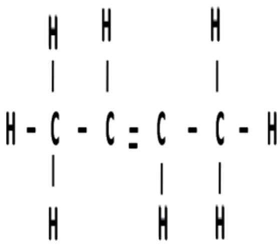
Write the IUPAC names for the structures below in the spaces provided





6 ....   **7** ....

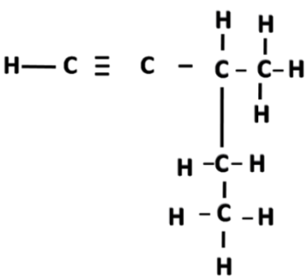




8 ....   **9** ....

In the hydrocarbons structures below, how many carbons are in the longest chain

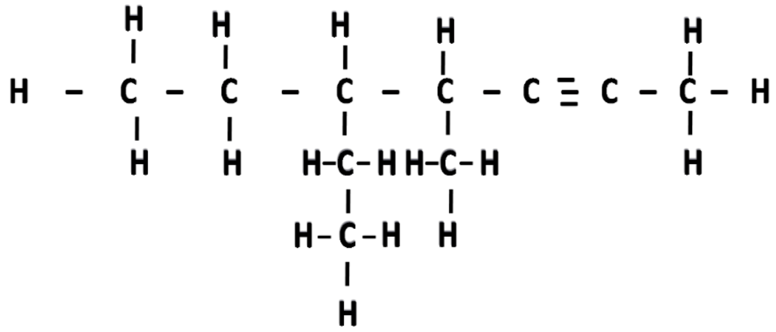
10.



A. **4**
B. **5**
C. **6**
D. **3**

APPENDIX B CONTINUED

11.



A. 5
B. 6
C. 7

12. Which of the following pair of compounds will produce an ester when warmed with few drops of concentrated H_2SO_4

(a) butanol and ethane

(b) propanoic acid and ethene

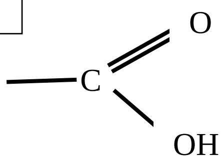
(c) Butanoic acid and ethanol

(d) ethanoic acid and butane

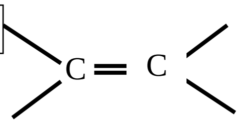
APPENDIX B CONTINUED

Give the functional group of the following organic compounds

(13)

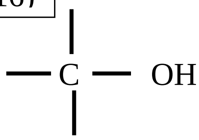


(14)



(15)

(16)



Consider the following organic compounds:

C_2H_4; C_2H_6; C_4H_9OH; CH_3COOH $C_2H_5COOCH_3$.

State the one which:

17. will undergo esterification reaction with C_2H_5COOH

18. will liberate carbon dioxide with sodium hydrogen trioxocarconate (IV)

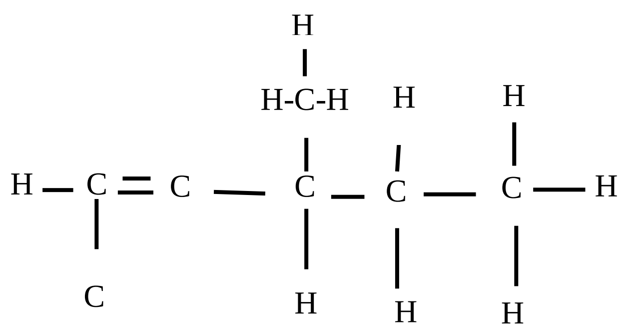
19. two can react together in the presence of H_2SO_4 to produce an ester

20. will produce C_2H_5COOH and CH_3OH

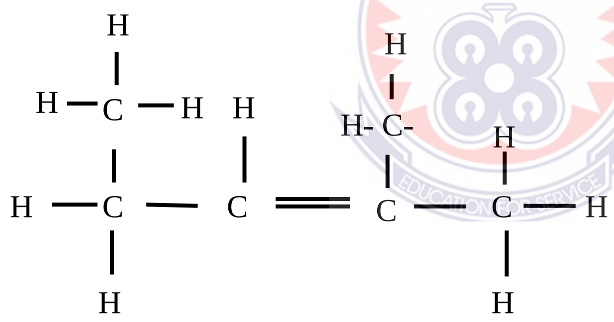
APPENDIX C (RETENTION-TEST)

GENDER: MALE FEMALE

Write the IUPAC names of the following structures in the spaces provided below

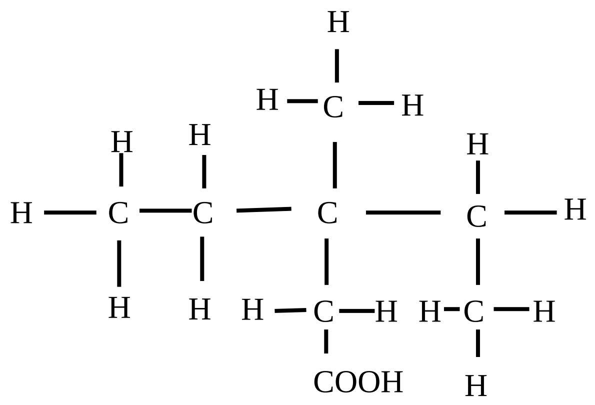


1 ....

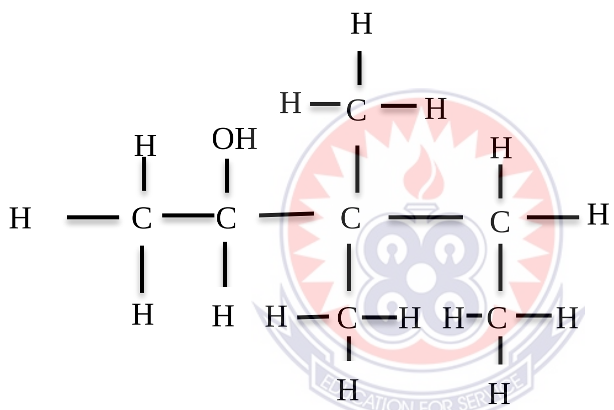


2 ....

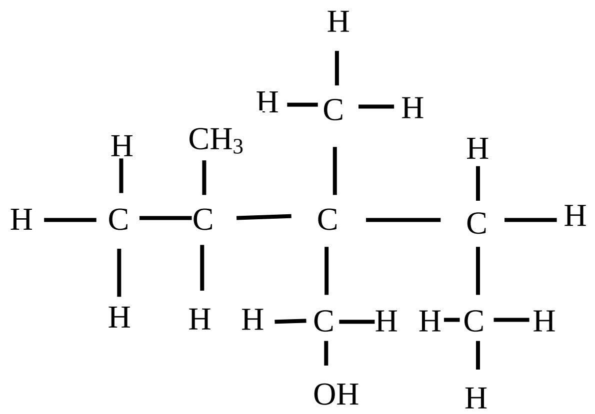
APPENDIX C CONTINUED



3 ....



4 ....

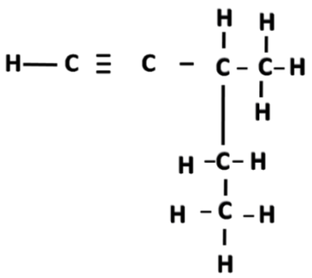


5 ....

APPENDIX C CONTINUED

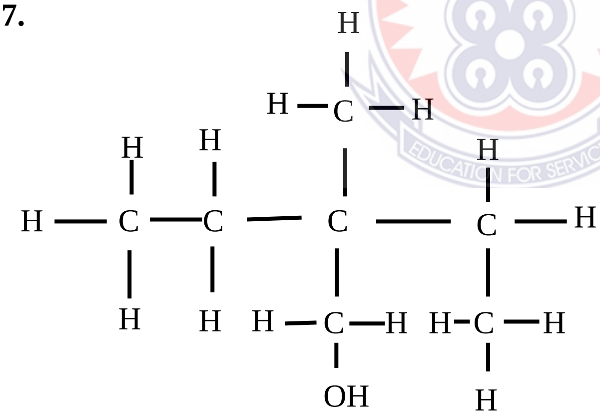
In the hydrocarbons structures below, how many carbons are in the longest chain

6.



- **A. 4**
- **B. 5**
- **C. 6**
- **D. 3**

7.



- **A. 5**
- **B. 6**
- **C. 7**
- **D. 4**

8. Which of the following pair of compounds will produce an ester when warmed with few drops of concentrated H_2SO_4

(a) butanol and hexene

(b) propanoic acid and pentyne

(c) ethanoic acid and pentanol

(d) ethanoic acid and butane

Give the functional group of the following organic compounds

9. Alkynes

10. Alkanoic Acids

11. Esters

Write out the structural formula of each of the following compounds in the spaces provided below them.

12. 5 – methyloct – 2 – ene

13. 2,3,3 - trimethyldecan-2-ol

14. C_4H_9COOH

15. 3–ethyl–4–methylhex–3–ene

16. Methanoic acid

Give the name of the compound formed from these reactions

17. $C_2H_5COOH + C_2H_5OH$

18. HCOOH + $CH_3CH_2CH_2CH_2OH$

19. C_2H_5COOH + CH_3OH

20. C_4H_9COOH + $CH_3CH_2CH_2CH_2OH$

APPENDIX D

QUESTIONNAIRE FOR STUDENTS

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

RESEARCH QUESTIONNAIRE FOR NON-SCIENCE STUDENTS IN SENIOR HIGH SCHOOLS

This questionnaire seeks to find out information about the effect of computer-assisted instructions on performance of students in organic chemistry. All information given are purely for research purposes and therefore remains confidential. Kindly respond to all questions as accurate as possible.

INSTRUCTIONS: Please tick [√] the box for appropriate answers or write the appropriate

Response

Section One: Demographic Data

Gender: Male [ ] Female [ ]

Class………………………

QUESTIONS	RESPONSES				
	Strongly agree	Agree	Not sure	Disagree	Disagree Strongly
1. CAI has improved my performance in organic chemistry concepts					
2. CAI motivated me in the learning of organic chemistry concepts					
3. CAI approaches improved my ability to interpret concepts in					

organic chemistry					
4. I like to be instructed by CAI instruction approaches in the learning of organic chemistry					
5. I learn better when my science teacher teach with graphic and visual modes such as computer simulations, video, charts, diagrams, power point tables and presentations					
6. I will learn concept better when teachers teach by using only verbal modal instruction					
7. CAI improves interest in learning concepts of organic chemistry					
8. CAI lessons encourage interactions with other students					
9. CAI lessons stimulates students thinking than traditional methods of instruction					
10. I will my teacher to use CAI in teaching other Chemistry concepts					

APPENDIX E

LETTER OF INTRODUCTION

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF INTERGRATED SCIENCE EDUCATION
P. O. Box 25, Winneba, Ghana
ise@uew.edu.gh
+233 (020) 2041077

Our ref. No.: ISED/PG.1/Vol.1/12
Your ref. No.:

Date: 11th March, 2021

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION
MR ASARE, PETER AYISI

We write to introduce, Mr Asare is a postgraduate student of the Department of Integrated Science Education, University of Education, Winneba, who is conducting a research titled:

The Effect of Computer-Assisted Instructions on Non- Science Students Performance in Selected Topics in Organic Chemistry

We would be very grateful if you could give him the assistance required.

Thank you.

Yours faithfully,

DEPT. OF INT SCIENCE EDU.
UNIVERSITY OF EDUCATION, WINNEBA
P. O. BOX 25
WINNEBA

ALEXANDRA N. DOWUONA
PRINCIPAL ADMIN. ASSISTANT
For : HEAD OF DEPARTMENT

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