University of Education,Winneba http://ir.uew.edu.gh

UNIVERSITY OF EDUCATION, WINNEBA

COMPUTER- ASSISTED INSTRUCTION (CAI): TOWARDS EFFECTIVE TEACHING AND LEARNING OF NOMENCLATURE OF CYCLIC HYDROCARBONS

HARRIET GYASI

MASTER OF PHILOSOPHY

2023

University of Education,Winneba http://ir.uew.edu.gh

UNIVERSITY OF EDUCATION, WINNEBA

COMPUTER- ASSISTED INSTRUCTION (CAI): TOWARDS EFFECTIVE TEACHING AND LEARNING OF NOMENCLATURE OF CYCLIC HYDROCARBONS

HARRIET GYASI

(220025250)

A thesis in the Department of Science Education, Faculty of Science Education submitted to the School of Graduate Studies, in partial fulfilment of the requirements for the award of the degree of Master of Philosophy (Science Education) in the University of Education, Winneba

SEPTEMBER, 2023

University of Education,Winneba http://ir.uew.edu.gh

DECLARATION

STUDENT'S DECLARATION

I, **HARRIET GYASI**, 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 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: PROF. ARKOFUL SAM

SIGNATURE: …………………….……..……

DATE: ………………………………….………

University of Education,Winneba http://ir.uew.edu.gh

DEDICATION

This work is dedicated to God for sustaining me throughout the study and also to my dear husband, Kingsley Osei–Bonsu and my children Akua Akyaa Osei–Bonsu, Abena Frimpomaa Osei–Bonsu and Yaa Asantewaa Osei–Bonsu.

University of Education,Winneba http://ir.uew.edu.gh

ACKNOWLEDGEMENT

I humbly thank the Almighty God for his guidance and protection of my life. My deepest gratitude also goes to my supervisor, Prof. Arkoful Sam whose guidance and supervision led to the successful completion of this work. I am also grateful to my colleagues especially, Paul Asiedu Agyapong and Richard Boakye for their assistance during the field data collection. I would like to acknowledge my course mates Prince Douglas Asamany, Philipina Tuffour, Solomon Boachie and Irene Sarpah for their advice and support in diverse ways. I express my gratitude to William Ghartey for helping in the questionnaire administration and data analysis.

Finally, my appreciation goes to my brother Evans Agyei Mensah for his fervent prayers.

University of Education,Winneba http://ir.uew.edu.gh

TABLE OF CONTENTS

Contents **Pages**

University of Education,Winneba http://ir.uew.edu.gh

University of Education,Winneba http://ir.uew.edu.gh

University of Education,Winneba http://ir.uew.edu.gh

University of Education,Winneba http://ir.uew.edu.gh

LIST OF TABLES

Tables **Pages**

University of Education,Winneba http://ir.uew.edu.gh

LIST OF FIGURES

University of Education,Winneba http://ir.uew.edu.gh

ABSTRACT

The study investigated the effect of Computer-Assisted Instruction (CAI) towards the effective teaching and learning of nomenclature of cyclic hydrocarbons among KNUST Senior high school students at Kumasi in the Ashanti Region of Ghana. The research study adopted an action research design. The sample comprised 45 form 3 General Science 1 students who were selected on purpose. Students were given a questionnaire to examine their prior conception of organic chemistry nomenclature. A week after, a pre-intervention test was administered to the research sample to determine their academic performance in the nomenclature of cyclic hydrocarbons before intervention activities. Within the 4-week period students learned about cyclic hydrocarbons (cycloalkanes, cycloalkenes and cycloalkynes) through CAI for 2 hours each week. The instruction were videos, pictures, and animations to enhance their learning experience. After four weeks of intervention, students were given a post-intervention test to answer. Afterwards, the scripts were collected and scored to generate data for the post-intervention test. Two different sets of questionnaires were given to students to answer. One questionnaire assessed students' attitudes towards the use of computer-assisted instruction for the teaching and learning of the nomenclature of cyclic hydrocarbons, while the other questionnaire investigated the role of CAI in promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons. Data collected from the administration of these tests and questionnaires were organized and used to statistically test the null hypotheses that were formulated prior at a 0.05 significance level. The outcome of the study revealed that after intervention activities, students' nomenclature showed they followed the IUPAC rules in naming cyclic hydrocarbons and were correctly done. CAI is an effective tool for teaching and learning the nomenclature of cyclic hydrocarbons, as evidenced by improved student conceptual understanding. Students generally have a positive attitude towards using CAI for learning the nomenclature of cyclic hydrocarbons, finding it effective and enjoyable. It is recommended that placing students at the center of the teaching and learning process is essential to actively involve them in the lessons in chemistry and also chemistry teachers should adopt CAI instead of traditional teaching methods when teaching chemistry concepts.

University of Education,Winneba http://ir.uew.edu.gh

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter gives an introduction to the research concept including a preview of background to the study, a statement of the problem, the study purpose, objectives and research questions. Similarly, it contains the significance of the study, issues limiting and delimiting the study, definition of terms used and abbreviations.

1.1 Background to the Study

The educational systems of societies have lately changed as a result of advances in science and technology. The relevance of trained individuals as knowledge creators, as well as users, is growing, which imposes new obligations on science educators (Gonen et al., 2006).

Using instructional technologies, particularly computers, is one of the most effective ways to make teaching and learning more interesting and effective (Tareef, 2014). With the use of computers in education, a lot of terms have come into and gone out of use in education (Owusu et al, 2010). Recent advancements in computer-assisted instruction (CAI) provide new opportunities to improve classroom teaching and learning (Abdoolatiff & Narod, 2009). As an instructional medium, computers are described in various forms such as computer-based learning (CBL), computer-enhanced learning (CEL), computer-based instruction (CBI), computer-aided instruction (CAI), computer-aided learning (CAL) and computer-assisted instruction (CAI). Among these, CAI has ended up being a successful and beneficial instructional approach for encouraging interest, uplifting mentality, building up students' retention

University of Education,Winneba http://ir.uew.edu.gh

capacity and boosting the students' performance (Osemmwinyen, 2009; Yusuf & Afolabi, 2010).

Since CAI improves students' academic achievements, its usage in teaching the nomenclature of cyclic hydrocarbons is limited in the existing literature. It is against this background that the study is been conducted to examine its effectiveness towards effective teaching and learning of naming cyclic hydrocarbons.

1.2 Statement of the Problem

The researcher after marking and scoring students' exercises, group work and end-of-semester examination observed that most students were unable to answer questions on naming of organic compounds correctly, especially the cyclic hydrocarbons. To confirm the observation of the researcher, all questions related to naming cyclic hydrocarbons in the end-of-semester examination were put together and given back to the same students as class test.

The adoption and use of CAI in schools have been advanced as one of the major avenues that would help improve performance in the subject (Msafiri et al., 2023). The benefits of the CAI method include ensuring the application of proven teaching methods to students; providing equal educational opportunities for students by using the same programme; changing the role of the teacher from that of a teacher to that of a guide; and, when properly handled, removing fright and embarrassment on students and bringing about meaningful learning and academic achievement (Orjika, 2012).

Though evidence shows that the use of CAI in classroom instruction impacts students' achievement in different topics of secondary chemistry curricula, there is limited information on how it could impact teaching and learning in naming of organic compounds specifically- cyclic hydrocarbons. This study has therefore become

University of Education,Winneba http://ir.uew.edu.gh

necessary to investigate the effective use of computer assisted instructions towards effective teaching and learning to improve students' performance in nomenclature of cyclic hydrocarbons.

1.3 Rationale for the Study

This study was necessary because nomenclature of cyclic hydrocarbon was a requirement for building students skills toward further studies on heterocyclic and aromatic organic compounds in the senior high school chemistry syllabus.

1.4 Purpose of the Study

The purpose of the study was to prove the effectiveness of CAI as an instructional approach to teaching and learning of nomenclature of hydrocarbons.

1.5 Objectives of the Study

The study objectives were to:

1. Assess students' prior conceptions about naming cyclic hydrocarbons.
2. Investigate the effectiveness of the use of computer-assisted instruction as a tool for teaching and learning nomenclature of cyclic hydrocarbons.
3. Assess students' attitudes towards the use of computer-assisted instruction for the teaching and learning of nomenclature of cyclic hydrocarbons.
4. Investigate the role of CAI in promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons.

1.6 Research Questions

The study was guided by the following research questions:

1. What are students' prior conceptions of nomenclature of cyclic hydrocarbons?
2. How effective is the use of computer-assisted instruction as a tool for teaching and learning the nomenclature of cyclic hydrocarbons?

University of Education,Winneba http://ir.uew.edu.gh

3. What are students' attitudes towards the use of computer-assisted instruction in the teaching and learning of nomenclature of cyclic hydrocarbons?
4. What is the role of CAI in promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons?

1.7 Null Hypothesis

The following null hypothesis was tested for statistical significance in order to answer research question two:

H_{01}. There is no statistically significant difference between the mean pre-intervention scores and post-intervention scores after the use of CAI in teaching cyclic hydrocarbons.

1.8 Significance of the Study

Computer-Assisted Instruction (CAI) can provide students with an interactive and engaging learning experience that can help them better understand and retain the material. This can lead to improved student performance on assessments and a deeper understanding of the topic. The study may help chemistry teachers to adopt some effective teaching strategies in helping SHS Chemistry students to improve their understanding in the area of organic chemistry. This research topic can contribute to the growing body of literature on the use of technology in education and can potentially lead to further research on the use of CAI for teaching other chemistry concepts.

1.9 Limitations of the Study

Breakdowns or faulty computers could limit this study as well as frequent power outages. The lack of relevant software and applications can also affect the performance of the students.

University of Education,Winneba http://ir.uew.edu.gh

1.10 Delimitations of the Study

The research was carried out at KNUST Senior High School. This was due to the researcher's proximity and population accessibility. It was also restricted to form three (3) elective chemistry students. This was because third-year students studied the nomenclature of cyclic hydrocarbon as part of their syllabus. The study focused specifically on the use of CAI for teaching the nomenclature of cyclic hydrocarbons and did not address other topics in chemistry or other subjects.

1.11 Organization of the Study

This study report was organized into five chapters. The first chapter served as the introduction to the study, and the second chapter covered a review of related literature. The third chapter outlined detailed information on the research methodology. The fourth chapter looked at the data that was collected, analyzed the data, answered the research questions, and discussed the results. The fifth chapter examined the summary of findings, conclusions, recommendations, and suggestions for further studies.

1.12 Operational Definition of Terms and Abbreviations

Computer -Assisted Instruction- Use computer and computer-supported programs in classroom instruction.

Pre-intervention test – A test that was given to students before they were exposed to teaching methods.

Post-intervention test - A test that was given to students after they were exposed to teaching methods.

CAI-Computer-Assisted Instruction

CAL-Computer-Assisted Learning

SHS -Senior High School.

IUPAC – International Union of Pure and Applied Chemistry.

KNUST- Kwame Nkrumah University of Science and Technology.

University of Education,Winneba http://ir.uew.edu.gh

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

The chapter provides a comprehensive overview of literature relevant to computer-assisted instructional (CAI) approaches for teaching. It covers various strands including the theoretical and conceptual frameworks, the role of computer technologies in education, the benefits of effective CAI usage, the impact of CAI on student attitudes, measurement of academic performance, conventional and non-conventional science teaching methods, and an empirical review of related studies. This synthesis of existing literature sets the stage for the study's exploration of teaching and learning through CAI.

2.1 Theoretical Framework Underpinning the Study

This study's theoretical foundation is the Mayer-proposed Cognitive Theory of Multimedia Learning (CTML). The cognitive theory of multimedia learning was popularized by the work of Richard E. Mayer and other cognitive researchers who argue that multimedia supports the way that the human brain learns. They assert that people learn more deeply from words and pictures than from words alone, which is referred to as the multimedia principle (Mayer, 2005a). Multimedia researchers generally define multimedia as the combination of text and pictures; and suggest that multimedia learning occurs when we build mental representations from these words and pictures (Mayer, 2005b). The words can be spoken or written, and the pictures can be any form of graphical imagery including illustrations, photos, animation, or video. Multimedia instructional design attempts to use cognitive research to combine words and pictures in ways that maximize learning effectiveness. The theoretical foundation

University of Education,Winneba http://ir.uew.edu.gh

for the cognitive theory of multimedia learning (CTML) draws from several cognitive theories including Baddeley's model of working memory, Paivio's dual coding theory, and Sweller's Theory of Cognitive Load. As a cognitive theory of learning, it falls under the larger framework of cognitive science and the information-processing model of cognition. The information processing model suggests several information stores (memory) that are governed by processes that convert stimuli to information (Moore et al., 2004).

Cognitive science studies the nature of the brain and how it learns by drawing from research in several areas including psychology, neuroscience, artificial intelligence, computer science, linguistics, philosophy, and biology. The term cognitive refers to perceiving and knowing. Cognitive scientists seek to understand mental processes such as perceiving, thinking, remembering, understanding language, and learning (Stillings et al., 2010). As such, cognitive science can provide powerful insight into human nature, and, more importantly, the potential of humans to develop more efficient methods using instructional technology (Sorden, 2005). The cognitive theory of multimedia learning (CTML) centres on the idea that learners attempt to build meaningful connections between words and pictures and that they learn more deeply than they could have with words or pictures alone (Mayer, 2009). According to CTML, one of the principle aims of multimedia instruction is to encourage the learner to build a coherent mental representation from the presented material. The learner's job is to make sense of the presented material as an active participant, ultimately constructing new knowledge.

University of Education,Winneba http://ir.uew.edu.gh

According to Mayer and Moreno (2009) and Mayer (2003), CTML is based on three assumptions: *the dual-channel assumption*, the *limited capacity assumption*, and the active processing assumption. The dual-channel assumption is that working memory has auditory and visual channels based on Baddeley's (1986) theory of working memory. Second, the limited capacity assumption is based on cognitive load theory (Sweller, 2007) and states that each subsystem of working memory has a limited capacity. The third assumption is the active processing assumption which suggests that people construct knowledge in meaningful ways when they pay attention to the relevant material, organize it into a coherent mental structure, and integrate it with their prior knowledge (Mayer, 2003). CTML accepts a model that includes three memory stores known as sensory memory, working memory, and long-term memory.

Sweller (2005), defines sensory memory as the cognitive structure that permits us to perceive new information, working memory as the cognitive structure in which we consciously process information, and long-term memory as the cognitive structure that stores our knowledge base. We are only conscious of information in long-term memory when it has been transferred to working memory. Mayer (2005a), states that sensory memory has a visual sensory memory that briefly holds pictures and printed text as visual images; and auditory memory that briefly holds spoken words and sounds as auditory images. Schnotz (2005), refers to sensory memory as sensory registers or sensory channels and points out that though we tend to view the dual channel sensors as eye to-visual working memory and ear-to-auditory working memory, other sensory channels can introduce information to working memory such as "reading" with the fingers through Braille or a deaf person being able to "hear" by reading lips. Working memory attends to or selects information from sensory memory for processing and integration. Sensory memory holds an exact sensory copy of what was presented for

University of Education,Winneba http://ir.uew.edu.gh

less than 0.25 of a second, while working memory holds a processed version of what was presented for generally less than thirty seconds and can process only a few pieces of material at any one time (Mayer 2014).

Long-term memory holds the entire store of a person's knowledge for an indefinite amount of time. Figure 1 is a representation of how memory works according to Mayer's cognitive theory of multimedia learning.

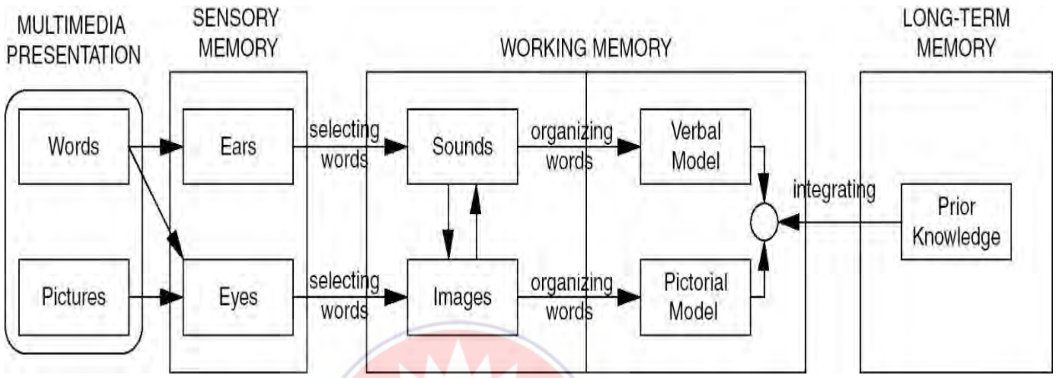


Figure 1: Mayer's cognitive theory of multimedia learning
Source: Adapted from Mayer and Moreno (2010a)

Mayer (2005a) states that there are also five forms of representation of words and pictures that occur as information is processed by memory. Each form represents a particular stage of processing in the three memory stores model of multimedia learning. The first form of representation is the words and pictures in the multimedia presentation itself. The second form is the acoustic representation (sounds) and iconic representation (images) in sensory memory. The third form is the sounds and images in working memory. The fourth form of representation is the verbal and pictorial models which are also found in working memory. The fifth form is prior knowledge, or *schemas*, which are stored in long-term memory. According to CTML, content knowledge is contained in schemas which are cognitive constructs that organize information for storage in long-term memory. Schemas organize simpler elements that can then act as elements in higher-order schemas. As learning occurs, increasingly

University of Education,Winneba http://ir.uew.edu.gh

sophisticated schemas are developed and learned procedures are transferred from controlled to automatic processing. Automation frees capacity in working memory for other functions. This process of developing increasingly complicated schemas that build on each other is also similar to the explanation given by Chi et al. (2012) for the transition from novice to expert in a domain. There is no single measurement instrument that is associated with CTML research. Mayer (2009), states that since the goal is to make a causal claim about instructional effectiveness, one of the most useful approaches in CTML research is quantitative experimental comparisons, with random assignment and experimental control being two important features. The main question in this type of research is whether a particular instructional method is effective. CTML researchers generally try to identify instructional methods that cause large effect sizes of .8 or greater across many different experimental comparisons. Learning is generally measured through tests of retention and transfer, and much of the recent research has focused on the instructional methods discussed earlier in this chapter. Because of its central role in CTML research, cognitive load theory research is also of interest. De Jong (2010), provides a lengthy criticism of the instruments and tests of measurement in cognitive load theory. He points out that one of the most frequently used methods for measuring CLT is self-reporting in a one-item questionnaire where learners indicate their perceived amount of mental effort. De Jong (2010) asserts that this approach often leads to inconsistency in the outcomes of studies that use this type of questionnaire. Another way that cognitive load has been measured is physiologically using indicators such as heart rate, blood pressure, and pupillary reactions. A third way of measuring cognitive load has been through the dual-task or secondary-task approach which indicates increased consumption of cognitive resources in the primary task when slower or inaccurate performance on the on secondary task occurs (Brünken et al.,

University of Education,Winneba http://ir.uew.edu.gh

2003). De Jong (2010) criticizes the measurement of cognitive load as a single construct, as most of these approaches tend to do. He calls for the development of better instruments and multidimensional scales that can reliably measure intrinsic, extraneous, and germane load separately.

2.2 Conceptual Framework

In Figure 2, the independent variables (CAI) are placed at the top in a rectangular box, with arrows pointing to the dependent variables (Students' performance, students' attitude, and active learning and students' engagement) below in a rectangular box. The intervening variables (Computer literacy, motivation, cognitive load and teacher experience) are shown in a circle connected to both the independent and dependent variables.

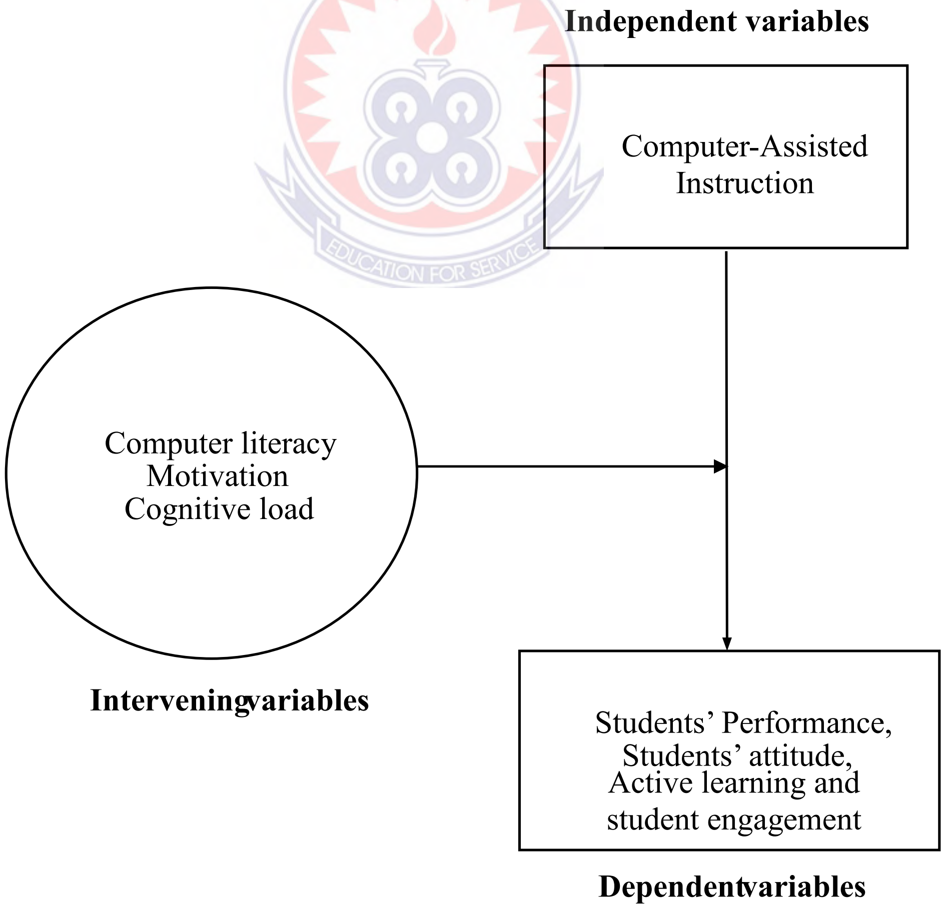


Figure 2: Conceptual framework of the study

University of Education,Winneba http://ir.uew.edu.gh

2.3 Computer-Assisted Instruction (CAI)

In 1967, the computer was used for the first time in the instruction of courses such as mathematics, languages, and social sciences (Aliasgari et al, 2010). In the late 1970s, "CAI" was developed and from then on, the computer was used directly in instruction activities (Aliasgari et al, 2010). Nowadays, the computer is used to practice and rehearse concepts, provide individual instruction through programmed learning, and simulate and personalize information in the process of instruction. On campus, data acquisition through the Internet and instruction and computer-assisted learning are considered among the basic skills of instructors and students (Gunn & Pitt, 2003). The computer has shifted students from memorizing concepts managed by a teacher to a stage of self-learning by the student (Aliasgari, 2010).

According to Gunn and Pitt (2003), the computer encourages the student to think about concepts. The use of a computer results in the active participation of learners in the process of instruction. Therefore, the student's attitude becomes more positive and the learning process more effective (Damoense, 2003).

According to Eze et al (2020), using a computer or computer system to display educational material is known as computer-assisted instruction (CAI)., the students and the available software and hardware. Most recent CAI software integrates features that encourage activities beyond the simple drill-and-practice, such as simulations, graphing and even modelling Eze et al (2020). According to Eze et al (2020), CAI is tutorials (drill and practice response-oriented interaction), problem-solving (laboratory and lecture exercises), simulation exercises (in lecture or laboratory settings), enrichment programs, remedial learning (continuous and repetitive), games (applications of problems or concepts) and testing (test banks with evaluation and

University of Education,Winneba http://ir.uew.edu.gh

analysis). According to Barot (2009), the computer provides immediate feedback letting students know of their achievements.

2.4 Generation

Generations were defined as a group of individuals, most of whom were the same approximate age, having similar ideas, problems, and attitudes, roughly differing from the next generation by 30 to 35 years of age. Ivanova and Smrikarov (2009) defined them as cohorts of people who were born in a certain date range and share a general cultural experience of the world. These cultural experiences were what defined Generation Z as people who were influenced by technologies such as the Internet, smartphones, and social networking sites. Their immediate predecessors included Generation X, individuals born between the mid-1960s and 1980 and Generation Y, individuals born between the mid-1980s and early 2000. Generation X was defined as those who were influenced by technologies such as cable television and video games (Jin et al, 2021). Generation Y was defined as those who were influenced by technologies such as the Internet, email, and text messaging (Jin et al, 2021). Having followed these two generations, the learners of Generation Z included students just entering high school born between 1996 and 2010. They were described as being technologically savvy, able to adapt to technology faster, more technology-focused and connected to the world via technology (Jin et al, 2021).

Generation Z's unique makeup called for a reform in education that strongly addressed their specific learning styles. The students must have been constantly stimulated by technology, and if they were not, they became uninterested in traditional grandfathered education (Jones et al., 2007). The traditional methods of teaching emphasized direct in-class instruction that was categorized as teacher-centred (Jin et al, 2021). There were five main styles of teaching used in the classroom: expert, formal authority, personal

University of Education,Winneba http://ir.uew.edu.gh

model, facilitator, and delegator (Jarvis, 2006). Twenty-first-century learners did learn through traditional methods of teaching but to increase the achievement of all learners, technology had to play a role. Stroller (2021) stated, our students have changed radically. Today's students are no longer the people our educational system was designed to teach. Today's students - K through college – represent the first generations to grow up with this new technology. It is now clear that as a result of this ubiquitous environment and the sheer volume of their interaction with it, today's students think and process information fundamentally differently from their predecessors. Prensky elaborated that today's students wanted to create using technology tools, work collaboratively with their peers, share class control, participate in decision-making, and necessitate a relevant education. He believed that by teaching students in the manner in which they have grown up learning, students would be more inclined or motivated to learn and thus an increase in achievement would occur. CAI had been identified as a motivating resource and thus the current study on CAI was conducted to determine the impact of CAI on achievement with its implementation into subjects beyond the core. Prensky said, "My preference for teaching Digital Natives is to invent computer games to do the job even for the most serious content.

After all, it's an idiom with which most of them are familiar". Szymkowiak et al (2021) further added to the discussion about Generation Z with their belief that technology was the most powerful way to increase teaching and learning in the classroom. Bowen said, "Technology can give students more and better interaction with course content" By using new technology, student engagement outside of the classroom could have increased and allowed for more time in class for human interaction (Szymkowiak et al, 2021) He said, "The best gift of new technologies is the ability to leave the tyranny of content online and focus class time on student learning" (Szymkowiak et al, 2021).

University of Education,Winneba http://ir.uew.edu.gh

With the use of computers in education came a change over time in the actual process of using computers in education.

2.5 Role of Computer Technologies in Education

The impacts of computer use on student success, attitudes, and other factors including learning rate were the subject of extensive research in the 1970s, 1980s, and early 1990s. This research covers a wide range of topics, from computerized learning activities which supplement conventional instruction, to computer programming, computerized record keeping, the development of databases, writing using word processors, and other applications. Research on the effects of computer usage on a large number of outcome areas was conducted, including, mathematics, language, arts, reading, science, problem-solving skills, and health and social studies. Well-designed and implemented tutorial CAI, used as a supplement to traditional instruction, produces an educationally significant improvement in students' final examination achievement (Chaudhari, 2013). When a teacher in the classroom applies this creative ability to use computers, enormous possibilities do exist for maximum learning. After studying more than 30 researches, (Chaudhari, 2013). concluded that compared to students receiving only traditional, teacher-direct instruction, students who had teacher instruction supplemented by CA were found to learn faster and had better retention rates. They also improved their attitudes toward school and their potential as learners. Effectiveness of CAI concerning different subjects like Science, and Mathematics; CAI was found effective in terms of students' achievement at the school level. It is worth noting that CAI was effective not only for effective dimensions such as attitude, interest, and behaviour patterns. Although a large majority of the studies have reported that higher attitude in different subjects at the secondary level is needed but was mainly confined to the science subjects. Effective use of computers in education emphasized

University of Education,Winneba http://ir.uew.edu.gh

for the last 30 years but most of the studies were carried out mainly in foreign countries and as the demand for CAI accelerated in India, studies were carried out during 1990 in India also (1998) developed software for Chemistry teaching and further studied the effectiveness of CAI on student's achievement. Chaudhari (2013). Worked on Science teaching through CAI and concluded that thoughtfully designed CAI is indeed effective in bringing about learning, but when the teacher is really good, a few students prefer traditional face-to-face teaching to CAI. The packages when used in the self-learning/group learning mode can be a better alternative to ineffective teaching.

According to Pilli and Aksu (2013), computer applications in teaching and learning can be classified as an object of instruction, a tool, an instructional device and a means of teaching logical thinking. Pilli and Aksu (2013) continued by saying that the computer may itself be the object of the instrument with which students interact as a key element of the learning process. In their view, students enjoy the use of computers to complete exercises and view materials on a computer screen rather than receiving information from written material or an instructor's presentation. Also, in its role as a tool, Lai et al (2012) in an interview assert that computer technology such as calculators, typewriters and presentation aids can be leveraged to assist both teachers and students in the classroom and this well makes a significant impact in teaching and learning. Lai et al (2012) further explained that in a class of about forty students, it is important for all the students to ask questions which cannot be done at go, but with the use of instant messaging tools, forty Windows can be opened for forty students which enable the teacher to see the thinking of the students. They continued to explain that children also get more excited when they learn with tools they are very good at using like computers.

University of Education,Winneba http://ir.uew.edu.gh

Bello (2022) defined computer-assisted instruction as a program of instructional material presented using a computer or computer system. Costa et al. (2008) submitted that computer-based instruction (CBI) enables students to learn by self-evaluating and reflecting on their learning process. Treboukhina et al. (2023) continued to assert that CBI is the broadest term and can refer to virtually any kind of computer use in the education setting, including drill and practice, tutorials, simulations instructional management, supplement exercise, programming, database development, writing using processors, and other applications. They emphasized that CAI motivates children to learn better by providing them with immediate feedback and reinforcement and also creates an exciting and interesting game-like environment.

2.6 Learning through Instructional Technologies

According to Moore (2014) "instructional technologies" referred to tools and resources used in teaching and learning. It includes hardware like blackboards, radio, television, tape recorders, videotapes and recorders and projectors; and, software like transparencies, films, slides, teacher-made diagrams, real objects, cartoons, models, maps and photographs. Similarly, Scanlan (2012) indicated that instructional technology encompasses all the materials and physical means an instructor might use to implement instruction and facilitate students' achievement of instructional objectives. This may include traditional materials such as chalkboards, handouts, flip charts, slides, overheads, real objects, and videotape or film, as well newer materials and methods such as computers, DVDs, CD-ROMs, the Internet, and interactive video conferencing.

University of Education,Winneba http://ir.uew.edu.gh

Subair and Talabi (2015) asserted that instructional technologies are generally designed to provide realistic images and substitute experiences to reach curriculum experiences. The technologies are considered the most efficient facilitators in the education set-up. They are not substitutes for the teacher. Their use, however, calls for an imaginative approach by the teacher who needs to constantly be on the alert for new ideas and techniques to make the lessons presented with different instructional technologies achieve effective outcomes.

According to Subair and Talabi (2015), some devices are designed to present information of a kind that would not be available in an ordinary school experience. Examples include films, television, and sound recordings. Other types of instructional technologies have the function to help the pupil grasp the underlying structure of a phenomenon. Visual media are primarily for seeing, audio devices for hearing, and multi-sensory materials for use via two or more senses.

Subair and Talabi (2015) held the view that instructional technologies are the various materials that appeal to the five senses- seeing, hearing, touching, feeling and tasting which enhances teaching and learning. Walson and Okanu-Igwela (2019) also identified instructional technologies as devices of hardware (equipment) and software (consumables) through which the learning process may be ensured and carried out. In other words, they are the collection of materials and equipment that can be used effectively for communication. These materials are used in the planning process of giving instruction. Instructional technologies with their various types affect different senses and act as an integral part of the teaching and learning process, thus helping to bring about meaningful experiences. In this study, instructional technology refers to videos, projectors and computers in addition to the chalkboard and flip charts that are brought to the teaching and learning process to induce understanding.

University of Education,Winneba http://ir.uew.edu.gh

2.7 Development of CAI

According to Chaudhari (2013), a teacher can develop a CAI by following the following process:

- ***Identify the Problem Area***

Select the Unit area where students are having problems and there is a requirement to develop CAI.

- ***Design-Specific Objectives***

After identifying the problem, design objectives related to the problem.

- ***Develop CAI Programme***

After completion of the program material, it should be programmed through the Computer Software for converting it into CAI. Different software are used are Microsoft Office Flash, Corel Draw, Page Maker and many other graphical software. The most commonly used software is PowerPoint. For the first time, Teachers can easily modify and even produce their own CAI material based on the needs of their classes Chaudhari (2013), Chaudhari (2013), worked on A Quick Guide for Computer-Assisted Instruction in Computational Biology and Bioinformatics and gave the following Guidelines when developing computer-assisted instructions:

- Ensure that CAI activities are integrated into the curriculum.
- Do not overuse CAI
- Plan for use of CAI well-adjusted to infrastructure and resources available
- Maximize interactivity
- Allow different rates of progression in class, but ensure that all students reach the objectives
- Ensure students understand the scope and objectives of assignments
- Be sure students understand the models presented on the screen
- Assess and evaluate student performance while using CAI,

University of Education,Winneba http://ir.uew.edu.gh

2.8 The Use of Instructional Technologies

The place of instructional technology in the teaching and learning process is undoubtedly essential. Scanlan and Lopez (2012) assert that instructional technologies are used whenever, in the best judgment of the teacher, they facilitate learning or increase understanding of the material being presented. Under this heading the following subheadings have been reviewed: Instructional technologies for motivation, for capturing students' attention and for explaining concepts.

2.9 Instructional Technologies for Motivation

Student engagement in the learning environment should be the aim or objective pursued in the educational field, according to Charles and Senter (2002). Teachers work hard to arouse this passion in their pupils so they will actively participate in class activities and have a thorough comprehension of the ideas being covered. There are two types of motivation: intrinsic and extrinsic.

Intrinsic motivation is important to students and teachers because of its effect on learning outcomes. Motivation is a significant predictor of academic performance which leads to the conclusion that intrinsic motivation is a major factor in determining academic success (Wilson & Corpus 2005). If intrinsic motivation is beneficial to student learning outcomes, then it stands to reason that educators should strive to cultivate and enhance the intrinsic motivation of students. Charles and Senter (2002) contended that when teachers speak of motivation as a component of a lesson, they refer to what they do to attract students' interest and engage them more or less willingly in the work provided. According to them, the use of technologies, which students can easily manipulate to obtain a required end product, can generate the desire to learn and

University of Education,Winneba http://ir.uew.edu.gh

do more. Resources that students can associate with their everyday life also help to generate that desire to do more.

2.9.1 Instructional technologies for capturing students' attention

Capturing the imagination and attention of today's students requires fresh approaches to teaching and learning. Perhaps this is one of the reasons why educators are turning to the use of technological devices to involve students more actively in learning.

Instructional technologies capture and sustain students' curiosity and attention throughout their lessons. Williams (2002) noted that the use of the overhead projector enables the teacher to maintain complete classroom control and interest in a lesson. This control is likely to be effective when the teacher wants to direct the student's attention either to the technology being used, the information being displayed by the technology, or to the teacher. By switching on the overhead projector, the students" attention is directed to the information being displayed and to the teacher when the overhead projector is switched off (Williams, 2002). This ability to direct students' attention may help to maintain their concentration either on the information being displayed or on the explanation being given by the teacher when the overhead projector is switched off. This concentration by the students on what is going on might help them to follow the lesson and learn whatever concepts are being explained. Such attention also could help teachers become aware of the readiness of students to understand what is being taught.

2.9.2 Instructional technologies for explaining concepts

The teacher can explain concepts that would be difficult to elaborate on orally using instructional technologies. When students see the material, its mechanism, and its function, teachers may be saved the hard explanation and students easily understand

University of Education,Winneba http://ir.uew.edu.gh

what the teacher is talking about. In addition, instructional technologies help pupils acquire listening and observational skills that assist in their understanding of complex concepts. About the use of videos, Kessler (2018) noted that the use of technology makes possible increased individualized instructional opportunities which enable the teacher to have adequate spare time for the preparation of instruction that will meet the needs of the learners. When teachers use technologies in their teaching and students are involved in the use of those technologies and notice the relationship and relevance of what the teacher is teaching and the technologies being used, the student's attitudes towards learning get improved, and that prepares them for the technologically oriented society (Kessler, 2018). The review on this has significantly directed the researcher as to what pertains.

2.10 Benefits of Effective Use of CAI

- ***Self-paced learning opportunities***

Learners can learn the content as per their capacity and can repeat the task if not understood by the learner (Barot, 2009).

- ***Immediate feedback to the student and the instructor***

Immediate feedback motivates the learner and gives direction and if the answer the student is wrong then it will help him to correct his mistake (Barot, 2009).

- ***Automatic adjustment to ability levels of students***

CAI programs design in such a way that it helps both brilliant students as well as slow learner. It is flexible as per user‘s need (Barot, 2009).

- ***Continuous interaction***

Continuous interaction should be possible with CAI (Barot, 2009).

University of Education,Winneba http://ir.uew.edu.gh

- ***Flexible time scheduling for the students and the instruction***

Programmes have flexibility in terms of time, place and pace (Barot, 2009; Yusuf, 2010).

2.11 Computer-Assisted Instruction and Chemistry Teaching

Chemistry is one of the most important subjects in science and contains several abstract concepts requiring complex concepts many of which are not applicable outside the classroom (Stieff & Wilensky, 2003) For this reason, students view chemistry as one of the most difficult subjects to study at all levels of schooling. Chemistry knowledge is represented by scientists at three levels; the macroscopic, the submicroscopic and the symbolic (Taber, 2013). Because interactions between molecules and atoms occur at a submicroscopic level, chemists refer to the objects and processes which they cannot observe directly at a symbolic level (Stieff & Wilensky, 2003). Understanding chemistry at a sophisticated level necessitates students being able to make connections or relations among the levels. However, research suggests that students have difficulties understanding the submicroscopic and symbolic levels. Concepts such as the particulate nature of matter, physical and chemical change, chemical equilibrium, solutions, acids and bases, chemical bonding, and conservation of mass are topics that students have difficulties visualizing at the submicroscopic level. Over the last two decades, a great deal of educational research has been conducted to determine students' alternative conceptions and difficulties in chemistry. Some current research has sought to investigate the underlying causes of difficulties students have when dealing with complex topics, and this research also seeks to develop curricula to help students overcome these difficulties (Heikkinen, 2011). Despite much research and curriculum development, it seems students still do not adequately learn many chemistry concepts (Heikkinen, 2011). The effectiveness of new and alternative teaching methods of

University of Education,Winneba http://ir.uew.edu.gh

teaching chemistry concepts has been the subject of intensive investigation and ever since educators first began to use computers in the classroom, researchers have tried to evaluate whether the use of educational technology had a significant impact on student achievement (Papanastasiou et al., 2003) In the chemistry education literature, there have been numerous studies reported positive effects of the use of computers on student achievement(Yu, 2021). Such studies suggest that the use of computer simulations is successful in promoting positive attitudes toward science and in particular that students' motivation is enhanced by cooperative learning involving student-computer within a variety of learning environments (Zacharia, 2003). Computer-assisted curricula also provide opportunities for inquiry-based approaches to the teaching of chemistry, and it seems they discourage rote memorization and algorithmic problem-solving while encouraging conceptual understanding and critical thinking (Lutviana et al, 2019). For this reason, many educators now advocate the use of computers in chemistry classrooms (Barnea, 2000), and computer assisted learning environments attempt to make explicit the information embedded in traditional molecular representations as well as to provide a visual representation of molecular interactions for students. In this way, students can learn chemistry by viewing molecular animations side-by-side with graphical output and chemical formulae. Such an approach is in contrast to traditional chemistry lectures that rely almost entirely on the verbal explanation of concepts meaning students have little opportunity to observe molecular interactions (Stieff & Wilensky, 2003). Research suggests that the use of computer-simulated experiments (CSE) together with a problem-solving approach has a positive effect on students' chemistry achievement, science process skills, and attitude toward chemistry at the high school level (Özmen, 2008). The results showed that the computer-simulated experiment approach and the problem-solving approach produced

University of Education,Winneba http://ir.uew.edu.gh

a significantly greater achievement in chemistry and that the use of integrated video media (Huppert, 2002) also enhances students' achievement and attitude toward chemistry. The particular way in which different levels of information are presented by such technologies – microcomputer-based laboratories, pH meters, or chemical indicators, influenced secondary students' understanding of acid, base, and pH concepts – also may be influential (Nakhleh & Krajcik, 2010). Recent researches show that computerized molecular modelling improves tenth-grade students' spatial ability, understanding of new concepts and achievement of structure and bonding (Barnea, 2000). Likewise, computer animations together with a conceptual change approach are reported to help students understand that electrons do not travel through aqueous solutions Ozmen (2008) when employing computer animations of chemical reactions at the molecular level. Hence, a key feature of such CAI teaching is that it helps students visualize what is happening at the molecular level. This also applies even to more complex systems such as ion formation and solution chemistry (Ebenezer, 2001) where animations in a hypermedia environment enable students to visualize that melting is different from dissolving, how ions are formed, and how hydration takes place. It is a key feature that students can interact with concepts when using CAI. So for example, interactive simulations using modelling and simulation packages for teaching chemical equilibrium helped shift students from memorizing facts to attempting to explain chemical equilibrium and solve chemical equilibrium problems with an overall stronger attempt made at conceptual understanding and logical reasoning (Stieff & Wilensky, 2003). It seems that using a CAI tutorial program as a supplement to the classroom results in significantly higher achievement at the knowledge, comprehension, and application levels. Likewise, Williamson and Abraham (1995) report computer animations about the particulate nature of matter for

University of Education,Winneba http://ir.uew.edu.gh

college students' understanding of chemical phenomena such as solutions, ions, phase transitions, precipitation, and dissolving result in higher achievement in evaluation tests (Ozmen, 2008). The studies related to the comparison between computer-assisted instruction and traditional instruction show that technology-based instruction strategies are more effective than traditional ones. For example, Morgil (2005) conducted a study with secondary school students to find out the effects of the computer on attitudes, motivation and learning, the possible advantages of computer-assisted test programs. Students were distributed into control and experimental groups and the assessment of the experimental group was done by using computers, whereas that of the control group was done through the written test. The statistical evaluations showed a higher achievement rate for the experimental group that received a computer-assisted test. In another study, Ertepınar (1995) tried to determine the effects of the two different teaching methods involving logical thinking skills, computer assisted instruction and students' portfolios on the achievements of high school chemistry students. The results of the study showed that the application of two methods and the logical thinking skills of the students had a significant contribution to the achievement of the students in chemistry. O'zmen and Kolomuc¸ (2004) investigated the effect of computer-assisted instruction on tenth-grade students' achievement in solution concepts. They found that the experimental group that took computer-assisted instruction had a better understanding than the control group that was given traditional instruction. Recently, Morgil (2005) compared traditional and computer-assisted learning in teaching acids and bases. At the end of the study, they found that there was a significant difference favouring the experimental group. These results show that CAI together with learner-centered teaching approaches is more effective in terms of student achievement and attitude than traditional learning strategies. In another study, Talib, Matthews, and

University of Education,Winneba http://ir.uew.edu.gh

Secombe (2005) investigated the effect of computer animated instruction on students' conceptual change in electrochemistry, qualitatively. The preliminary results of the study showed that targeted conceptions were more intelligible and plausible to the subjects in the experimental group in comparison to their counterpart in the control group. A particularly active area of research for remedying students' alternative conceptions is chemical bonding. Chemical bonding is one of the most important topics in undergraduate chemistry and the topic involves the use of a variety of models varying from simple analogical models to sophisticated abstract models possessing considerable mathematical complexity (Coll & Taylor, 2002; Coll & Treagust, 2003). It is also a topic that students commonly find problematic and develop a wide range of alternative conceptions. The concepts of the electron, ionization energy, electronegativity, bonding, geometry, molecular structure, and stability are central to much of chemistry, from reactivity in organic chemistry to spectroscopy in analytical chemistry (Nicoll, 2001). It also important for students to grasp these concepts in understanding why and how chemical bonds occur. In the science education literature, there have been numerous studies to determine students' understanding and misconceptions about chemical bonding (Coll & Taylor, 2002) These studies have revealed prevalent and consistent misconceptions across a range of ages and cultural settings and the results of these studies show that students at all levels do not learn chemical bonding with traditional teaching methods as expected. Ozmen (2004) has reviewed and collected some of the most important alternative conceptions determined in these studies. Identification and remediation of alternative conceptions are an important part of the learning process meaning teachers need to be aware of their students' existing ideas that might need to be challenged. It is reported that in many cases science learning difficulties occur because students' conceptions are not taken

University of Education,Winneba http://ir.uew.edu.gh

into account, and therefore communication barriers between teachers and learners may not be overcome. The literature also notes that student alternative conceptions are stable and highly resistant to change by traditional teaching methods. This suggests that alternative teaching methods are required to remedy non-scientific beliefs. Although in Turkey for more than a decade, studies have been conducted on teaching chemistry concepts, no systematic studies have been undertaken to explore if CAI has any significant impact on students' learning and achievement about chemical bonding. It is widely reported that computerized training contributes to the development of the visualization skills of students (Barnea, 2000). It is possible in a computer simulation program to create animated colour graphic images capable of presenting the nature of the chemical bonding through computer simulations that may be difficult to achieve when using traditional chalkboard drawings. Studying in a CAI environment means students have opportunities to internalize concepts related to chemical bonding through active participation in the enriched learning environment. This forms the basis for the present study which was designed to examine: (i) achievement, (ii) attitude changes for secondary chemistry students exposed to computer-assisted instruction and (iii) the effect of CAI in the remediation of the misconceptions was investigated thirdly.

2.12 Application of CAI in Teaching and Naming Hydrocarbons

In the design of hydrocarbons CAI courseware, choosing appropriate pictures and marking are helpful for students to observe the details of action (Liu, 2019). Through animation design to show the structure, sequence, image and essentials of the naming action, it can more concretely and intuitively reflect the technical characteristics and difficulties of the action, help students from perceptual knowledge to rational knowledge, so as to better imitate and form the correct action image (Liu, 2019).

University of Education,Winneba http://ir.uew.edu.gh

Appropriate Teaching Videos can help students break through learning difficulties**.** For instance, a non-linear video editing software could be used to make full use of students' vision and hearing to form action images, clarify the technical structure and essentials of action, and establish a complete technical concept. It is helpful for students to learn and master naming skills, and improve hydrocarbons naming skills, and cultivate the ability of continuous hydrocarbon naming (Liu, 2019). Video broadcast of naming helps students to master the whole of naming of organic compounds (Liu, 2019).

2.13 Concept of Attitude

The word "attitude" has been defined by many scientists around the world. They all come to the same conclusion that attitudes toward science are viewed as a combination of individual values, feelings, and beliefs toward science (Hacieminoglu, 2016). Similarly, attitudes are the act of feeling or thinking either positively or negatively toward something in the environment (George, 2000). Attitudes are feelings of "like or dislike of an object, person, or an event that characterizes a human being (Heng & Karpudewan, 2015). Moreover, attitudes are considered outcomes that can be acquired during the learning process (George, 2000). Therefore, students' attitudes change in their learning process either directly or indirectly through observation, experiences, and the learning environment. Hence the change in attitude is mostly influenced by teachers, parents, peers' characteristics, and the classroom environment.

(George, 2000).

2.14 Impact of CAI on Students' Attitude

A study conducted by Antwi et al (2015) investigated the effect of computer-assisted instruction (IWebP) on SHS students' interests and attitudes towards some selected concepts of Electricity and Magnetism. The study involved a whole class of Form Two

University of Education,Winneba http://ir.uew.edu.gh

Home Economics students in a Ghanaian Senior High School, selected through purposive and convenience sampling techniques, totalling 48 students (46 girls and 2 boys). The students were taken through a series of Interactive Webquest Packages (IWebP) developed by the researchers with the help of software from SMART Technologies. Data was collected through the use of the Students' Observation Checklist (SOC) and Questionnaire on students' attitude towards the teaching and learning of electricity and magnetism (Physics). The findings from the SOC and the Questionnaire indicated that students' interest was highly developed and also showed positive attitude towards the teaching and learning of physics with computer-assisted instruction. A study conducted by Ozmen (2008) examined the effect of computer-assisted instruction on conceptual understanding of chemical bonding and attitude grade students; 25 in an experimental and 25 in a control group. The Chemical Bonding Achievement Test (CBAT) consisting of 15 two-tier questions and the Chemistry Attitude Scale (CAS) consisting of 25 items were the principal data collection tools used. The CBAT and CAS instruments were administered in the form of a pre-test and post-test. Analyses of the scores of the two groups in the post-test were compared and a statistically significant difference was found between groups in favour of the experimental group. It also seems students from the experimental group were more successful than the control group students in the remediation of alternative conceptions. The results of this study suggest that teaching-learning of topics in chemistry related to chemical bonding can be improved by the use of computer-assisted teaching materials.

2.15 Concept of Academic Performance

The impacts of poor academic performance in Ghana have been of much concern to all educational stakeholders. The impact is that it has led to a fallen standard of education in the central region and Ghana as a whole. Students' academic performance is an

University of Education,Winneba http://ir.uew.edu.gh

objective score of attainment after a specified instructional program. Academic performance is seen as the knowledge attained or skills shown in the school subject. To indicate such achievement, test scores or marks are assigned by the teachers. It is the institutional evaluation of the classroom work based on the grades awarded. Academic performance according to Bolarinwa. (2020) is of two categories that is positive (good) and negative (poor) performance.

Academic performance as a variable in students' learning has been an area of concern in present-day research. Dibal et al (2022) defined academic performance as the exhibition of knowledge acquired or skills developed by students in school subjects. It is the degree of performance in the subject as exhibited by a student. Academic performance is the exhibition of knowledge attained or skills developed by students in the school subject usually designed by test scores or by marks assigned by teachers which can be low or high. Academic performance means how well one does in school. Poor grades are considered bad academic performance.

Academic performance refers to what skills the student has learned and is usually measured through assessments like achievement tests, performance assessments and portfolio assessments (Mlyakado & Timothy, 2014). The assessment provides information on the anecdotal report of the student`s academic performance over a given period. The academic performance which is measured by the examination results is one of the main objectives of the school. The academic performance involves three concepts; the ability to study, retain and recall facts, being able to study effectively and see how facts fit together and form larger patterns of knowledge and being able to think for yourself about facts and thirdly, being able to communicate (Coulson, 2008). According to Amaechin and Ezeh. (2019) is the level of performance attained via the combination of inputs from students' motivation and conduct. Adediwura and Tayo

University of Education,Winneba http://ir.uew.edu.gh

(2007) asserted that academic performance is generally referred to how well a pupil is accomplishing his or her tasks and studies, but there are quite several factors that determine the level and quality of pupils` academic performance. This no doubt supports the view of Nicholas (2004) that the most current information on improving academic performance shows that there are three conditional influences linked to levels of academic performance among school pupils.

These influences according to the information include:

- High-quality parenting (the degree to which a young star is provided with an enriched, warm and responsive learning and home environment)
- High-quality child-care environments (stimulating activity and nurturing as reflected in high-quality parenting)
- High-quality first-grade classrooms (with a focus on literacy instruction, evaluative feedback, instructional conversation, and encouraging child responsibilities).

Academic performance Index (2013), revealed that academic performance is how students deal with their studies and responsibilities given to them by their teachers. Kubey et al (2001) gives an objective definition of the term academic performance as traditionally used, the term academic performance refers to some method of stating or expressing a student's academic rank. Generally, this is a grade for a particular subject area or an average for all subjects expressed on a 0-to-100 or other quantitative scale. Ahmodu et al (2022), noted that academic standard refers to what students should be able to know and be able to do. It should provide explicit expectations for students at each grade level along with an explicit description of the content knowledge and academic skills that are required. Also, Sibandze et al (2020) noted that academic performance is the actual performance of students in academic subjects and basic

University of Education,Winneba http://ir.uew.edu.gh

knowledge Sibandze et al (2020), opined that the outcome of the examination results will determine who gets promoted to the next class or otherwise. Nurudeen et al (2023) defined academic performance as the students' level of attainment in the grade point average of subjects offered in his/her year examination. Adefila (2004) had written answers to graded questions or exercises in one of the most popular, reliable and convenient methods of assessing students' progress and achievement. He further asserted that questions and exercises reflect the content of the lesson and help considerably towards objective assessment of the students' academic output Olatunji et al (2016), stated that the students' academic performance is germane to their performance in academic endeavours. He asserts that students' academic performance is a measure of how well they have mastered the learning tasks presented to them the way they handle controversial issues and pass relevant judgment and the level at which they pass examination. In the same vein, Sibandze et al (2020), asserted that students' academic performance is the main focus of overall educational performance. Academic performance is referred to as educational outcome. It is a yardstick used to determine how far a student has mastered a subject of study within a given period. Academic performance is a viable tool that can be used to determine and predict the standard of any educational system in Nigeria in terms of its efficiency and effectiveness. It portrays the quality of education offered in Ghana.

2.16 Measurement of Academic Performance

Determining academic performance serves as a source of motivation for students` learning. Students are encouraged to learn more seriously when they know that their learning will be evaluated and when they realize that their efforts and performances are being recognized. Kirschner and Karpinski (2010), asserted that evaluation or determination of academic performance is concerned more fundamentally with

University of Education,Winneba http://ir.uew.edu.gh

deciding on the value or executed worthwhile of a learning process as well as the effectiveness with which it is been. He maintains that usually two basic areas are evaluated. First is the academic performance of the students about the philosophy and objectives of the education he/she is receiving. The second is how well the curriculum goals are been realized for the level of education. Evaluation is the systematic process of determining the extent to which instructional objectives are achieved by students. Consequently, examination results and the teacher`s judgment are used to categorize or classify students. Irreversibly decisions are made regarding the students` worth and their future in the educational system. By this system of categorizing students, some are made to feel that they are deficient, performing low academically, while others feel that they are able, good and desirable academically. This labelling of individuals may likely have some unfavourable influence on a person` self-concept.

This is basically what teachers do when they set tests or give assignments. This is the main job of examination bodies like the WAEC etc. Yusuf (2012) described evaluation as the collection and use of information as a basis for rational decision-making on the subject topics which need to be improved, or modified. It is a quality control exercise to ensure that resources are used maximally. The process will indeed yield information regarding the worthiness, appropriateness, and validity of something for which a reliable measurement or assessment has been made.

However, various assessment or measurement tools and techniques may be used in evaluating or determining the teaching-learning process as well as the outcomes associated with it. Yusuf (2012) has identified the following instruments to be used in evaluating the teaching-learning process:

1) test 2) observation 3) project 4) questionnaire 5) interview 6) checklist 7) sociometric technique or sociometry.

University of Education,Winneba http://ir.uew.edu.gh

Alabi (2011) asserted that test is an important aspect of the educational process. It is the stage at which the students` knowledge, skill, ability and competencies are assessed, and judgment is made about such performance. The outcomes of such judgment are used in diagnosing as well as placement of students. Kobiowu and Alao (2010) defined a test as the assessment of a person`s performance when confronted with a series of questions, problems, or tasks set for him/her To ascertain the amount of knowledge that he has acquired, the extent to which he/she can utilize it, or the quality and effectiveness of the skills he has developed. Scott (2001) stated that measuring academic performance can occur at multiple levels and serves multiple purposes. For example, classroom -teachers often conduct formative and summative tests to evaluate students` mastery of course content and provide grades for students and parents. States tests are designed primarily to measure progress at the school and school level.

Megan (2011) suggested that standardised observational assessment can guide teachers and administrators in promoting effective teaching and learning, enhancing students' social and academic development as well as assessing their level of academic outcomes. Centre for American progress (CAP) advanced that students` performance can be measured through administrating achievement tests, analyzing stated testing results, using informal surveys to measure academic achievement and looking at grade reports.

Accurately measuring academic performance is an important part of planning for a child’s education. However, no one source of information should be used to assess academic performance. A student may demonstrate knowledge of one instrument and not of another. Using good strategies to assess academic performance from multiple

University of Education,Winneba http://ir.uew.edu.gh

sources will ensure good information and the best possible educational planning. The academic performance of students can also be measured in the following ways:

a. **Administer a standardized achievement test:** A standardized test has to be given by someone who meets the qualifications required in the testing manual. Usually, that is a person who has coursework in administering that type of assessment. Standardized achievement tests compare the students being tested with the average student of the same age in a sample of students across the country. The advantage of these types of standardized tests is that they are well-researched and usually have pretty good validity and reliability. The disadvantage is that they do not tell where that child is at given what they have been taught in their classroom in their school district

b. **Analyze test results:** Each country chooses its own standardized test to measure achievement and each defines its level of proficiency on that test. However, a student could have guessed well on the test or they could have had a bad day on the day of the test. This is one good way of telling what a student has learned but it should be considered along with other sources of information (Lavin, 2006)

c. **Use informal surveys to measure academic performance:** Teacher surveys based on what has been taught in the classroom can be a good indicator of academic achievement. These are sometimes included in textbooks or they can easily be made up. They are a good tool to use to see what has been learned, what has been retained over time, and what has not been mastered and needs to be re- taught.

d. **Look at grade reports:** Grades are one tool to use to measure academic performance. They are a great indicator of academic success and short- term

University of Education,Winneba http://ir.uew.edu.gh

> learning. However, grades do not necessarily measure long –term learning or mastery. For example, some students may do well on tests because they can memorize information and relate it at test time. However, it may be questionable if it was actual learning if they forget it right after the test and cannot demonstrate that knowledge at a later time. Grades are partially based on short-term knowledge that comes from weekly tests and homework, and only part of the grades is more long-term knowledge (Lavin, 2006).

In educational institutions, success is measured by academic performance or how well a student meets standards set out by the local or central government and the institution itself. As career competition grows ever fiercer in the working world, the importance of students doing well in school has caught the attention of parents, legislators, and government education departments alike (Udoh & Ajala, 2005). Academic performance is what you have shown you can do in a certain subject. Ability is what you can do in an ideal circumstance. You can think of it as being internal and hidden until you show what you can do with your performance. Academic achievement or (academic) performance is the outcome of education. It is the extent to which a student, teacher or institution has achieved their educational goals. The tracking of academic performance fulfils several purposes. Areas of achievement and failure in a student's academic career need to be evaluated to foster improvement and make full use of the learning process. Results provide a framework for talking about how students fare in school and a constant standard to which all students are held. Performance results also allow students to be ranked and sorted on a scale that is numerically obvious minimizing complaints by holding teachers and schools accountable for the components of every grade. According to Von- Stumm et al. (2011), academic performance is the outcome of education, the extent to which a student, teacher or

University of Education,Winneba http://ir.uew.edu.gh

institution has achieved their educational goals. Academic performance is commonly measured by examinations or continuous assessments or the Cumulative Grade Point Average (CGPA) of students.

Popoola, (2010) defined academic performance as an expression used to present a student scholastic standing and which is a function of various factors such as the method of teaching, teachers' qualifications, child's home background, school environment, attitude, and interest among others. Academic performance is an objective score of attainment after a specific instructional programmed. (Yara & Tunde-Yara, 2010).

2.17 Conceptual Understanding of Students in Organic Chemistry

Students' conceptual understanding of organic chemistry has invaluable implications for chemistry teaching and learning in schools in Ghana and the entire world. Chemistry teachers will get insight from this review and plan for organic chemistry instruction considering students' prior knowledge, knowing areas where students have difficulties about the topic and engaging innovative teaching strategies that enable students to be active in the process of teaching and learning, interact with peers, enjoy practical experiences that may improve their discoveries. Students should not be treated as empty vessels or blank slates on the contrary, learning activities should be related to their prior knowledge and interests, and emphasize understandable material to enhance students' productive thinking. The use of the self-explanatory textbook (conceptual textbook) containing common students 'conceptions in organic chemistry and their corresponding correct explanations can help students be aware of possible conceptions. Teachers need to have sufficient knowledge of the subject content that enables them to enhance students' conceptions and lead them to a brighter scientific future.

University of Education,Winneba http://ir.uew.edu.gh

For the maximization of students' conceptions about organic chemistry, cooperative learning models such as the think-pair-share approach; Jigsaw approaches, reverse jigsaw, reciprocal peer teaching approach, Student Terms- Achievement Divisions (STAD),Think-Aloud Pair Problem Solving Approach (TAPPSA); group grid approach; group writing assignment approach, base group learning, numbered head together and many other different innovative teaching strategies are recommended to apply in organic chemistry instruction. There is a need for further research on instructional methods to improve students' conceptual understanding of organic chemistry and other chemistry topic. It may be a product of some intuitive re-appraisal. It could be concrete, abstract or even blurred. Pella (1977) in Adamu (2016) defined concepts as a summary of the essential characteristics of a group of ideas. Basically, in science, there are instances where the ideas in the mind of individuals may be different from what is scientifically correct (Sani, 2016). What is of great concern about conceptions is that individuals continue to build knowledge on their current understanding which may have a positive impact on future learning. The study of conception has generated considerable interest among science educators such that it is essential for a successful teaching and learning interplay. Various authorities have different views on what conception is, for instance, Sani (2016), described conception as personal constructions, which are formed on what an individual feel or sees. These experiences have a profound effect on the learner's willingness and ability to accept other more scientifically grounded explanations of how the world works. They opined also that conceptions are proven beliefs or views of scientific principles or notions about certain scientific ideas. Chiu and Hui (2005) agreed that students do not grasp fundamental ideas covered in classroom teaching instructions. Even some of the best students give the right answers but only using correctly memorized words.

University of Education,Winneba http://ir.uew.edu.gh

Prominent among the factors that have been identified to be responsible for these conceptions is a method of instruction, proper exposure to laboratory activities, organizational skills and adequate exposure to problem-solving procedures among others (Sani, 2016). It is acknowledged that learners actively select information and also construct it for them to learn meaningfully. All existing knowledge, including concepts and information processing strategies, play a vital role in shaping learning outcomes because they influence new stimuli and the subsequent generation of meaning. As learning is a personal construct there is the likelihood that some constructions will be erroneous and consequently may adversely affect subsequent learning. Identification of these misconceptions will be the first step in trying to look for a way to remedy them. It has been shown that if the right approach or method is used in teaching organic chemistry, the problem of misconception can be minimized (Heeman, 2015; Bryan, 2007). A student who has a partial understanding of a concept or misconception will likely resort to rote learning. In contrast, a student who properly understands the concept would approach the problem requiring a solution in his way and may be able to tackle most puzzles correctly. There is also a strong indication that lack of awareness of misconceptions by students in chemistry may be contributing factor to students' poor academic performance in chemistry. Despite the several studies by various science educators, there is as yet little or no study in central region Ghana aimed at establishing the major conception in the learning of organic chemistry.

The thoughts, notions, opinions and ideas which can be regarded as the developing image of the mental process are known as concepts; they can be concrete, abstract, or even blurred (Oyserman et al., 2012). They are also the summary of the important characteristics of a collection of ideas (Solonchak & Pesina, 2015). A Concept can be observed in two ways, in its abstract nature or concrete. The real concepts are enhanced

University of Education,Winneba http://ir.uew.edu.gh

by students' experiences, whereas abstract concepts are considerably challenging for students to perceive (Uce & Ceyhan, 2019). These similar concepts are described by various researchers and some of them include conceptions, personal constructs, multiple private versions of science, developing conceptions, and interpretation of facts (Aufschnaiter & Rogge, 2010) Conception was held by several pre-service natural sciences educators about geometric isomers (Sendur & Toprak, 2013). It is from the use of 1,2- dichloroethene as an example of geometric isomers that the scholars assume that only alkene combinations comprising two halogen bonds on C=C bonds have geometric isomers (Sharma & Decicco, 2018). Besides, taking organic chemistry as a difficult concept in chemistry affects students in the understanding of the advanced organic chemistry conception. Organic compounds' physical properties are taken by some students as surmounting. They assume that only the bond polarity is contingent on the atom electronegativity and they fail to distinguish the concepts of boiled and burned and finally accept that a covalent bond would break when an organic complex boils. Besides, they could not categorize types of reactions, and they trust that a hydrogen bond includes a covalent bond (Taagepera & Noori, 2000).

New concepts can be easy to learn if misconceptions are corrected among students, some of them can be detached simply although most of them are strongly held and regularly not affected by regular classroom instruction since these are something learners trust (Belachew et al., 2018). Students usually have difficulty in learning organic chemistry due to no algorithms' problem-solving of this topic as it has an extensive new vocabulary and requires three-dimensional thinking (Wu et al., 2001). Among the major conceptions of organic chemistry for students is the understanding of the three- dimensional nature of molecules which they have extreme difficult converting between the two-dimensional drawings used in textbooks and on boards to

University of Education,Winneba http://ir.uew.edu.gh

represent molecules and their three-dimensional structures without this understanding to continue the course, students have to pretend they understand the three-dimensional structures (Bateman et al., 2002).

Moreover, research data by Bryan, (2007), Kay and Yiin (2010) in Singapore revealed some student's conceptions of organic chemistry sub-topics like in the introduction to organic chemistry and hydrocarbons in some sub-topics like isomerism, the reactivity of alkanes and alkenes, halogen alkanes (alkyl halides), alcohols, esters and the benzene ring while students in some African countries saw organic chemistry as a difficult topic to be followed in their further studies (Horowitz et al., 2013; Gebrekdian et al., 2014; Mafuniko, 2008; Sarkodie & Adu Gyamfi, 2015).

The use of micro kits in creating small-scale organic chemistry experiments has been known to improve students' conceptions in most south-east Asian countries including Thailand, Japan, Taiwan, and Indonesia (Supasorn, 2015). When this strategy was introduced to chemistry students in Ghana, it was found to be a tool to enhance students' understanding and academic performance (Hanson, 2014). Students who applied them in practical experiences made conceptual improvements as they surmount their challenges in principles that directed the study of organic chemistry (Hanson, 2017). In this manner, they are exposed to a kind of concrete experience as they observed the causes and effects of phenomena in different variables (Darling-Hammond et al., 2019). These concrete experiences enhanced their concept formation and subsequently academic performance. Furthermore, the acknowledgement and revision of the conceptions of students involves innovative teaching strategies rather than passively learning approaches. A common method of instruction includes meta-cognition which is to boost the students' thinking about techniques of addressing a particular problem

University of Education,Winneba http://ir.uew.edu.gh

(Fisher, 2006). This technique necessitates students to express and defend their understanding. The recognition of the authenticities of the current classroom requires the application of innovative teaching methods that provide the active participation of students and incorporate their metacognition and critical thinking then the creation of a deep foundation of factual knowledge which enables students organizing the knowledge within a conceptual structure based on the experienced events (Cakir, 2008: Canelas, Hill, & Novicki, 2017). Teachers monitor the concepts changing of the students through the evaluation techniques as the teaching proceeds.

Through different approaches that apply formative assessment in education, educators find ways to help students redirect scientific misconceptions and assist them to reconstruct their conceptual framework (Dunlosky et al., 2013). However, deciding to create manners to help learners overcome their misunderstandings one might try employing different methods including the application of innovative teaching methods that allow learners to actively participate in the learning process and to discover more (Uce & Ceyhan, 2019).

The process of teaching and learning organic chemistry could be structured by enabling students to overcome challenges for them to be prepared for the world of tomorrow offering them information and helpful examples which they are familiar with showing them the cognitive processes that lead to conceptual generalizations and algorithms (Sibomana et al, 2020). Organic chemistry teachers should try to include conceptual questions assessing students' understanding of the fundamental notions in the subject instead of just setting questions which require only mostly recall and rote learning. The way a student processes the learned information and applies it goes hand in hand with his or her learning style (Woldeamanuel, et al., 2014).

University of Education,Winneba http://ir.uew.edu.gh

Evaluation of students' abilities is assumed to be one of the most widespread yet controversial exports both in academics and the real world (Deary et al., 2007). The evaluation is mostly intended to provide an objective measure of individual differences based on cognitive aspects that undoubtedly exist within society. The outcome of such evaluation has proven to produce both practical and theoretical implications. Most importantly, it would justify the rationale for the use of such instruments as a selection guide in a wide range of fields including educational and occupational fora.

In chemistry, studies have shown that students' level of achievement is based on their mathematical and visual-spatial abilities. Relative to mathematical ability, Salau (2000) pointed out that there exists an impenetrable link between mathematics and other science subjects while Peters (2006) insist that the mathematical ability of students is very important in the learning of chemistry especially in the present age of computer and information technology which owes a lot to mathematics.

Adesoji and Oginni (2012) on their part assert that like any other school subject, chemistry requires the mental ability of the students to be able to cope with the learning of the subject. Their findings showed that mental ability made the highest contribution followed by mathematical ability. Findings by Ajewole et al. (2006) showed that 36.2% of the total variance in the students' performance in chemistry is accounted for by the four student's aptitude indices. Among the indices, mental ability made the highest contribution followed by mathematical ability. This shows that the performance of students depends largely on the students' aptitude indices in chemistry. Visuospatial aptitude which entails three components, spatial visualization, spatial orientation and spatial relations (Barnea, 2000) been strongly linked to obtaining academic mastery of several science disciplines. For example, Wu and Shah (2004) found that science students, who were mostly physics majors, possessed more highly developed

University of Education,Winneba http://ir.uew.edu.gh

visualization skills than non- science students. Wu and Shah (2004) investigated and found spatial aptitude in successful students of physics. Wu and Shah (2004) found similar results for biology students while Wu and Shah (2004), made similar studies for chemistry students and found similar results. Therefore, researchers have come to agree that visuospatial ability is an important cognitive operation for success in science due to the correlation found between spatial ability and achievement in science.

Talanquer (2014) found that the main obstacles to developing spatial abilities in chemistry were insufficient understanding of the depth cues provided in two-dimensional representations and the inability to visualize the position of atoms after rotation. Thus, they advocated for the use of instruction methods such as DMI that guide students to visualize three-dimensional structures from their two-dimensional representations and encouraged the use of teaching aids that incorporate models, stereo-diagrams, mirrors, shadows and dynamic pictures that have been used in related remedial instruction programs and have proved to be useful in improving learner skills related to spatial ability.

Wu and Shah (2004) illustrated in their study finding that students with high spatial scores perform significantly better on questions which require problem solving skills, such as completing a reaction or outlining a multi-step synthesis, and questions which require students to mentally manipulate two-dimensional representations of a molecule. Spatial ability was not significant, however, for questions which could be answered by rote memory or by the application of simple algorithms. Bodner and McMillan (1986) suggested a high correlation between spatial ability and performance in a general chemistry course for science and engineering majors. This correlation was seen not only on highly spatial tasks such as predicting the structures of ionic solids ($r = 0.29$), but also on tasks such as multiple-choice stoichiometry questions ($r = 0.32$)

University of Education,Winneba http://ir.uew.edu.gh

that do not involve spatial skills. According to Carter et al. (1987) as cited in Wu and Shah (2004) scores on the spatial tests consistently contributed a small but significant amount to success on measures of performance in chemistry. Correlations were largest for sub-scores that grouped questions testing problem solving skills rather than rote memory or the application of simple algorithms, and correlations were also large for verbally complex questions that required the students to dissembled and restructure relevant information.

Empirical data exist that attest to the effect of DMI on students' mathematical and visual spatial abilities thus overall abilities in chemistry. For instance, Morgil (2005) worked together on the effect of digital media learning on computational attitudes, three-dimensional spatial visualization abilities, and learning styles of students in acids and bases. The findings showed that computational attitudes, three-dimensional spatial visualization abilities, and learning styles of the students did not affect their test scores. However, a 52% improvement was observed in the post-test results of the students of the experimental group and a 31% improvement was observed in the post-test result of the students of the control group. Thus, a significant difference was found favouring digital-assisted instruction signifying that the teaching strategy promotes more students' learning abilities. Similarly, Steffen et al. (1996) posited that when students construct and animate molecules, they get a chance to see how a chemist or organic chemist thinks about structure. This helps bridge the gap between the traditional chalkboard drawings and more sophisticated visualization techniques scientists use.

Barnea (2000) found that students who were exposed to computerized molecular modeling (CMM) software in a study of its effect on high-school chemistry students' performance and gender differences performed better than those who were not in all three performance aspects. Their achievement scores were higher and though students'

University of Education,Winneba http://ir.uew.edu.gh

spatial ability improved in both groups, students from the experimental group scored higher implying that they gained better insight into the model concept than the control group and could explain more phenomena with the aid of a variety of models. An analysis of the findings for the average students in both groups indicated a unique and discernible improvement in all three spatial ability subtests – paper folding, card rotation, and cube comparison – with that of experimental group being significantly higher. This was interpreted to imply that this group of learners gained better insight into the model concept and could explain more phenomena with the aid of a variety of models. It was thus concluded that CMM helps in particular to improve the examined cognitive aspects of the average student more. This was attributed to a better understanding of chemical bonding and improved three-dimensional perception of molecular structure gained through the CMM experience of students in the experimental group. This improvement in their perception of various geometrical shapes and the relation between the molecular formula and geometric structure is in accord with the findings of Gabel and Bunce (2004).

Studying organic chemistry at the microscopic level (that is, nature and arrangement of molecules used to illustrate the characteristic properties of hydrocarbons and other compounds) and symbolic level (that is, representations of atoms, molecules, and compounds, such as chemical symbols, formulae, and structures) is arguably difficult for chemistry students (Ben-Zvi et al., 2002). The reason is that the microscopic and the symbolic levels of chemistry are abstract, and therefore learning chemistry for comprehension and analysis depends much more on the use of the sensory organs. Little wonder that chemistry students find it challenging in comprehending and analyzing molecular formulae, structural formulae and symbols. The concept of IUPAC nomenclature of compounds is at the symbolic level and could be said to be difficulty

University of Education,Winneba http://ir.uew.edu.gh

for most students. Chemistry students' comprehension is obstructed by the superficial features of representations (Kozma & Russell, 2013). Therefore, most chemistry students see formulae of organic compounds (for example, CH_3OH or C_2H_6O) as a combination of alphanumeric rather than molecular formulas (Wu et al., 2001). The difficulty of some students in understanding organic representations is also seen as an area where most students are unable to make translations among formulae (Keig & Rubba, 1993).

According to Keig and Rubba (1993), for learning to be meaningful and reasonable to a student, it has to be constructed or premised on an important set of concepts that him or she is used to. This means that an attempt must be made to link chemical phenomena which are abstract to their representations to make them understandable.

Kavanaugh and Moomaw (1981) posited chemistry students presume chemistry to be a difficult subject. This in effect has resulted in many students having difficulties in understanding scientific concepts in chemistry. Jones (1991) revealed that most students drop out of the physical sciences of which chemistry is included to the biological sciences and other fields of academics as such students perceive them to be difficult. The findings of Baah (2012) revealed that students have difficulty in writing structural formulae of organic compounds from the IUPAC names. Bello (1988) has revealed that the difficulties of students in solving stoichiometric problems are responsible for their inability to write chemical formulae as required by the IUPAC system. In naming some organic compounds (molecular formulae) using the IUPAC system, Baah (2012) found out that chemistry students are faced with some difficulties due to their inability to correctly write the names of some hydrocarbons and organic compounds. These difficulties, according to Baah (2012), are a result of the chemistry

University of Education,Winneba http://ir.uew.edu.gh

students' inability to locate the central carbon chains of some given structural or molecular formulae. Also, these difficulties are a result of the chemistry students' inability to write the correct names of some hydrocarbons and to deduce the Carbon and Hydrogen numbers of the straight carbon chain of some structural formulae as a result of their lack of knowledge about the concept (Baah, 2012). According to Wu et al. (2001), many students learning chemistry have challenges learning symbolic and molecular representations. They therefore conducted a study with 51 eleventh-grade students of a small public high school in a midsize university town in the Midwest to investigate how chemistry students develop and understand chemical representations using a computer-based visualizing tool for 6 weeks. To them, the computer-based visualizing tool was referred to as eChem.

One of the chemical concepts studied within the 6 weeks by Wu et al. (2001) was the IUPAC nomenclature of organic compounds such as hydrocarbons. Wu et al. (2001) pointed out that with the help of eChem; the chemistry students were able to apply modern rules of IUPAC nomenclature to draw structures of some given organic compounds. For instance, the students were made to name and draw the structure of a six-carbon atom compound with a side group. The understanding of the high school chemistry students used in the study was said to have improved reasonably resulting in high performance on IUPAC nomenclature of organic compounds. This is based on the fact that there was statistically significant difference between the means of pre-test (N = 71, M = 31.1) and post-test (N = 71, M = 59.5) results after they had been subjected to a paired two-sample t-test analysis (SD 2.5, t (70) = 13.9 p 0.001) with an effect size of 2.68 (Wu et al., 2001).

University of Education,Winneba http://ir.uew.edu.gh

2.18 Conventional Science Teaching Methods

Chifwa (2015) posits that for teachers to decide what teaching method to use, the teacher must know what teaching methods are available, what strengths and weaknesses these methods have, what purpose each method serves and how to use the methods. Teaching methods are chosen based on fitness for a particular purpose. The number of factors determine what strategies a teacher should use to accomplish a given learning outcome. These factors may include the age and academic level of students, amount of time available, physical environment, availability of teaching and learning resources as well as the topic being presented. Danjuma (2022), posits that for any meaningful learning and teaching to take place, there should be suitable means of presenting the content to the learners at all levels of education. The means or strategies of presenting the content to the learners depend on familiarity with the basic principle of effective teaching methods in science. Bichi (2009) states that the basic principles of effective pedagogy in science teaching include mastery of science contents, the wise use of instructional methods, knowing the psychology of the students, the teacher's knowledge about himself and a conducive environment for learning. Bichi (2009) further stated that the basic principles to note are the child-centred method, the better learning outcome, the more teacher-centred, this method is the less effective learning outcome. A variety of teaching methods increase students' attention and interests and also help the teacher to manage the class well (Petty 2013). Teaching methods on a continuum are lecture method, demonstration method, discussion method, project method, laboratory activity method, inquiry method, discovery method, process method, and problem-solving.

University of Education,Winneba http://ir.uew.edu.gh

2.18.1 Demonstration method

Petty (2009) defined a demonstration as a repetition of a series of planned activities which are designed to illustrate a certain phenomenon or event. Mohan (2010) agrees that a demonstration method has several advantages that make it very useful in teaching Physics as it allows learners to observe real objects and events, helps in economizing resources, minimizes risks and hazards associated with certain experiments among other advantages, although a major disadvantage is limited learner participation and students do not develop manipulative skills.

2.18.2 Project method

The Project Method is a teaching approach which allows students to identify and choose a piece of work, topic or problem to investigate. Here, students are allowed to go out to obtain relevant information for the project. The Project method is entirely student-centred and students could either work individually or in groups. The teacher's role is to monitor how the project is being executed, give encouragement and offer assistance when necessary. At the end of the project, students are expected to write their report. Students' reports must be discussed in class. Since this method enables them to investigate on their own, it leads students to develop science process skills, stimulates the development of a scientific attitude and of course facilitates meaningful learning of science (Danjuma, 2022).

2.18.3 Guided discovery method

The Guided Discovery Method is an approach in science teaching which was postulated by Brunner (1961) and is seen to enable students to get first-hand experience in getting facts, concepts, principles and processes by using mental processes and manipulating scientific equipment and materials. Brunner believed that a child who is exposed to

University of Education,Winneba http://ir.uew.edu.gh

guided discovery gets four benefits: a shift from extrinsic to intrinsic motivation, an increase in intellectual attainment, valuable to students' investigation processes and, serves as a memory aid. The Guided Discovery Method applies to virtually all areas of teaching and the types of activities in which the students are involved, vary from topic to topic and with the age and ability of the student. The amount of guidance the students receive from the teacher also varies but is never excessive. The method encourages the mental skills development of students as well as their observing, measuring, and classifying abilities among others (Nurdin, 2011)

2.18.4 Problem-solving method

The Problem-solving Method is an instructional strategy in which problems (scientific or related to the real world) are carefully formulated and presented to students (Bichi 2009). In the process of solving problems, students interact with one another using instructional materials and ultimately construct knowledge and acquire the process of science. The Problem-solving method is a way of helping students to see the personal relevance and the applicability of the science they learn. Problem-solving provides opportunities for students to work as scientists, systematically investigating phenomena and finding solutions to scientific problems. Problem-solving promotes investigative thinking in children and it enables the learner to experience new ideas.

2.18.5 Laboratory activity method

Alade and Adeyemo (2010) defined laboratory learning as a method of learning that involves the application of scientific principles and concepts through hands-on experimentation and observation. Laboratory learning provides students with hands-on experience and allows them to apply theoretical concepts in practical settings. One of the key advantages of laboratory learning is that it allows students to develop critical

University of Education,Winneba http://ir.uew.edu.gh

thinking and problem-solving skills through experimentation and exploration (Dunlosky & Metcalfe, 2009).

A laboratory learning method is a teaching approach that involves students actively participating in hands-on experiments and activities to learn scientific concepts and principles. According to a study by Hofstein and Lunetta (2004), laboratory learning can enhance students' understanding of scientific concepts, as well as improve their attitudes towards science and scientific inquiry.

Again, a study that explores the effectiveness of the laboratory learning methods is "The Effectiveness of Laboratory Learning Method for Physics Teaching: A Meta-Analysis Study" by Li et al (2018). The study reviewed 51 studies published between 2000 and 2017, which investigated the effectiveness of laboratory learning methods in physics education. The authors found that the laboratory learning method was significantly more effective than traditional lecture-based teaching in improving students' academic achievement, conceptual understanding, and problem-solving ability in physics.

According to a study by Miao et al. (2018), the laboratory learning method is an effective teaching method in science education. The study found that students who participated in laboratory activities performed better on exams and had a deeper understanding of the subject matter compared to those who did not.

Another study by Zengin and Arslan (2017) examined the effectiveness of laboratory learning methods in teaching biology. The study found that students who participated in laboratory activities had better achievement scores and were more motivated to learn than those who did not participate in laboratory activities. According to a study by Goh and Chiang (2018), laboratory learning is an effective method for promoting students' scientific inquiry skills, problem-solving abilities, and conceptual understanding. The

University of Education,Winneba http://ir.uew.edu.gh

study found that laboratory activities helped students to better understand complex scientific concepts and develop critical thinking skills.

2.18.6 Discussion method

Chifwa (2015) observes that the discussion method is one of the teaching methods used to teach science subjects. During classroom discussions, students learn how to express themselves clearly, justify opinions and tolerate different views. During discussions, learners also get a chance to ask for clarifications, examine their thinking, evaluate ideas and put together personal viewpoints. This method enables learners to collaboratively construct their knowledge (Mohan, 2010). The discussion method is a two-way interaction method. To a large extent, it is student-centred since students participate actively. It increases curiosity about the subject, and enhances a more positive perception of students about the value of the subject. To get information on what to contribute during the discussion, students need to spend more time reading. Although the discussion method is effective, it could be time-consuming and the classroom could appear noisy if not well-moderated by the teacher (Bichi, 2009).

2.18.7 Lecture method

A lecture is oral presentation intended to present information or teach people about a particular subject. Lectures are used to convey critical information, history, background, theories and equations. According to Danjuma (2015), the lecture method is a teacher-centred method, which is seen as the traditional talk–chalk method of teaching. Here, the teacher does the talking while students serve as receivers only by listening and taking down notes. About Genetics, the lecture method is only useful in introducing the topic to the students since they have little prior knowledge. This method promotes initial understanding of concepts and principles. However, for this method to be very effective it should be used together with other methods such as group work,

University of Education,Winneba http://ir.uew.edu.gh

pairing, practical work and role play (Chifwa, 2015). The lecture method is not suitable for slow learners and students with language problems, it can be boring, the students are not actively involved in the lesson, and the concentration span students is short (Petty, 2009; Davar, 2012).

2.19 Non-conventional Instructional Design

Instructional Design (ID) also known as instructional system design (ISD) is the art and science of creating an instructional environment and materials that will bring the learner from the state of not being able to accomplish certain tasks to the state of being able to accomplish those tasks. The approach to instructional design is effective because it forces attention to what is going to be learned (learning objectives) and what must already be known before the learning transactions. Once the learning objectives have been identified, they are progressively sequenced from lower-order to higher-order learning (Lujara 2008). Instructional systems design combines knowledge of educational theory and practice with appropriate technologies to enable learning. It involves choosing appropriate technologies and designing interactions that promote effective and efficient knowledge transfer. The effectiveness of any instructional material depends also upon appropriate planning; hence the instruction has to be planned if it is to be effective and designed in some systematic way. The development of content for eLearning can well benefit from the instructional design approach. However, there is a need to revisit the traditional instructional design to incorporate the Learning Object (LO) paradigm (Lujara, 2008). Various approaches can be used to make learning objects available over the web. The simplest approach is to generate web pages containing these resources and make the web pages available through a website for the course. The other approach is to use a full-fledged course management system such as a Learning Content Management System (LCMS).

University of Education,Winneba http://ir.uew.edu.gh

2.19.1 Asynchronous mode

Asynchronous or self-study learning consists of content that is available online at any time that the student wants to access it. It is where communication, collaboration and learning can occur at different times and different places, and users can select when they wish to communicate. Based on the developed techniques of networking, asynchronous learning is split up into online and off-line status (Huang & Gui, 2022)

2.19.1.1 Off-line learning

Computer-Aided Instruction (CAI) is a typical method of off-line learning. In general, the content of CAI - text, graphs, pictures, audio and video are stored in a CD-ROM. A recent product, the Digital Versatile Disk (DVD) can store seven times more information than a CDROM. Therefore, these two kinds of disks are basic storage for offline learning. In general, interactive response on an off-line state is faster than the on-line state. Once the contents have been stored, editing is not allowable. Hence, it is suitable to construct core courses that are well-developed fundamental curricula (Huang & Gui, 2022).

2.19.1.2 On-line learning

The content of online learning is built by the hypermedia technique, which is stored in the network computer server. Students can study or review the contents of the website at any time. There are two types of data sources, first is the static type based on text, graphs and pictures combined as the auxiliary parts of the resources to provide the learner with a complete concept. The second is dynamic; it involves motion pictures, associated texts, matched sounds etc. The static resources require less bandwidth than the dynamic content; however, it lacks a sense of reality that enables the learners to get a whole picture of the subject. On the other hand, the latter type enables the learners to

University of Education,Winneba http://ir.uew.edu.gh

feel a sense of reality. Students would pay more attention to the subjects due to the colourful and diversified environment; hence the outcome is better than the former one. But, huge amount of data and slow transmission speed of the internet are its weaknesses. Contents are allowed to renew at any time, therefore, it always remains up -to-date (Huang & Gui, 2022).

2.19.2 Synchronous mode

Synchronous learning generally occurs in real-time with highly interactive and structurally dynamic characteristics, led by the instructor. It allows people to interact with each other at the same time in different places, synchronous e-Learning imitates a classroom, which means classes take place in real time and connect instructors and students via streaming audio or video or through a conference room. Synchronous learning requires the presence of both parties at the same time for the learning to take place. Therefore, it is also referred to as live or real-time interaction (Huang & Gui, 2022). Discussion between students and instructor is in real-time via the system equipment. Instructors and students may not meet each other faceto-face. Moreover, the common source of content is distributed to learners at the same time in different places, avoiding repetition of the lecture. The environment is named Videoconference Classroom. Although it has several advantages, steady and wide bandwidth network configuration is needed. The most important advantages of synchronous learning are immediate feedback and more motivation and obligation to be present and participate (Huang & Gui, 2022).

2.19.3 Blended learning

Blended learning also called hybrid learning, is the mixing and integration of different learning delivery approaches including classroom and e-Learning to create a single learning programme. To complement traditional methods of delivery, e-Learning is

University of Education,Winneba http://ir.uew.edu.gh

often used in a blended manner. With blended learning, technology-delivered learning and the classroom come together to generate the best possible offering. Past patterns suggest that the likely future will neither solely depend on online learning nor solely depend on instructor-led classroom learning. It appears that the hybrid or blended models most frequently emerge as the most effective learning strategies. Determining the right blend of technology-delivered and classroom-based learning is almost like perfecting a recipe (Huang & Gui, 2022).

2.20 Empirical Review of the Study

A study conducted by Ekundayo (2022) investigated the effects of Computer-Assisted Instruction (CAI) on students' achievement in Chemistry among boys and girls in public secondary schools in Ondo State. A quasi-experimental design was adopted for the study. The sample for the study consisted of 240 senior secondary school two (SSS II) intact class Chemistry students selected in stages using a simple random sampling technique. Three schools were selected from three local government areas from the three senatorial districts in Ondo State. The students in the experimental groups were exposed to CAI while the control group was taught with the conventional teaching method. The Chemistry Achievement Test (CAT) with a reliability coefficient of 0.81 was used to collect relevant data for the study. The experimental group was treated using the CAI package while the control group was treated using conventional classroom teaching. Analysis of Covariance (ANCOVA) and t-test were used to test the research hypotheses at a 0.05 level of significance. The result from the study showed that there was no significant difference between the achievement of male and female students in both the experimental and the control groups respectively. The results showed that when exposed to CAI, female students performed better than their counterparts. Based on the findings of the study, it could be concluded that the use of

University of Education,Winneba http://ir.uew.edu.gh

CAI has not shown any better effectiveness in the achievement of students. However, the method is a modern day of imparting knowledge. In another dimension, when both males and females are taught with the use of CAI, the method appeared to favour females more than males. This suggests that the method is gender-biased. Based on the findings of the research, it is recommended that the potential of computer-assisted instruction should be utilised to enhance better achievement of the students in Chemistry, most especially among females while male students also be encouraged to key into the use of the method for the flexibility of teaching and learning.

Another study conducted by Dap-og and Orongan (2022) study determined the student's academic achievement and engagement in science. A quasi-experimental research design was utilized. The study results showed that students exposed to CAI obtained "fairly satisfactory" results in the post-test, while those exposed to non-CAI showed "needs improvements" both in the pretest and post-test. Moreover, for students' engagement in science, the CAI group had a high engagement level for affective, cognitive, and behavioural domains. In contrast, the non-CAI group had moderate engagement before and after the intervention. The students' academic performance in science exposed to CAI is significantly higher than those exposed to non-CAI. Also, there is a significant difference in students' engagement level for a cognitive domain in favour of CAI. It is concluded that CAI as a science learning tool enhances the students' cognitive engagement.

Chebotib and Kering (2021) examined Students' Attitudes towards computer-assisted learning in Biology subject in a selected secondary school in Uasin Gishu County, Kenya. This study designed a CAL lesson and measured student attitudes towards learning mutations in the biology lesson using a pretest-posttest control group design to compare computer assisted learning with conventional teaching methods. The study

University of Education,Winneba http://ir.uew.edu.gh

used the experimental design to compare the differences between the experimental and the control group from a total of 54 students from Kerotet Girls High School in Uasin-Gishu County, randomly sampled and equally placed into the groups. First, the study measured the attitudes towards biology using a conventional tool before assigning them to the groups. The experimental group used the CAL, while the control group used the conventional methods (lecture and discussion). The experiment was spread over five lessons lasting one hour totalling 300 minutes. The achievement and attitudinal components were assessed by the Biology Achievement Test (BAT) and Student Attitude Questionnaire (SAQ) respectively. The data generated were entered into statistical software and analyzed using descriptive and inferential statistics.

Importantly, $\chi2$ was conducted at $\acute{\alpha} = 0.05$ significances level of significance. At the onset, there were no significant differences in the students' attitudes with $\chi2$ ranging from 3.933 to 7.522($p > 0.5$) between both groups but at the end, there were changes in attitudes towards biology with higher positive attitudes towards the use of ICT in biology subject. The achievement scores for the experimental group were statistically and significantly different ($t = 10.89$, $p < 0.05$) from the control group. Thus, the students exposed to the CAL lesson show higher positive mental attitudes and performed significantly better on the BAT. However, the finding must be interpreted with caution in light of the sample size. The study revealed that the computer-assisted learning module influences students' attitudes and can be considered an efficient instruction medium for aligning students' attitudes in secondary schools in Kenya.

The study recommends that the schools explore several techniques and means that include CAL to grow and sustain students' attitudes towards biology subjects and STEM discipline as a whole.

University of Education,Winneba http://ir.uew.edu.gh

Adherr et al (2019) examined the effect of computer-assisted instruction (CAI) on students' cognitive achievement in chemical bonding. The study was conducted in the Kwahu East District of the Eastern Region of Ghana to investigate the effect of Computer Assisted Instruction (CAI) on the cognitive achievement of students in chemical bonding. The study employed a quasi-experimental research design implemented by a pre-test and post-test control group containing intact, non-equivalent groups of students. The sample size of the study was forty-six (46) students - Twenty-Two (22) in the experimental group and twenty-four (24) in the control group. A researcher-developed instrument, Chemical Bonding Achievements Test (CBAT) was used for the collection of data. The instrument contained twenty (20) questions with a reliability coefficient of 0.72. The experimental and control groups were taught with CAI and Lecture teaching methods, respectively. Quantitative data collected were analyzed descriptively and inferentially. The findings of the study revealed that teaching with CAI significantly enhanced the achievement of students in chemical bonding than those taught with the lecture method. The study further revealed that the performance of low achievers was improved when they had lessons with CAI. The study recommends the immediate implementation of CAI in Chemistry lessons since it could increase students 'attendance to class, motivation, attitude and cognitive achievement in the subject.

Owusu et al (2010) investigated the effect of computer-assisted instruction on the performance of senior high school biology students in Ghana. This study investigated the comparative efficiency of computer-assisted instruction (CAI) and conventional teaching methods in biology on senior high school students. A science class was selected in each of the two randomly selected schools. The pretest-posttest non-equivalent quasi-experimental design was used. The students in the experimental group

University of Education,Winneba http://ir.uew.edu.gh

learned science concepts (cell cycle) through the CAI, whereas the students in the control group were taught the same concepts by the conventional approach. The conventional approach consisted of lectures, discussions and question and answer teaching methods. Mann–Whitney U tests were used to analyze students' pretest and posttests scores. The results indicated that students that were instructed by the conventional approach performed better on the posttest than those instructed by the CAI. However, the performance of low achievers within the experimental group improved after they were instructed by the CAI. Even though the CAI group did not perform better than the conventional approach group, the students in the CAI group perceived CAI to be interesting when they were interviewed.

Egolum and Igboanugo (2021) examined the effects of computer-assisted instruction and power point presentation on academic achievement of secondary school chemistry students. The sample consisted of one hundred and fifty (150) SSII Chemistry students who were randomly selected from four secondary schools in Onitsha Education Zone of Anambra State. The design for the study was a quasi-experimental research design. The validated instrument used for data collection was Chemistry Achievement Test (CAT). It had a reliability coefficient of 0.87 using the Cronbach Alpha technique. Data were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA). The results obtained showed that the Chemistry students taught using CAI performed significantly higher than those taught using PPP. The male students taught using CAI and PPP achieved significantly higher than their female counterparts. It was recommended among others, that Chemistry and other science subjects teachers should be encouraged to use CAI in teaching as it use has been found to enhance students' achievement in Chemistry. Also, seminars, workshops and symposia should be

University of Education,Winneba http://ir.uew.edu.gh

organized for practising Chemistry and other science teachers to acquaint them with the use of computers in teaching.

Abidoye (2015), Ayotola (2010) Gambari et al (2014) and Salisu (2015) found that computer assisted instruction had a significant effect on students' academic performance in different subjects of which Physics is not part. Hamzat et al (2017) found that students who were exposed to computer-assisted instruction had significantly higher achievement scores than those who were not exposed. Anigbo and Orie (2018) revealed that Microsoft PowerPoint instructional strategy technology significantly enhanced students' academic achievement. Ezza et al (2019) found that instructional technology significantly enhanced learners' compositing skills. Ruzicka and Milova (2019) found that there was a significant effect of video analysis in providing feedback on the process of downhill skiing skill acquisition. Ugwuanyi and Okeke (2020) found that flipped classroom instructional technology was effective in enhancing the achievement of physics students at both post-test and follow-up measurements. Ugwuanyi and Okeke (2020) found that PowerPoint presentations had a significant effect on students' achievement in physics and mathematics. Ugwuanyi et al (2020) found that animated PowerPoint presentations (PPP) significantly enhanced the achievement of students' motivation and achievement of students in physics. Ejimonye et al (2020) found that the 2D animation technique had a significant effect on students' motivation and achievement of quantitative/ mathematical content of economics respectively, Ugwuanyi et al (2020) found that digital-based learning significantly (p>05) improved the achievement of primary school pupils both at the post-test and follow-up measures. The above review reveals that computer-assisted instruction has a significant impact on students' motivation in science and other social science subjects.

University of Education,Winneba http://ir.uew.edu.gh

2.21 Summary of this Chapter

This chapter reviewed literature relating to the effect of computer-assisted instruction on students' academic achievement. However, none of the reviewed studies reviewed the effect of computer-assisted instruction on students' academic performance in the study of cyclic hydrocarbons. Hence, that is why this study was conducted.

University of Education,Winneba http://ir.uew.edu.gh

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter contains the research approach and research design used in this study. It also discusses the population of the study, the sampling and sampling technique, the research instrument that was used to collect data for this study, validity and reliability of the research instruments, pre-intervention activities, intervention activities, post-intervention activities, data analysis procedure and ethical consideration.

3.1 Research Approach

The choice of research approach is crucial as it provides direction on how to conduct the research. In this particular study, a quantitative research approach was utilized. As explained by Bhandari (2020), a quantitative research approach involves gathering and analyzing numerical data, which can be used to identify patterns and averages, make predictions, test causal relationships, and generalize findings to broader populations. Bhandari (2020), outlines the benefits of using a quantitative research approach, which includes the ability to replicate the study in various cultural contexts, periods, and participant groups. Furthermore, statistical comparison of results is possible, and large samples can be analyzed using consistent and dependable quantitative data analysis techniques. The use of established hypothesis testing procedures also requires careful consideration and reporting of research variables, data collection methods, predictions, and testing methods before concluding.

University of Education,Winneba http://ir.uew.edu.gh

3.2 Research Design

The research design that was used in the study was Action research. Action research is categorised as one of the quantitative research designs. According to Cohen et al (2017), action research focuses on the development, implementation, and testing of a programme, product or procedure. Action research has grown in popularity throughout the past two decades (Cohen et al, 2017). It is becoming a more accepted tool for teachers to assess their teaching strategies and reflect upon their effectiveness. McNiff and Whitehead (2012), defined action research as the name given to an increasingly popular movement in educational research that encourages teachers to be reflective of their practices to enhance the quality of education for themselves and their students. An important aspect of this research is the use of different methods for data collection to determine student acquisition of knowledge through varied teaching methods (Cohen et al, 2017).

3.3 Research Population of the Study

A research population is generally a large collection of individuals or objects that was the main focus of scientific inquiry, and it is for the benefit of the population that research is conducted (Johnson & Christensen, 2019). The population of the study included all Science students of KNUST Senior High School, including Agricultural Science and General Science students. For the study, the target population was all the members of a group defined by the researcher's specific interest to answer research questions. However, the target population was all form three Science students who studied Chemistry as an elective subject. The accessible population consisted of all Form 3 General Science 1, General Science 2 students, and Agricultural Science students of KNUST Senior High School.

University of Education,Winneba http://ir.uew.edu.gh

3.4 Sampling and Sampling Technique

Sampling refers to the process of selecting a portion of the population to represent the target population (Johnson & Christensen, 2019). According to Johnson and Christensen (2019) for a study, the size of the sample selected for the study is immaterial and depends solely on what the researcher is researching. Form 3 General Science 1 students comprising 45 students were selected as the sample for the study. The purposive sampling was employed to conveniently select a chemistry class that the researcher was handling in order that normal class schedules are not disrupted Purposive sampling also known as judgmental, selective or subjective sampling is a type of non-probability sampling technique where the units that are investigated are based on the judgement of the researcher (Johnson & Christensen, 2019).

3.5 Research Instruments

The research instruments that were used in the study for data collection are a pre-intervention test, a post-intervention test and 3 sets of different 5- point Likert scale questionnaires ranging from strongly agree to strongly disagree. The first questionnaire was based on students' prior conception of cyclic hydrocarbons, the second questionnaire seeks to examine students' attitudes towards CAI in the teaching and learning of cyclic hydrocarbons and the third questionnaire was used to examine the role of CAI in promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons. Activity worksheets and tests were also used to collect data to assess the effectiveness of CAI in naming cyclic hydrocarbons.

3.6 Validity of Research Instruments

Validity refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration (Kubiak et al, 2014). There are various types of validity, which include construct validity, content validity, criterion-related

University of Education,Winneba http://ir.uew.edu.gh

validity, and face validity (Gall & Borg, 2007). Of these, content validity, defined as the degree to which a measure covers the range of meanings included in a concept (Kubiak et al, 2014). To determine the content validity of the research instruments, two chemistry teachers together with the researcher's supervisor reviewed the items to assess their relevance and suitability.

3.7 Reliability of Research Instruments

Instruments were trial tested on students of the same characteristics who are not part of the main study. The instruments were administered to the participants of the trial test twice. The time gap between the two administrations of the instruments was one week. The duration of one week was thought sufficiently long for the participant not to remember their previous responses (in the first administration of the instruments. Data from the first and second administrations of the instruments were used to compute the reliability of the instruments. The test-retest reliability method was used to determine the reliability of the test items and a coefficient value of 0.72 was obtained which revealed that the test is highly reliable. To ascertain the reliability of the instrument, Statistical Package for Social Sciences (SPSS) version 26.0 was used to determine the Cronbach Alpha coefficient value for the questionnaire, which was found to be 0.748. According to Leech (2011), a Cronbach alpha coefficient value of 0.70 and above indicates a reasonable internal consistency and an alpha value between 0.60 and 0.69 indicate minimal adequate reliability. The questionnaire items were therefore reliable as the Cronbach alpha coefficient value was above 0.70.

University of Education,Winneba http://ir.uew.edu.gh

3.8 Data Collection Procedure

Data was collected in the following ways:

3.8.1 Pre-intervention activities

Students were given a questionnaire to examine their prior conception of organic chemistry nomenclature. A week after, a pretest was administered to the research sample to determine their academic performance in the nomenclature of cyclic hydrocarbons before intervention activities.

3.8.2 Intervention activities

In 4 weeks, students learned about cyclic hydrocarbons (cycloalkanes, cycloalkenes and cycloalkynes) through computer-assisted instruction (CAI) for 2 hours each week. The instruction were videos, pictures, and animations to enhance their learning experience.

Week 1: Introduction to Cycloalkanes

Duration: 2 hours

Activity 1: Introduction to Cycloalkanes (30 minutes)

The session began by introducing students to cycloalkanes, their properties, and examples of cycloalkanes.

A video or animation was used to explain the concept of cycloalkanes and their nomenclature.

Examples of cycloalkanes and their names were presented.

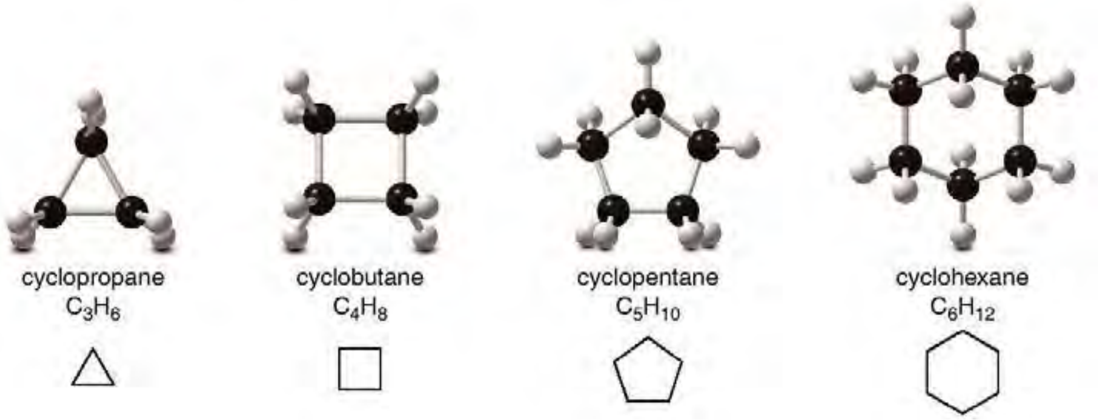
Activity 2: Naming Cycloalkanes (60 minutes)

The naming of cycloalkanes was explained using IUPAC rules.

Animations and pictures were used to show how to name different cycloalkanes.

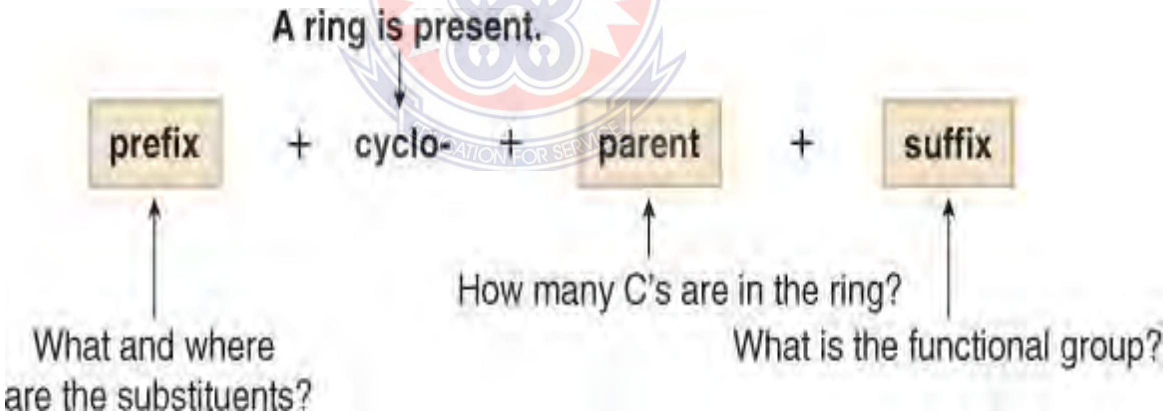
University of Education,Winneba http://ir.uew.edu.gh

Cycloalkanes have molecular formula CnH2n and contain carbon atoms arranged in a ring. Simple cycloalkanes are named by adding the prefix cyclo- to the name of the acyclic alkane having the same number of carbons.

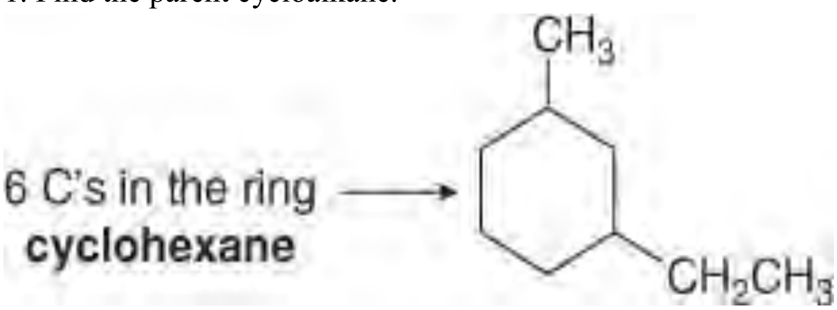


Naming Cycloalkanes

Cycloalkanes are named by using similar rules, but the prefix cyclo immediately precedes the name of the parent.

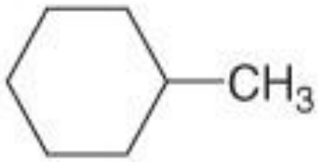


1. Find the parent cycloalkane.

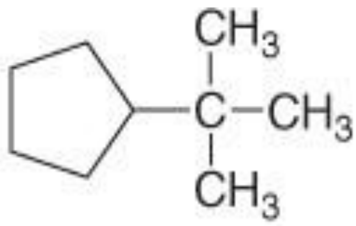


University of Education,Winneba http://ir.uew.edu.gh

2. Name and number the substituents. No number is needed to indicate the location of a single substituent.



methylcyclohexane



tert-butylcyclopentane

For rings with more than one substituent, begin numbering at one substituent and proceed around the ring to give the second substituent the lowest number.

Students were asked to practice naming cycloalkanes on their own, and feedback and clarification were provided on any misconceptions.

Activity 3: Practice Naming Cycloalkanes (30 minutes)

Students were assigned a set of cycloalkanes to name using IUPAC rules.

Feedback and clarification were provided on any mistakes.

Week 2: Introduction to Cycloalkenes Duration: 2 hours

Activity 1: Introduction to Cycloalkenes (30 minutes)

The session began by introducing students to cycloalkenes, their properties, and examples of cycloalkenes.

A video or animation was used to explain the concept of cycloalkenes and their nomenclature.

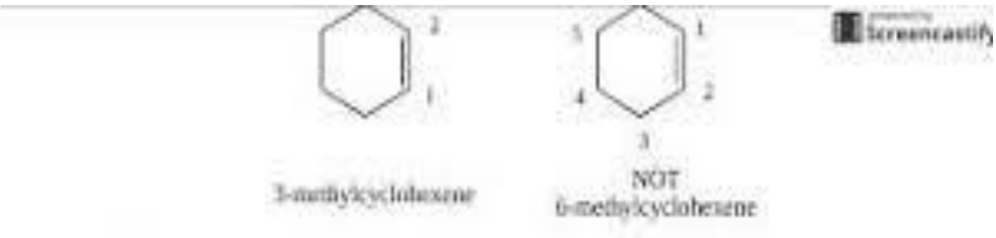
Examples of cycloalkenes and their names were presented.

Activity 2: Naming Cycloalkenes (60 minutes)

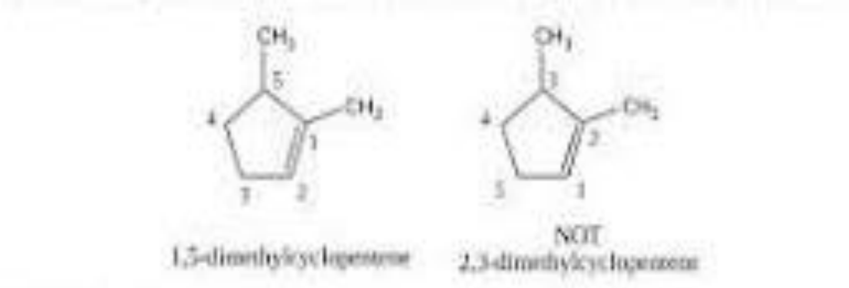
The naming of cycloalkenes was explained using IUPAC rules.

Animations and pictures were used to name different cycloalkenes.

University of Education,Winneba http://ir.uew.edu.gh



b. If there is a substituted on one of the double bond carbons, it gets number 1.



Students were asked to practice naming cycloalkenes on their own, and feedback and clarification were provided on any misconceptions.

Activity 3: Practice Naming Cycloalkenes (30 minutes)

Students were assigned a set of cycloalkenes to name using IUPAC rules.

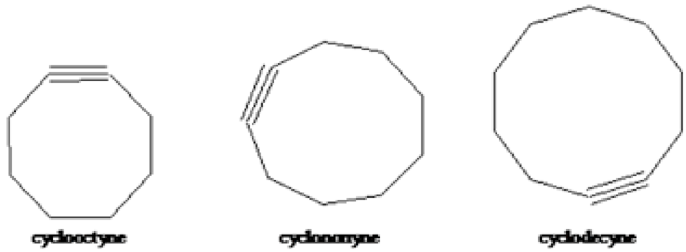
Feedback and clarification were provided on any mistakes.

Week 3: Introduction to Cycloalkynes Duration: 2 hours

Activity 1: Introduction to Cycloalkynes (30 minutes)

The session began by introducing students to cycloalkynes, their properties, and examples of cycloalkynes.

A video or animation was used to explain the concept of cycloalkynes and their nomenclature.



Examples of cycloalkynes and their names were presented.

University of Education,Winneba http://ir.uew.edu.gh

Activity 2: Naming Cycloalkynes (60 minutes)

The naming of cycloalkynes was explained using IUPAC rules.

Animations and pictures were used to show how to name different cycloalkynes. Students were asked to practice naming cycloalkynes on their own, and feedback and clarification were provided on any misconceptions.

Activity 3: Practice Naming Cycloalkynes (30 minutes)

Students were assigned a set of cycloalkynes to name using IUPAC rules.

Feedback and clarification were provided on any mistakes.

Week 4: Review and Assessment Duration: 2 hours

Activity 1: Review (60 minutes)

The concepts learned in the previous three weeks were reviewed.

A video or animation was used to summarize the key concepts.

Examples were provided, and students were asked to practice naming cycloalkanes, cycloalkenes, and cycloalkynes on their own.

Feedback and clarification were provided on any misconceptions.

Activity 2: Assessment (60 minutes)

A quiz was administered to assess the students' understanding of cycloalkanes, cycloalkenes, and cycloalkynes nomenclature.

The quiz included questions on naming different types of cycloalkanes, cycloalkenes, and cycloalkynes.

The quiz also included objective questions to test the students' understanding of the concepts.

Feedback and clarification were provided on any mistakes.

University of Education,Winneba http://ir.uew.edu.gh

Activity 3: Wrap-up and Feedback (30 minutes)

The session ended with a wrap-up of the key concepts learned in the previous four weeks. Students were allowed to provide feedback on the intervention activity and suggest any improvements for future sessions.

The instructor provided final feedback on the students' performance and progress throughout the intervention activity.

3.8.3 Post-intervention activities

After one week of intervention, students were given a post-intervention test to answer. Afterwards, the scripts were collected and scored to generate data for the post-intervention test. Two different sets of questionnaires were given to students to answer. One questionnaire assessed students' attitudes towards the use of computer-assisted instruction for the teaching and learning of the nomenclature of cyclic hydrocarbons, while the other questionnaire investigated the role of CAI in promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons. Data collected from the administration of these tests and questionnaires were organized and used to statistically test the null hypotheses that were formulated prior at a 0.05 significance level.

3.9 Data Analysis Techniques

Microsoft Excel (2019) and SPSS statistical tool Version 25 were applied to analyze the data collected. t-tests were employed to validate whether or not there was a significant difference between students' scores on the pre- and post-intervention tests. Also, where necessary, measures of central tendencies (i.e., mean, mode, and median) were used to analyze the data. The analyzed questionnaire data was organized into frequencies and percentages. The sources of data for the research questions, methods

University of Education,Winneba http://ir.uew.edu.gh

of data collection, and how the data was collected and analyzed were summarized in the table of the matrix below.

Table 1: Data Collection and Analyses Technique

Research Question	Data Sources	Data Collection Instrument	Data Analyses Technique
1. What are students' prior conceptions of the nomenclature of cyclic hydrocarbons?	Students	5-point Likert scale questionnaire	SPSS, frequencies and percentages of selected students' responses
2. What is the effectiveness of computer-assisted instruction as a tool for teaching and learning the nomenclature of cyclic hydrocarbons?	Students	Lesson notes, Activity work sheets	t-test
3. What are the students' attitude towards the use of computer-assisted instruction in the teaching and learning of nomenclature of cyclic hydrocarbons?	Students	5-point Likert scale questionnaire	SPSS, Frequency/Percentage counts
4. What is the role of CAI in promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons?	Students	5-point Likert scale questionnaire	SPSS, Frequency/Percentage counts

University of Education,Winneba http://ir.uew.edu.gh

3.10 Ethical Considerations

An introductory letter was obtained from Science Education Department of the University of Education, Winneba and sent to the school to make the authorities aware of the conduct of this study. The researcher ensured that prospective participants were made aware of the purpose of the study and their rights as participants. Following that, prospective participants were assured of the confidentiality of the data collected. Additionally, permission was sought from the school authorities before the commencement of the study.

University of Education,Winneba http://ir.uew.edu.gh

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The purpose of this chapter is to present data from the study to determine the effect of computer-assisted instruction towards the effective teaching and learning of cyclic hydrocarbons. It also emphasized the discussion of data findings.

4.1 Presentation of the Results by Research Questions

The data analyzed to address the formulated research questions are presented in the same sequence as the research questions.

Research Question 1: What are students' prior conceptions of nomenclature of cyclic hydrocarbons?

This research question sought to assess students' prior conceptions of nomenclature of cyclic hydrocarbons.

Table 2 provides insight into students' prior conceptions regarding the nomenclature of cyclic hydrocarbons. By identifying students' prior conceptions can foster a more accurate understanding of cyclic hydrocarbon nomenclature, leading to improved learning outcomes.

University of Education,Winneba http://ir.uew.edu.gh

Table 2: Students' Responses to Questionnaire on their Prior Conceptions of Nomenclature of Cyclic Hydrocarbons

S/N	Premise	Number of Respondents = 45				
		SA F(%)	A F(%)	U F(%)	D F(%)	SD F (%)
1	I am familiar with the properties of hydrocarbons.	5 (11.1)	4 (8.9)	9 (20.0)	11(24.4)	16 (35.6)
2	All organic compounds contain carbon and hydrogen.	2 (4.4)	4(8.9)	10(22.2)	21(46.8)	8(17.7)
3	Substituents are not named in alphabetical order in naming hydrocarbons.	7(15.6)	14(31.1)	15(33.3)	5(11.1)	4(8.9)
4	I can differentiate between structural isomers and name them correctly.	3(6.7)	2(4.4)	11(24.4)	6(13.3)	23(51.2)
5	In naming hydrocarbons, the end of the name is given by the number of bonds between carbon atoms.	2 (4.4)	1(2.2)	8(17.7)	22(48.9)	12(26.8)
6	I am comfortable with naming hydrocarbons containing functional groups. (Alcohols. Ethers).	0(0.0)	3(6.7)	4(8.9)	27(60.0)	11(24.4)
7	Identification of single, double and triple bonds in hydrocarbons structures are difficult.	18(40)	15(33.3)	3(6.7)	7(15.6)	2(4.4)
8	I struggle to grasp the nomenclature of branch chain hydrocarbons.	24(53.3)	17(37.8)	0(0.0)	3(6.7)	1 (2.2)
9	I find the nomenclature of hydrocarbons to be confusing and difficult to understand.	23(51.2)	14(31.1)	1(2.2)	5 (11.1)	2 (4.4)
10	Rules in naming hydrocarbons are difficult to understanding.	16(35.6)	14(31.1)	8 (17.8)	6 (13.3)	1(2.2)

Key: **SA** = Strongly Agree, **A**= Agree, **U** =Undecided, **D**= Disagree, **SD**= Strongly Disagree, F= Frequency

Source: Field data, 2023

University of Education,Winneba http://ir.uew.edu.gh

Discussion of Results

From Table 2, 20% of respondents agreed that they are familiar with the properties of hydrocarbons, 20% were undecided and 60% of respondents stated that they disagree with this statement. Approximately, 13.3 % of respondents agreed that all organic compounds contain carbon and hydrogen, 22% were undecided and 64.5% of respondents stated that they disagree with this premise. Approximately, 46.7% of respondents agreed that substituents are not named in alphabetical order, 33.3% of them were undecided and 20% of the respondent disagreed with this statement. A total of 11.1% of respondents agreed that they can differentiate between structural isomers and name them correctly, 24.4% were undecided and 64.5% of respondents disagreed with this statement. Approximately 6.6% of respondents agreed that in naming of hydrocarbons the end of the name is given by the number of bonds between carbon atoms, 17.7% responded that they were undecided while 75.7% of respondents indicated that they disagree with this statement. Also, 6.7 % of respondents agreed that they were comfortable with naming hydrocarbons containing functional groups, 8.9% of respondents stated that they were undecided and 84.4% of respondents disagreed with this premise. About 73.3% of respondents indicated that identification of single, double and triple bonds structures is difficult, 6.7% of respondents were undecided and 20 % disagreed with this statement. Surprisingly, 91.1% of the respondents indicated that they struggle to grasp the nomenclature of branch chain hydrocarbons and 8.9% of respondents disagreed. Interestingly, 82.3% of respondents agreed that they find the nomenclature of hydrocarbons to be confusing and difficult to understand and 2.2% of respondents were undecided while 15.5% of respondents disagreed with this statement. Baah (2012), found out that chemistry students are faced with some difficulties due to their inability to correctly write the names of some hydrocarbons and organic compounds. According to Wu et al. (2001), many students learning chemistry have

University of Education,Winneba http://ir.uew.edu.gh

challenges learning symbolic and molecular representations. Erduran and Scerri (2003) for instance stated emphatically that learning of chemistry poses a challenge to a majority of students, particularly in its sub-disciplines which include inorganic chemistry, organic chemistry and physical chemistry. Sirhan (2007) states chemistry is often regarded as a difficult subject, an observation that sometimes repels students from continuing with their studies in chemistry.

Lastly, 66.7 % of respondents finds rules in naming hydrocarbons to be difficult to understand, 17.8% were undecided and 15.5 % of respondents indicated otherwise. Students in some African countries saw organic chemistry as a difficult topic to be followed in their further studies (Horowitz et al., 2013; (Gebrekdian et al., 2014; Mafuniko, 2008; Sarkodie & Adu-Gyamfi, 2015). From the study, it can be revealed that students have a poor prior conception of the nomenclature of cyclic hydrocarbons.

Findings

The prior conceptions held by students were:

i. unfamiliarity of hydrocarbon prosperities e.g. low boiling and melting point temperatures, poorly or not soluble in polar solvents, e.g. Water.
ii. struggled with naming convections including the ordering of substituents and understanding the functional groups e.g. hydroxyl (OH), methyl (CH_3).
iii. difficulty to differentiate between structural isomers and branch chain hydrocarbons.
iv. difficulty in applying the IUPAC rules in naming straight chain alkanes, alkenes and alkynes

University of Education,Winneba http://ir.uew.edu.gh

Research Question 2: **What is the effectiveness of computer-assisted instruction as a tool for teaching and learning the nomenclature of cyclic hydrocarbons?**

This research question sought to examine the effectiveness of CAI as a tool for teaching and learning nomenclature of cyclic hydrocarbons.

Figure 3 displays a Chart showing scores of each student on the pre-intervention test and the post-intervention test.

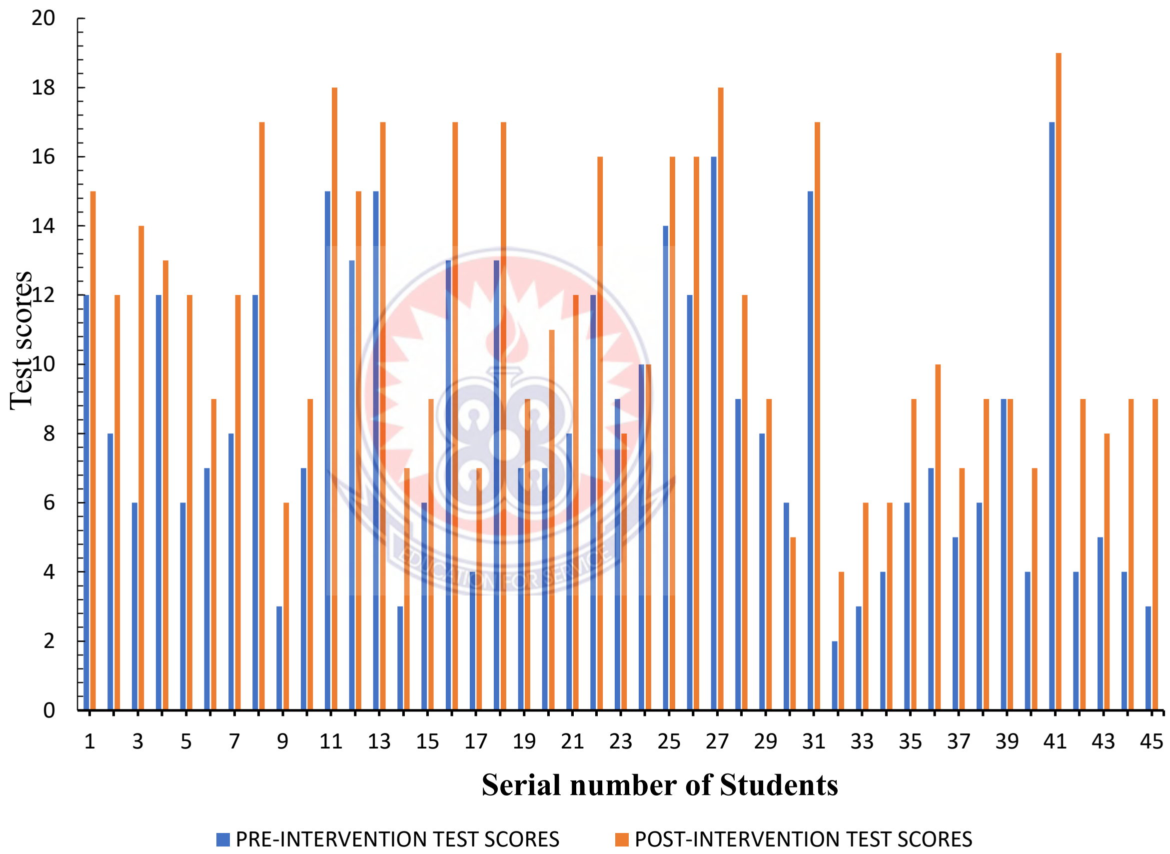


Figure 3: Chart showing scores of each student on the pre-intervention test and the post-intervention test

Figure 3, shows the scores of research samples at the pre-intervention test level and the post-intervention test level. These results revealed that the majority of students scored better in the nomenclature of cyclic hydrocarbons after being taught with computer-assisted instruction.

University of Education,Winneba http://ir.uew.edu.gh

Table 3 shows summary of the results of KNUST SHS students before and after intervention (Computer assisted instruction)

Table 3: Summary of Results of Students before and after Intervention

Tests	Mean Max=20	Mode	Mean Diff.	Standard Deviation	p-value	Remarks
Pre-intervention test	8.33	6	2.91	4.12	0.000413	Significant
Post-intervention test	11.24	9		4.13		

P > 0.05= Not Significant, P < 0.05 = Significant

Discussion of Results

Table 3 shows the results of students in the pre-intervention test and the post-intervention test. Students obtained a mean score of 8.33 on the pre-intervention test and 11.24 on the post-intervention test. The most occurring score or mode in the pre-intervention test is 6 but the mode in the pre-intervention test is 9. A mean difference of 2.91 was obtained. The standard deviation value of 4.12 was obtained at the pre-intervention test level and a standard deviation value of 4.13 was obtained for the post-intervention test. T-test was used to determine the statistically significant difference between the pre-intervention test scores and the post-intervention test scores and a p-value of 0.000413 which is lower than the significance level alpha (0.05) was obtained. With this result, one should reject the null hypothesis Ho_1. Hence, there is a significant difference between the pre-intervention scores and the post-intervention test scores when CAI in teaching and learning of nomenclature of cyclic hydrocarbons. These results strongly show that computer-assisted instruction can be an effective tool for enhancing the learning of cyclic hydrocarbon nomenclature.

CAI has been empirically proven to be an excellent teaching approach that increases students' achievement, stimulates their interest, and reduces their exhausting and abstract nature (Gambari & Adeghenro, 2008). The results agree with the findings of

University of Education,Winneba http://ir.uew.edu.gh

Adherr et al (2019), who examined the effect of computer assisted instruction (CAI) on students' cognitive achievement in chemistry. The study further revealed that the performance of low achievers was improved when they had lessons with CAI. The study recommends the immediate implementation of CAI in Chemistry lessons since it could increase students 'attendance to class, motivation, attitude and cognitive achievement in the subject. Egolum and Igboanugo (2021), examined the effects of computer-assisted instruction and PowerPoint presentations on the academic achievement of secondary school chemistry students. The results obtained showed that the Chemistry students taught using CAI performed significantly higher than those taught using PowerPoint Presentations. Abidoye (2015), Ayotola (2010) Gambari et al. (2014) and Salisu (2015) found that computer-assisted instruction had a significant effect on students' academic performance in different subjects of which Chemistry is not part. Anigbo and Orie (2018) revealed that Microsoft PowerPoint instructional strategy technology significantly enhanced students' academic achievement. Ezza et al. (2019) found that instructional technology significantly enhanced learners' compositing skills. Ruzicka and Milova (2019) found that there was a significant effect of video analysis in providing feedback on the process of downhill skiing skill acquisition. Ugwuanyi and Okeke (2020) found that PowerPoint presentations had a significant effect on students' achievement in physics and mathematics. Ugwuanyi et al. (2020) found that animated PowerPoint presentations (PPT) significantly enhanced the achievement of students' motivation in Chemistry. Ejimonye et al (2020), found that the 2D animation technique had a significant effect on students' motivation and achievement of chemistry concepts. Respectively, Ugwuanyi et al (2020) found that digital-based learning significantly ($p>05$) improved the achievement of primary school pupils both at the post-test and follow-up measures. The above review reveals

University of Education,Winneba http://ir.uew.edu.gh

that computer-assisted instruction has a significant impact on student's academics in science and other science subjects.

Findings

i. Students were able to identify the number of carbon atoms in the ring structure.
ii. Identify the hydrogen atoms bonded to the central atoms.
iii. Assign numbers to all substituents in naming cycloalkane, cycloalkenes and cycloalkynes.
iv. There was a clear increase in the mean score from the pre-intervention test to the post-intervention test.

Research Question 3: **What are the students' attitudes towards the use of computer assisted instruction in the teaching and learning of nomenclature of cyclic hydrocarbons?**

This research question sought to assess student attitude towards the use of computer assisted instruction in the teaching and learning of nomenclature of cyclic hydrocarbons.

Table 4 presents an investigation into students' attitude regarding the utilization of computer-assisted instruction in the teaching and learning of cyclic hydrocarbon nomenclature.

University of Education,Winneba http://ir.uew.edu.gh

Table 4: Students' Responses to Questionnaire on their attitude towards CAI for the Teaching and Learning of Nomenclature of Cyclic Hydrocarbons

S/N	Premise	SA F (%)	A F (%)	U F (%)	D F (%)	SD F (%)
		Number of Respondents = 45				
1	Using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons is an effective way to learn.	28 (62.3)	10(22.2)	5(11.1)	2 (4.4)	0(0.0)
2	I enjoy using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons.	31 (68.9)	10 (22.2)	1(2.2)	0(0.0)	3 (6.7)
3	Computer-assisted instruction helps me understand the nomenclature of cyclic hydrocarbons better.	20 (44.5)	15 (33.3)	5 (11.1)	4 (8.9)	1 (2.2)
4	Using computer-assisted instruction makes learning the nomenclature of cyclic hydrocarbons easier.	22 (48.9)	9 (20.0)	8 (17.8)	6 (13.3)	0 (0)
5	I am confident in my ability to learn the nomenclature of cyclic hydrocarbons using computer-assisted instruction.	19 (42.2)	17 (37.9)	2 (4.4)	2 (4.4)	5 (11.1)
6	I would recommend using computer-assisted instruction to others for learning	21(46.7)	10 (22.2)	8 (17.8)	6 (13.3)	0 (0.0)
7	I find using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons to be confusing.	4 (8.9)	7 (15.5)	3 (6.7)	13 (28.9)	18(40.0)
8	Computer-assisted instruction makes learning the nomenclature of cyclic hydrocarbons more difficult for me.	3 (6.8)	6 (13.3)	2 (4.4)	15(33.3)	19(42.2)
9	I get frustrated when using computer-assisted instruction to learn the nomenclature of cyclic hydrocarbons.	2(4.4)	0 (0.0)	11(24.4)	19 (42.3)	13 (28.9)

University of Education,Winneba http://ir.uew.edu.gh

10	I find it difficult to concentrate when using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons.	1(2.2)	4 (8.9)	2 (4.4)	26 (57.8)	12 (26.7)
12	I feel like I'm not learning as much when using computer-assisted instruction to learn the nomenclature of cyclic hydrocarbons.	3 (6.8)	2 (4.4)	6 (13.3)	15 (33.3)	19(42.2)
13	I would rather use traditional methods for learning the nomenclature of cyclic hydrocarbons than computer-assisted instruction.	2 (4.4)	0 (0.0)	9 (20.0)	7 (15.6)	27 (60.0)
14	Computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons is boring.	3 (6.8)	0 (0.0)	4 (8.9)	12 (26.6)	26 (57.7)

Key: SA = Strongly Agree, **A**= Agree, **U** =Undecided, **D**= Disagree, **SD**= Strongly Disagree, F= Frequency

Source: Field data, 2023

Discussion of Results

From Table 4, a total of 84.5% of respondents agreed that using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons is an effective way to learn while 11.1% of respondents were undecided. Lastly, 4.4 % of respondents disagreed with this statement.

According to Tareef (2014), using instructional technologies, particularly computers, is one of the most effective ways to make teaching and learning more interesting and effective. A total of 91.1% of respondents agreed that they enjoy using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons, 2.2% of respondents were undecided while 6.7% of respondents disagreed with this statement.

University of Education,Winneba http://ir.uew.edu.gh

The study recommends that the schools explore several techniques and means that include CAL to grow and sustain students' attitudes towards chemistry subjects.

Approximately, 77.8% of respondents agreed that computer-assisted instruction helps them understand the nomenclature of cyclic hydrocarbons better while 11.1% of respondents were undecided while 11.1% of respondents disagreed with this statement. Okonkwo (2020) discovered that when many difficult concepts are made clearer through appropriate teaching techniques such as CAI, low academic self-concept in Chemistry is overcome. Also, 68.9% of respondents agreed that using computer-assisted instruction makes learning the nomenclature of cyclic hydrocarbons easier, 17.8% were undecided and 13.3% of respondents disagreed with this statement. In total, 80.1% of respondents agreed that they are confident in their ability to learn the nomenclature of cyclic hydrocarbons using computer-assisted instruction, 4.4% of respondents indicated that they were undecided and 15.5% of respondents stated that they disagree. Approximately, 68.9% of respondents agreed that they would recommend using computer-assisted instruction to others for learning, 17.8% were undecided and 13.3% of respondents disagreed with this statement. In total, 24.4% of respondents stated that they find using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons to be confusing, 6.7% were undecided and 68.9% of respondents disagreed. In total, 20.1% of respondents indicated that computer-assisted instruction makes learning the nomenclature of cyclic hydrocarbons more difficult, 4.4% of respondents indicated otherwise and 75.5% of respondents disagreed. Approximately 11.1% of respondents agreed that they find it difficult to concentrate when using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons, 4.4% of respondents were undecided and 84.5% of respondents disagreed with this statement. A total of 11.2% of respondents agreed that they feel like

University of Education,Winneba http://ir.uew.edu.gh

they are not learning as much when using computer-assisted instruction to learn the nomenclature of cyclic hydrocarbons, 13.3% were undecided and 75.5 % disagreed.

In total, 4.4% of respondents agreed that they would rather use traditional methods for learning the nomenclature of cyclic hydrocarbons than computer-assisted instruction, 20% were undecided and 75.6% of respondents disagreed with this statement. A total of 6.8% of respondents agreed that computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons is boring, 8.9 % of respondents were undecided whilst 84.2% disagreed with this statement. From the above results, it can be revealed empirically that, CAI improves students' attitude towards the nomenclature of cyclic hydrocarbons and students have a positive attitude towards this approach.

Findings

These were students' attitude toward CAI after it was used in teaching and learning nomenclature of cyclic hydrocarbons.

i. increased in respondent interest and participation.

ii. students finding it easier to learn with CAI.

iii. confidence in learning and recommend to others.

iv. few students found CAI confusing, more difficult and boring.

Research Question 4: What is the role of CAI in promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons?

This research question sought to investigate the role of CAI in promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons.

University of Education,Winneba http://ir.uew.edu.gh

Table 5 shows students' responses to questionnaire on the role of CAI as a tool for promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons.

University of Education,Winneba http://ir.uew.edu.gh

Table 5: Students' Responses to Questionnaire

S/N	Premise	SA F (%)	A F (%)	U F (%)	D F (%)	SD F (%)
		Number of Respondents = 45				
1	I found the use of CAI to be distracting and unhelpful in learning the nomenclature of cyclic hydrocarbons.	2 (4.4)	4(8.9)	9(20.0)	17(37.8)	13(28.9)
2	I found it difficult to stay focused during CAI sessions for learning the nomenclature of cyclic hydrocarbons.	0(0.0)	1(2.2)	0(0.0)	23(51.1)	21(46.7)
3	I found that CAI allowed for more interaction and engagement with the material compared to traditional teaching methods for learning the nomenclature of cyclic hydrocarbons.	22(48.9)	15(33.4)	6(13.3)	2(4.4)	0(0)
4	I enjoyed the flexibility and convenience of using CAI for learning the nomenclature of cyclic hydrocarbons.	21(46.6)	17(37.8)	0(0.0)	4(8.9)	3(6.7)
5	CAI helped me to apply my knowledge of cyclic hydrocarbons to solve problems.	24(53.4)	11(24.4)	9(20)	1(2.2)	0(0.0)
6	CAI encouraged me to take a more active role in my learning about cyclic hydrocarbons.	26(57.6)	12(26.7)	4(8.9)	3(6.8)	0(0.0)
7	I was satisfied with the level of feedback provided by CAI while learning about cyclic hydrocarbons.	22(48.9)	19(42.3)	0(0.0)	2(4.4)	2(4.4)
8	The pace of CAI was too slow for my learning style.	4(8.9)	2(4.4)	0(0.0)	19(42.3)	20(44.4)

Key: SA = Strongly Agree, **A**= Agree, **U** =Undecided, **D**= Disagree, **SD**= Strongly Disagree, F= Frequency

Source: Field data, 2023

University of Education,Winneba http://ir.uew.edu.gh

Discussion of Results

Concerning Table 5, a total of 13.3 % of respondents agreed that they found the use of CAI to be distracting and unhelpful in learning the nomenclature of cyclic hydrocarbons, 20% of respondents were undecided and 66.7% of respondents disagreed with this statement. In total, 2.2% of respondents agreed that they found it difficult to stay focused during CAI sessions for learning the nomenclature of cyclic hydrocarbons while 97.8% of respondents disagreed with this statement.

Approximately, 82.3% of respondents agreed that CAI allowed for more interaction and engagement with the material compared to traditional teaching methods for learning the nomenclature of cyclic hydrocarbons, 15.5 % of respondents were undecided while 2.2% of respondents disagreed with this statement. In total, 84.4% of respondents agreed that they enjoyed the flexibility and convenience of using CAI for learning the nomenclature of cyclic hydrocarbons and 15.6% of respondents disagreed with this. A total of 77.7% of respondents agreed that CAI helped them to apply their knowledge of cyclic hydrocarbons to solve problems, 20% were undecided and 2.2% of respondents disagreed with this statement. Approximately 84.3 % of respondents agreed that CAI encouraged them to take a more active role in their learning about cyclic hydrocarbons,8.9% of respondents indicated that they were undecided and a total of 6.8% disagreed with this statement. Gonzalez and Birch (2000) established that computer-assisted learning has the potential to promote active learning in a wide range of disciplines of which science, and for that matter chemistry, is not an exception Another study conducted by Dap-og and Orongan (2022) study determined the effect of CAI on students' academic achievement and engagement in science. According to the study, there is a significant difference in students' engagement level for a cognitive domain in favour of CAI. It is concluded that CAI as a science learning tool enhances

University of Education,Winneba http://ir.uew.edu.gh

the students' cognitive engagement. A total of 91.2% of respondents agreed that they are satisfied with the level of feedback provided by CAI while learning about cyclic hydrocarbons and 8.8% of respondents indicated that they disagree with this statement

A total of 13.3% of the respondents agreed that the pace of CAI was too slow for my learning style while 86.7% of respondents disagreed with this statement. The results above reveal that CAI makes students active and engages them in the teaching and learning process. This result agrees with the findings of Busari et al. (2016) who discovered in their study that CAI engages students, makes them active class participants, and motivates them.

Findings

These were the role of CAI in promoting active learning and enhanced students' engagement in the naming of cyclic hydrocarbons.

i. students staying focused during CAI sessions.
ii. CAI allowed for move interaction and engagement compared to traditional teaching methods.
iii. respondents enjoyed the flexibility and convenience of using CAI for learning.
iv. CAI helps in better understanding and facilities learning.

University of Education,Winneba http://ir.uew.edu.gh

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter contains a summary of findings, conclusions, recommendations and suggestions offered to improve upon the teaching and learning of organic nomenclature of cyclic hydrocarbons.

5.1 Summary of Major Findings

The findings of this study are summarised as follows:

1. Unfamiliarity of hydrocarbon prosperities e.g. low boiling and melting point temperatures, poorly or not soluble in polar solvents, e.g. Water.
2. Majority struggled with naming conventions, including substituent ordering and functional group roles.
3. Difficulty differentiating between structural isomers and naming branch chain hydrocarbons.
4. Widespread confusion and difficulty understanding hydrocarbon nomenclature rules and conventions.
5. Implementation of computer-assisted instruction (CAI) led to improved performance in cyclic hydrocarbon nomenclature learning.
6. Strong agreement among respondents regarding the effectiveness of CAI for learning.
7. High levels of engagement and enjoyment reported by most respondents using CAI.
8. Agreement that CAI aids in better subject understanding and facilitates learning.
9. Confidence in learning with CAI and willingness to recommend it to others.

University of Education,Winneba http://ir.uew.edu.gh

10. Majority disagreement with perceptions of CAI being confusing, difficult, or leading to decreased concentration or learning.
11. Preference for CAI over traditional methods among most respondents.
12. Majority disagreement with the perception of CAI being boring.
13. Mixed responses regarding the impact of CAI on focus and usefulness in learning cyclic hydrocarbon nomenclature, with a significant majority seeing it as helpful and engaging.

5.2 Conclusions

In conclusion, students expressed difficulties in understanding hydrocarbon proprieties, struggles with naming and identifying structural isomers, and challenges in grasping the nomenclature of branch chain hydrocarbons. Computer-assisted instruction (CAI) have positive impact on students' academic performance in naming cyclic hydrocarbons. Again, students had positive attitude towards CAI in teaching and learning of cyclic hydrocarbon nomenclature. These insights emphasize the significance of integrating CAI into chemistry teaching to enhance students' understanding and motivation.

5.3 Recommendations

Based on the findings from this study, the following recommendations were made:

1. Placing science students of KNUST SHS at the center of the teaching and learning process is essential to actively involve them in the naming of cyclic hydrocarbons.
2. Chemistry teachers of KNUST SHS should adopt the computer-assisted instruction (CAI) instead of traditional teaching methods when teaching chemistry concepts.

University of Education,Winneba http://ir.uew.edu.gh

3. Providing specialized training for all KNUST SHS teachers on effectively utilizing computers and other technologies to teach chemistry concepts is crucial.
4. It is important to organize regular in-service training for KNUST SHS teachers to update their knowledge on the significance of diversifying their instructional approaches to achieve positive outcomes.
5. KNUST SHS should take the initiative to provide the necessary ICT tools and devices required for implementing the CAI.
6. KNUST SHS chemistry teachers should give prompt feedback to students after every task is essential to help them identify their strengths and weaknesses and work on improving them.
7. The curriculum should prioritize the use of CAI to enhance students' practical and inquiry skills, which are vital for learning science. Students should be given both theoretical and practical assignments to deepen their understanding.

5.4 Suggestions

It is suggested that other researchers could:

i. Undertake a cross-sectional study to assess the effects of CAI on the teaching and learning of organic nomenclature in public senior high schools in the Central Region of Ghana.

ii. Conduct a comparative study to investigate the effects of CAI on the teaching and learning of organic nomenclature in rural and urban districts in Ghana.

iii. Conduct a study to examine the effects of CAI on the performance of male and female senior high school chemistry students in selected institutions in the Central Region of Ghana.

University of Education,Winneba http://ir.uew.edu.gh

REFERENCES

Abdoolatiff, S., & Narod, F. B. (2009). *Investigating the effectiveness of computer simulations in the teaching of "Atomic Structure and Bonding". In Chemistry education in the ICT age* (pp. 85-100). Springer.

Abidoye, J. A. (2015). Effect of the multimedia-based instructional package on secondary school students' academic achievement in Geography in Oyo State, Nigeria. *Journal of Research in National Development*, *13*(1), 21-25.

Academic Performance Index (2013). *Policy brief*. University of Southern California.

Adamu, A. A., (2016). Antecedents of internal crisis communication and its consequences on employee performance. *International Review of Management and Marketing*, *6*(7), 33-41.

Adediwura, A. A., & Tayo, B. (2007). Perception of teachers' knowledge, attitude and teaching skills as a predictor of academic performance in Nigerian secondary schools. *Educational Research and Reviews*, *2*(7), 165.

Adefila, J. J., (2004). *The effect of dividend policy on the market price of shares in Nigeria.* Case Study of Fifteen Quoted Companies. *International Journal of Accounting, 2*(1), 1-10.

Adesoji, F. A., & Oginni, A. M. (2012). Students' aptitude indices as predictors of learning outcomes in chemistry. *British Journal of Arts and Social Sciences*, *8*(2), 174-182.

Adherr, N. S. K., Ayiwah, M. W., & Boi-Doku, A. (2019). The effect of computer assisted instruction (CAI) on students' cognitive achievement in chemical bonding. A case study of schools in the Kwahu East District of Ghana. *Journal of Education and Practice, 10* (20).

Ahmodu, A. L. O. L. O., Olamide, L., & Iyabo, S. S. (2022). *School facilities and students' academic performance in Oshodi-Isolo LGA senior secondary schools*. Lagos State.

Ajewole, G. A. Oginni, A. M., & Okedeyi A. S. (2006). Management of resources for science, Technology and Mathematics Education: Problems and the way forward. *47th Annual Conference Proceedings*, 67 – 71.

Alabi, A. T. (2011). Funding strategies and sustenance of early childhood education in Nigeria: The way forward. *European Scientific Journal*, *8*(1), 12-21.

Alade, A. A., & Adeyemo, A. A. (2010). Practical work in chemistry: analysis of SS2 students' experiences and difficulties. *Journal of Education in Science, Environment and Health, 1*(1), 103-111.

Aliasgari, M., Riahinia, N., & Mojdehavar, F. (2010). *Computer assisted instruction and student attitudes towards learning mathematics*. Education, Business and Society: *Contemporary Middle Eastern Issues*, *3*(1), 6-14.

University of Education,Winneba http://ir.uew.edu.gh

Amaechina, U. O., & Ezeh, S. C. (2019). School environment and academic performance of secondary school students in Enugu Education Zone. *Benue State University Journal of Educational Management*, *1*(2), 125-131.

Amara, A. (2006). FPGA vs. ASIC for low power applications. *Microelectronics Journal*, *37*(8), 669-677.

Anigbo, L. C., & Orie, M. J. (2018). Effect of PowerPoint instruction on students' academic achievement in computer science (database management system) in Colleges of Education in Rivers State. *Computer Engineering and Intelligent Systems*, *9*(1), 1-6.

Antwi, V., Anderson, I. K., & Sakyi-Hagan, N. (2015). Effect of Computer-Assisted Instruction on Students' Interests and Attitudes in Learning Electricity and Magnetism in a Ghanaian Senior High School. *International Journal of Innovative Research and Development*, *4*(4), 302-315.

Arvind, V. R., & Heard, J. W. (2010). Physics by simulation: Teaching circular motion using applets. *Latin American Journal of Physics Education, 4*(1), 35-39.

Ayotola, A. (2010). What can technology not do? Views of Nigerian higher education teachers on technology integration issues. *East Africa Journal of Educational Research & Policy*, *4*.

Azar, A., & Aydın Şengüleç, Özlem. (2011). Computer-assisted and laboratory-assisted teaching methods in physics teaching: the effect on student physics achievement and attitude towards physics. *International Journal of Physics and Chemistry Education*, *3*(SI), 43–50.

Baah., R. (2012). An investigation into senior high school students' understanding and difficulties in writing chemical formulae of inorganic compounds. *International Journal of Research Studies in Educational Technology*, *1*(2), 31-39.

Baddeley, A., (1986). Dementia and working memory. *The Quarterly Journal of Experimental Psychology Section A*, *38*(4), 603-618.

Bakaç, C., Deng, M., Aich, G., & Gartmeier, M. (2020). Fictional video cases on parent-teacher conversations: authenticity in the eyes of teachers and teacher education students. *Education Sciences*, *10*(3), 63.

Barnea, N. (2000). Teaching and learning about chemistry and modelling with a computer managed modelling system. *Developing Models in Science Education, 307-323.*

Barot, H. M. (2009). *Development and effectiveness of CAI in Sanskrit for standard IX students.*

Bateman, K., & NG James, M. (2011). Plant protein proteinase inhibitors: structure and mechanism of inhibition. *Current Protein and Peptide Science*, *12*(5), 341-347.

University of Education,Winneba http://ir.uew.edu.gh

Bateman, R. C., Booth, D., Sirochman, R., & Richardson, J. R. (2002). Teaching and assessing three-dimentional molecular literacy in undergraduate biochemistry. *Journal of Chemical Education, 79*(5).

Bayrak, B., Kanlı, U. & Kandil İngeç, Ş. (2007). To compare the effects of computer-based learning and laboratory-based learning on students' achievement regarding electric circuits. *The Turkish Online Journal of Educational Technology, 6*(1), 15-24.

Belachew, W., Barke, H. D., & Yitbarek, S. (2018). Effects of conceptual change instructional approach on achievement of pre-service chemistry teachers in aliphatic hydrocarbon concepts. *African Journal of Chemical Education*, *8*(2), 7-23.

Bello, R., (2022). Visualizing street pavement anomalies through fog computing v2i networks and machine learning. *Sensors*, *22*(2), 456.

Ben-Zvi, R., Eylon, B. S., & Silberstein, J. (2002). Is an atom of copper malleable? *Journal of Chemical Education*, *63*(1), 64.

Bhandari, B. (2020). Self-directed learning: assessment of students' abilities and their perspective. *Advances in Physiology Education*, *44*(3), 383-386.

Bichi, A. A. (2009). *Teachers' awareness of the value component of the national policy on education in Nigeria*.

Bodner, G. M., & McMillen, T. L. (1986). Cognitive restructuring is an early stage in problem solving. *Journal of Research in Science Teaching*, *23*(8), 727-737.

Bolarinwa, O. M. (2020). Influence of Sports on Academic Performance of Secondary School Students in Ekiti State, Nigeria. *International Review of Social Sciences and Humanities*, *2*(1), 240-248.

Brunken, R., Plass, J. L., & Leutner, D. (2003). Direct measurement of cognitive load in multimedia learning. *Educational Psychologist*, *38*(1), 53-61.

Brunner (1961). Studies in Cognitive Growth, London: Wiley. Copeland, R. W. (1974): *How Children Learn Mathematics*, New York: Macmillan Donovan, A. Johnson (1971): Guidelines for Teaching Mathematics: In UNESCO Source

Bryan, L. C. H. (2007). Identifying students' misconceptions in 'a-level'organic chemistry. *Journal of Chemical Education*, *34*, 12.

Busari, O. O, Ernest, S.B. & Ugwuanyi, P. N (2016). Effect of computer-assisted instruction (CAI) on senior secondary students' achievement in the chemical reaction and equilibrium in Egbeda local government area of Oyo State. *International Journal of Secondary Education, 4*(4), 39-43.

Cakir, M. (2008). Constructivist approaches to learning in science and their implications for science pedagogy: A literature review. *International Journal of Environmental and Science Education*, *3*(4), 193-206.

University of Education,Winneba http://ir.uew.edu.gh

Canelas, D. A., Hill, J. L., & Novicki, A. (2017). Cooperative learning in organic chemistry increases student assessment of learning gains in key transferable skills. *Chemistry Education Research and Practice*, *18*(3), 441-456.

Carter, C. S., Larussa, M. A., & Bodner, G. M. (1987). A study of two measures of spatial ability as predictors of success in different levels of general chemistry. *Journal of Research in Science Teaching*, *24*(7), 645-657.

Charles, C. M., & Senter, G. W. (2002). *Elementary classroom management* (3rd ed.). Cambridge University Press.

Chaudhari, P. (2013). Computer Assisted Instruction (CAI): Development of instructional Strategy for Biology teaching. *Educationonia Confab*, *2*(1), 106-116.

Chebotib, N., & Kering, V. K. (2021). Students' Attitudes towards computer-assisted learning in Biology Subject in a selected secondary school in Uasin Gishu County, Kenya. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *11*(2), 55-

Chi, M. T. H, Glaser, R., Rees, E., & Steinberg, R. J. (2012). How knowledge is structured and used by experts in real-world setting. In J. E Brophy (Eds), *The Cambridge handbook of expertise and expert performance* (pp, 125 -152). Cambridge University Press.

Chifwa, J. (2015). *The teaching of Genetics in selected secondary schools in Kitwe District, Zambia* (Doctoral dissertation).

Chiu, H. M., & Hui, S. L. (2005). Conceptions of science and science teaching. *Research in Science Education, 35*(1), 95-125.

Cohen, L., Manion, L., & Morrison, K. (2017). *Action research. In research methods in education* Routledge (pp. 440-456).

Coll, K. Taylor, N. (2002). Mental models in chemistry: senior chemistry students' mental models of chemical bonding. *Chemistry Education Research and Practice*, *3*(2), 175-184.

Coll, R. K., & Treagust, D. F. (2003). Investigation of secondary school, undergraduate, and graduate learners' mental models of ionic bonding. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *40*(5), 464-486.

Costa, M. F., Oiwa, N. N. & Ventura, D. F. (2008). A computer-controlled color vision test for children based on the Cambridge Colour Test. *Visual Neuroscience*, *25*(3), 445-450.

Cotton, K. (2001) Computer Assisted Instruction. *Eurasian Journal of Physics and Chemistry Education,* (Special Issue), 34-42.

Coulson, A. (2008). *Public school academic performance: National trends.*

University of Education,Winneba http://ir.uew.edu.gh

Damoense, M. Y. (2003). Online learning: Implications for effective learning for higher education in South Africa. *Australasian Journal of Educational Technology*, *19*(1).

Danjuma, G. S. (2022). Effectiveness of concept mapping and competitive instructional strategies on basic education student performance in thermal energy in Taraba state, Nigeria. *Academic Journal*, 7-7.

Dap-og, E. R., & Orongan, M. J. Q. (2022). Computer-assisted instruction on students' academic achievement and engagement in science. *International Journal of Teaching and Learning*, *1*(1), 46-57.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., & Brigid, B. D., Osher. (2019). Implications for the educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2).

Davar, M. (2012). *Teaching of science*. PHI Learning Private Limited

De Jong, T. (2010). Cognitive load theory, educational research, and instructional design: Some food for thought. *Instructional Science*, *38*(2), 105-134.

Deary, I. J., Strand, S., Smith, P., & Fernandes, C. (2007). Intelligence and educational achievement. *Intelligence*, *35*(1), 13-21.

Dibal, G. C., Danjuma, I. M., & Musa, O. D. (2022). Relationship between teachers self-efficacy and academic performance of senior secondary school students in computer studies in Borno state, Nigeria. *Galaxy International Interdisciplinary Research Journal*, *10*(5), 129-134.

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, *14*(1), 4-58.

Ebenezer, J. V. (2001). A hypermedia environment to explore and negotiate students' conceptions: Animation of the solution process of table salt. *Journal of Science Education and Technology*, *10*, 73-92.

Egolum, E. O., & Igboanugo, B. I. (2021). Re–Engineering Chemistry Education for National Development through Development of Creativity Skills in Secondary School Students in Anambra State. *Unizik Journal of Stm Education*, *5*(1), 121-130.

Ejimonye, J. C., Ugwuanyi, C. S., Okeke, C. I. O., & Nwoye, M. N. (2020). Two-dimensional animation and students' achievement in mathematical economics: implications for science teaching. *International Journal of Engineering Research and Technology*, *13*(6), 1220-1230.

University of Education,Winneba http://ir.uew.edu.gh

Ekundayo, S. K. (2022). Effects of Computer-Assisted Instruction (CAI) On Students' Academic Achievement in Chemistry among Boys and Girls in Public Secondary Schools in Ondo State, Nigeria. *British Journal of Education*, *10*(2), 31-41.

Erduran, S. & Scerri (2009). Beyond philosophical confusion: establishing the role of philosophy of chemistry in chemical. *Journal of Baltic Science Education*, *8*(1).

Erduran, S., & Scerri, E. (2003). The nature of chemical knowledge and chemical education. In Gilbert, J.; de Jong, O.; Justi, R.; Treagust, D., van Driel, J, eds., *Chemical education: Towards research-based practice* (7–27). Kluwer.

Ertepinar, H. (1995). The relationship between formal reasoning ability, computer-assisted instruction and chemistry achievement. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *11*(11).

Ertepinar, H. (2015). Teacher Beliefs toward Using Alternative Teaching Approaches in Science and Mathematics Classes Related to Experience in Teaching. *International Journal of Environmental and Science Education*, *10*(5), 603-621.

Eze, T. I., Onwusa, S. C., & Nwaosa, F. I. (2020). Effectiveness of computer tutorial model, drill and practice on students 'achievement and retention in fabrication and welding technology in technical colleges. *European Journal of Education Studies*, *7*(10).

Ezza, E. S., Alhuqail, E., & Elhussain, S. (2019). Technology-Based Instructional Intervention into an EFL Writing Classroom. *Cypriot Journal of Educational Sciences*, *14*(4), 507-519.

Finkelstein, N. D., Adams, W. K., Keller, C. J., Kohl, P. B., Perkins, K. K., Podolefsky, N. S., ... & LeMaster, R. (2005). When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment. *Physical Review Special Topics-Physics Education Research*, *1*(1), 010-103

Fisher, J. D., (2006). An information-motivation-behavioural skills model of adherence to antiretroviral therapy. *Health Psychology*, *25*(4), 462.

Gabel, D. L., & Bunce, D. M. (2004). Research on problem-solving: Chemistry. *Handbook of Research on Science Teaching and Learning*, *11*, 301-326.

Gall, M. D., Gall, J. P., & Borg, W. R. (2007). *Educational research: an introduction* (8. utg.). AE Burvikovs, Red.) Pearson.

Gambari, A. I., & Adeghenro, D. V. (2008). Effects of computer-assisted instruction on mathematics achievement amongst students in Minna Metropolis. *Ilorin Journal of Education, 27*, 63-70.

Gambari, I. A., Ezenwa, V. I., & Anyanwu, R. C. (2014). Comparative effects of two modes of computer-assisted instructional packages on solid geometry achievement. *Contemporary Educational Technology*, *5*(2), 110-120.

University of Education,Winneba http://ir.uew.edu.gh

Gana, C. S. (2013). *Effects of computer assisted instruction with animation on achievement and retention of students of colleges of education in quantum physics.* Department of Science Education.

Garanga, M. M., Amadalo, M. M., Wanyonyi, M., Akwee, P. E., & Twoli, N. (2012). Evaluation of students' perceptions towards structure and chemical bonding upon using molecular models in selected Kenyan Public Secondary Schools. *Global Journal of Management Science and Technology*, *1*(4), 68-75.

Gebrekdian, T., Annette, L., & Lise, K. (2014). Small-scale chemistry for a hands-on approach to chemistry practical work in secondary schools: experiences from Ethiopa. *African Journal of Chemical Education, 4*, 48-94.

George, J. M. (2000). Emotions and leadership: The role of emotional intelligence. *Human Relations*, *53*(8), 1027-1055.

Goh A., & Chiang V. N. (2018). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, *88*(1), 28-54.

Gönen, S., Kocakaya, S., & Inan, C. (2006). The Effect of the Computer Assisted Teaching and 7e Model of the Constructivist Learning Methods on the Achievements and Attitudes of High School Students. *Turkish Online Journal of Educational Technology-TOJET*, *5*(4), 82-88.

González, G. M., & Birch, M. A. (2000). Evaluating the instructional efficacy of computer mediated interactive multimedia: Comparing three elementary statistics tutorial modules. *Journal of Educational Computing Research*, *22*(4), 411-436.

Gunn, A., & Pitt, S. J. (2003). The effectiveness of computer-based teaching packages in supporting student learning of parasitology. *Bioscience Education*, *1*(1), 1-14.

Hacieminoglu, E. (2016). Elementary School Students' Attitude toward Science and Related Variables. *International Journal of Environmental and Science Education*, *11*(2), 35-

Hailegebreal, T. D. (2012*). Effects of pedagogy-based technology on chemistry students' performance in higher education institutions of Ethiopia: a case study of Debre Berhan University* (Doctoral dissertation).

Hamzat, A., Bello, G., & Abimbola, I. O. (2017). Effects of computer animation instructional package on students' achievement in practical biology. *Cypriot Journal of Educational Science, 12*(4), 218–227. doi:10.18844/cjes. v11i4.1217

Hanson, R. (2014). Using small-scale chemistry equipment for the study of some organic chemistry topics-a case study in an undergraduate class in Ghana. *Small*, *5*(18).

Hanson, R. (2017). Enhancing students 'performance in organic chemistry through contextbased learning and micro activities-a case study. *European Journal of Research and Reflection in Educational Sciences, 5*(6), 7-20.

University of Education,Winneba http://ir.uew.edu.gh

Hargunani, S.P. (2010). The teaching of Faraday's and Lenz's theory of electromagnetic induction using java based on Faraday's lab simulations. *Latin American Journal of Physics Education, 4*(3), 520-522.

Heeman, G. M. (2015). Understanding and correcting student misconceptions in earth and environmental science. *Journal of Geoscience Education, 62*(6), 534-537.

Heikkinen, (2011). Exploring the effects of cumulative contextual cues on interpreting vibrotactile messages. In *Proceedings of the 13th International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 1-10).

Heng, C. K., & Karpudewan, M. (2015). The interaction effects of gender and grade level on secondary school students' attitude towards learning chemistry. *EURASIA Journal of Mathematics, Science and Technology Education*, *11*(4), 889-898.

Hoffman, J. L., Wu, H. K., Krajcik, J. S., & Soloway, E. (2003). The nature of middle school learners' science content understandings with the use of on-line resources. *Journal of Research in Science Teaching, 40*(3), 323- 346.

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, *88*(1), 28-54.

Horowitz, G., Rabin, L. A., & Brodale, D. L. (2013). Improving student performance in organic chemistry: help seeking behaviours and prior chemistry aptitude. *Journal of the Scholarship of Teaching and Learning, 13*(3), 120-133.

Huang, T., & Gui, W. (2022). A novel learning-based asynchronous sliding mode control for discrete-time semi-Markov jump systems. *Automatica*, *143*, 110428.

Huppert, J., (2002). Computer simulations in the high school: Students' cognitive stages, science process skills and academic achievement in microbiology. *International Journal of Science Education*, *24*(8), 803-821.

Ivanova, A., & Smrikarov, A. (2009). The new generations of students and the future of e-learning in higher education. *Proceedings of e-Learning*, *9*, 17-25.

Jarvis, P. (2006). Teaching styles and teaching methods. In *The theory and practice of teaching* Routledge (pp. 42-52).

Jin, Y. Q., Lin, C. L., Zhao, Q., Yu, S. W., & Su, Y. S. (2021). A study on traditional teaching method transferring to E-learning under the COVID-19 pandemic: From Chinese students' perspectives. *Frontiers in Psychology*, *12*, 632787

Johnson, R. B., & Christensen, L. (2019). *Educational research: Quantitative, qualitative, and mixed approaches*. Sage Publications.

Jones, C. G. (1991). On the evolution of plant secondary chemical diversity. *Philosophical Transaction of the Royal Society of London. Series B : Biological Sciences, 333(1267), 273-280.*

University of Education,Winneba http://ir.uew.edu.gh

Jones, J. C. (2017). Computer-assisted instruction. Retrieved on 29th November 2016 from http://www.newworldencyclopaedia.org.entry.

Jones, V., Jo, J., & Martin, P. (2007, February). Future Schools and How Technology can be used to Support Millennial and Generation-Z Students. In *ICUT 2007 (Proc. B), 1st Int. Conf. Ubiquitous Information Technology* (Vol. 12, p. 14).

Kavanaugh, R. D., & Moomaw, W. R. (1981). Inducing formal thought in introductory chemistry students. *Journal of Chemical Education*, *58*(3), 263.

Kay, C. C., & Yiin, H. K. (2010). *Misconceptions in the teaching of chemistry in secondary schools in Singapore & Malaysia*. Proceedings of the Sunway Academic Conference 2010/1. Sunway College Johor Bahru.

Keig, P. F., & Rubba, P. A. (1993). Translation of representations of the structure of matter and its relationship to reasoning, gender, spatial reasoning, and specific prior knowledge. *Journal of Research in Science Teaching*, *30*(8), 883-903.

Kessler, G. (2018). Technology and the future of language teaching. *Foreign language annals*, *51*(1), 205-218.

Kirschner, P. A., & Karpinski, A. C. (2010). Facebook® and academic performance. *Computers in Human Behaviour*, *26*(6), 1237-1245.

Kobiowu, S. V. &Alao, F. (2010). The challenges of examination instructional strategies and Developing societies: The Nigerian Scenario. Retrieved from http:www.Porto.Ucp/ open/ modules/ doc/ hml.

Kozma, R. B., & Russell, J. (2013). Multimedia and understanding: Expert and novice responses to different representations of chemical phenomena. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *34*(9), 949-968.

Krajcik, J. S., & Soloway, E. (2001). Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *38*(7), 821-842.

Kubey, R. W., Lavin, M. J., & Barrows, J. R. (2001). Internet use and collegiate academic performance decrements: Early findings. *Journal of Communication*, *51*(2), 366-382.

Kubiak, S. P., Kim, W. J., Bybee, D., & Eshelman, L. (2014). Assessing the validity of the self-appraisal questionnaire in differentiating high-risk and violent female offenders. *The Prison Journal*, *94*(3), 305-327.

Lai, C., Wang, Q., & Lei, J. (2012). What factors predict undergraduate students' use of technology for learning? A case from Hong Kong. *Computers & Education*, *59*(2), 569-579.

University of Education,Winneba http://ir.uew.edu.gh

Lakpini, M. A. (2006). *Effect of PIPS and conceptual change instructional strategy on the achievement, retention and attitude of senior secondary school* (SSII) biology students with varied ability levels. Ahmadu Bello University.

Lavin. D. E. (2006). The Prediction of Academic Performance; A Theoretical Analysis in Review of Research. Russell Sage Foundation

Leech, N. L., (2011). Assessing internal consistency in counseling research. *Counselling Outcome Research and Evaluation*, *2*(2), 115-125.

Li, J., Li, Z., Yang, Y., Kong, B., & Wang, C. (2018). Laboratory study on the inhibitory effect of free radical scavenger on coal spontaneous combustion. *Fuel processing technology*, *171*, 350-360.

Lujara, S. (2008). *Development of e-learning content and delivery for self-learning environment: Case of selected rural secondary schools in Tanzania.* Blekinge Institute of Technology

Lutviana, E., Rahardjo, S. B., Susanti, E., Yamtinah, S., Mulyani, S., & Saputro, S. (2019). The computer-assisted test assessment instrument to measure students' learning difficulties in chemical bonding. In *Journal of Physics: Conference Series* (Vol. 1156, No. 1, p. 012019). IOP Publishing.

Mafumiko, F. M. (2008). The potential of micro-scale chemistry experimentation in enhancing teaching and learning of secondary chemistry: Experiences from Tanzanian classrooms. *NUE Journal of International Cooperation 3*, 63-79.

Mayer, R. E. (2003). The promise of multimedia learning: using the same instructional design methods across different media. *Learning and Instruction*, *13*(2), 125-139.

Mayer, R. E. (2009). A testing effect with multimedia learning. *Journal of Educational Psychology*, *101*(3), 621.

Mayer, R. E. (2014). Benefits of emotional design in multimedia instruction. *Learning and Instruction*, *33*, 12-18.

Mayer, R. E. (Ed.). (2005a). *The Cambridge handbook of multimedia learning*. Cambridge University Press.

Mayer, R. E., & Moreno, R. (2009). A split-attention effect in multimedia learning: Evidence for dual processing system in working memory. *Journal of Educational Psychology*, *90*(2), 312.

Mayer, R. E., & Moreno, R. E. (2010a). *Techniques that reduce extraneous cognitive load and manage intrinsic cognitive load during multimedia learning*.

Mayer, R. E., (2005b). When static media promote active learning: annotated illustrations versus narrated animations in multimedia instruction. *Journal of Experimental Psychology: Applied*, *11*(4), 256.

University of Education,Winneba http://ir.uew.edu.gh

McNiff, J., & Whitehead, J. (2012). *Action research for teachers: A practical guide*. Routledge.

Megan, W. (2011). *A practical guide to conducting classroom observation.* Retrieved from http://www.Alafrica.comlpractical-guide-to-conductingclassroom.observation. hml.

Miao, Z., Yao, J., Sha, L., & Chen, Y. (2018). Exploration of an interactive "Virtual and Actual Combined" teaching mode in medical developmental biology. *Biochemistry and Molecular Biology Education*, *46*(6), 585-591.

Mlyakado, B. P., & Timothy, N. (2014). Effects of Students' sexual relationship on academic performance among secondary school students in Tanzania. *Academic Research International*, *5*(4), 278-286.

Mohan, L. (2010). Students' attitudes towards the use of audio-visual aids during didactic lectures in pharmacology. *Journal of Clinical and Diagnostic Research*, *4*(6), 3363-3368.

Moore, D. M. M., Burton, J. K., & Myers, R. J. (2004). *Multiple-Channel Communication: The Theoretical and Research Foundation of Multimedia*.

Moore, K. D. (2014). *Effective instructional strategies: From theory to practice*. Sage Publications.

Morgil, I. (2005). Traditional and computer-assisted learning in teaching acids and bases. *Chemistry Education Research and Practice*, *6*(1), 52-63.

Nakhleh, M. B., & Krajcik, J. S. (2010). Influence of levels of information as presented by different technologies on students' understanding of acid, base, and pH concepts. *Journal of Research in Science Teaching*, *31*(10), 1077-1096.

Nicholas, K. S. (2004). *The perceived impact of campus beautification on middle school students' behaviour and academic performance*. The University of the Pacific.

Nicoll, G. (2001). A report of undergraduates' bonding misconceptions. *International Journal of Science Education*, *23*(7), 707-730.

Nurdin, E. A. (2011). The promise and caveats of implementing discovery-inquiry learning. *Jurnal Pengajaran MIPA*, *23*(1), 76-80.

Nurudeen, M., Abdul-Samad, S., Owusu-Oware, E., Koi-Akrofi, G. Y., & Tanye, H. A. (2023). Measuring the effect of social media on student academic performance using a social media influence factor model. *Education and Information Technologies*, *28*(1), 11651188.

Ochoyi, U. E., & Ukwumunu, A. I. (2008). Integration of ICT in the secondary school curriculum in Nigeria: Problems and Prospects. In *Proceedings of the 49th Annual Conference of Science Teachers Association of Nigeria*.

University of Education,Winneba http://ir.uew.edu.gh

Okonkwo, G. (2020). *Effect of computer–assisted instruction on senior secondary school student's academic self-concept in chemistry*.

Olatunji, S. O., Aghimien, D. O., Oke, A. E., & Olushola, E. (2016). Factors Affecting Performance of Undergraduate Students in Construction Related Disciplines. *Journal of Education and Practice*, *7*(13), 55-62.

Onasanya, S. A., Daramola, F. O., & Asuquo, E. N. (2006). Effect of the computer-assisted instructional package on secondary school student's performance in introductory Technology in Ilorin, Nigeria. *The Nigeria Journal of Educational Media and Technology*, *12*(1), 29-36.

Orjika, M. O. (2012). *Effect of computer-assisted instruction packages on secondary school student's achievement and interest in Biology.* Department of Science Education.

Osemwinyen, A. C. (2009). *Effects of e-learning on retention and achievement in secondary school mathematics in Abuja, Nigeria*. University of Nigeria.

Owusu, K. A., Monney, K. A., Appiah, J. Y., & Wilmot, E. M. (2010). Effects of computer assisted instruction on performance of senior high school biology students in Ghana. *Computers & Education, 55* (2), 904–910.

Oyserman, D., Elmore, K., & Smith, G. (2012). Self, self-concept, and identity. In M. R. Leary & J. P. Tangney (Eds.), *Handbook of self and identity* (2nd ed.). pp. 69–104). Guilford Press.

Özmen, H. (2004). Some student misconceptions in chemistry: A literature review of chemical bonding. *Journal of science education and technology*, *13*, 147-159.

Özmen, H. (2008). The influence of computer-assisted instruction on students' conceptual understanding of chemical bonding and attitude toward chemistry: A case for Turkey. *Computers & Education*, *51*(1), 423-438.

Özmen, H., & Kolomuç, A. (2004). Bilgisayarli öğretimin çözeltiler konusundaki öğrenci başarisina etkisi. *Kastamonu Eğitim Dergisi*, *57*.

Papanastasiou, E. C., Zembylas, M., & Vrasidas, C. (2003). Can computer use hurt science achievement? The USA results from PISA. *Journal of Science Education and Technology*, 325-332.

Pella, D. (1997). Modelling progressive hardening of shotcrete in convergence-confinement approach to tunnel design. *Tunnelling and Underground Space Technology*, *12*(3), 425-431.

Peters, M. (2006). Developing computer competencies for pre-service language teachers. *Teacher Education in CALL*, 154-165.

Petty, G. (2009). *Teaching today: A practical guide* (4th ed.). Nelson Thornes Publishers Ltd.

University of Education,Winneba http://ir.uew.edu.gh

Petty, J. (2013). Interactive, technology-enhanced self-regulated learning tools in healthcare education: A literature review. *Nurse Education Today*, *33*(1), 53-59.

Pilli, O., & Aksu, M. (2013). The effects of computer-assisted instruction on the achievement, attitudes and retention of fourth-grade mathematics students in North Cyprus. *Computers & Education*, *62*, 62-71.

Popoola, G. A. (2010). Influence of reading habit on student academic performance in a senior second school in Ibadan. In *Multifaceted strategies for social-emotional learning and whole learner education* (pp. 141-162

Ruzicka, I., & Milova, J. (2019). Increasing the Efficiency of Motor Learning with the Help of Video Analysis. *Cypriot Journal of Educational Sciences*, *14*(4), 723-730.

Salau, A. M. (2000). Meaningful learning and cognitive load in chemistry learning environment. *American Journal of Physics, 68(*10), 946 - 954.

Salisu, A. (2015). *Impact of animated-media strategy on achievement, retention and interest among secondary school geography students in weather concepts,* Kastina State, Nigeria. Ahmadu Bello University.

Samuel, N. N. C., & Okonkwo, O. I. (2020). Effects of computer-assisted instruction on senior secondary school student's academic self-concept in Chemistry. *Journal of International Academic Research for Multi-disciplinary, 8*(7), 13-20.

Sani, N. A. (2016). Halal Laws": From Conception to Current Challenges. In *Proceedings of the Persiswa Law Conference* (pp. 23-24).

Sarkodie, P. A., & Adu-Gyamfi, K. (2015). Improving students' performance in naming and writing structural formulae of hydrocarbons using the ball-and-stick models. *Chemistry: Bulgarian Journal of Science Education, 24*(2), 203-2019.

Scanlan, M. (2012). Book Review: Bryk, A., Sebring, P. B., Allensworth, E., Luppescu, S., & Easton, J. (2009). *Organizing schools for improvement: Lessons from Chicago*. University of Chicago Press.

Scanlan, M., & López, F. (2012). Vamos! How school leaders promote equity and excellence for bilingual students. *Educational Administration Quarterly*, *48*(4), 583-625.

Schnotz, W. (2005). An integrated model of text and picture comprehension. *The Cambridge Handbook of Multimedia Learning*, *49*(2005), 69.

Scott, B. (2001). Relevance of Assessing Secondary School of Students learning outcome. *International Journal of Educational Research, 30*(15) 220-33.

Sendur, G., & Toprak, M. (2013). The role of conceptual change texts to improve students' understanding of alkenes. *Chemistry Education Research and Practice, 14*, 431-449. doi:10.1039/c3rp00019b

University of Education,Winneba http://ir.uew.edu.gh

Shaw, K. (2006). *Computer aided instruction*. www.keithshaw.co.uk (Retrieved 8 May 2014)

Sibandze, S. F., Oloyede, O. I., & Pereira, L. (2020). Exploring the impact of blended learning on learners' academic performance in Accounting. *IOSR Journal of Humanities and Social Science*, *25*(5), 1-11.

Sibomana, A., Karegeya, C., & Sentongo, J. (2020). Students' conceptual understanding of organic chemistry and classroom implications in the Rwandan perspectives: A literature review. *African Journal of Educational Studies in Mathematics and Sciences*, *16*(2), 13-32.

Sirhan, G. (2007). Learning difficulties in chemistry: An overview. *Journal of Turkish Science Education, 4*(2), 2-20.

Smrikarov, A. S. (2011). Evaluation of mobile learning system. *Procedia Computer Science*, *3*, 632-637.

Solonchak, T., & Pesina, S. (2015). Cognitive properties of images and metaphors. *Procedia-Social and Behavioural Sciences*, *192*, 650-655.

Sorden, S. D. (2005). A cognitive approach to instructional design for multimedia learning. *Informing Science*, *8*, 263.

Steffen, L. K., Gill, M., Gundersen, J., & Nelson, J. E. (1996). Creating simple, low-cost, animations for organic chemistry instruction. *The Chemical Educator*, *1*, 1-8.

Stieff, M., & Wilensky, U. (2003). Connected chemistry: Incorporating interactive simulations into the chemistry classroom. *Journal of Science Education and Technology*, 285-302.

Stillings, N. A., Chase, C. H., Weisler, S. E., Feinstein, M. H., & Rissland, E. L. (2010). *Cognitive science: An introduction*. MIT Press.

Stoller, J. K. (2021). A Perspective on the Educational "SWOT" of the Coronavirus Pandemic. *Chest*, *159*(2), 743-748.

Subair, S. T., & Talabi, R. B. (2015). Teacher shortage in Nigerian schools: Causes, effects and administrators coping strategies. *Asia Pacific Journal of Education, Arts and Sciences*, *2*(4), 31-37.

Supasorn, S. (2015). The use of micro kits to improve learning achievement in chemistry at lower secondary level. *Australian Journal of Teacher Education, 40*(8), 75-88.

Sweller, J. (2005). Implications of cognitive load theory for multimedia learning. *The Cambridge Handbook of Multimedia Learning*, *3*(2), 19-30.

Sweller, J. (2007). Learner control, cognitive load and instructional animation. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, *21*(6), 713-729.

University of Education,Winneba http://ir.uew.edu.gh

Szymkowiak, A., Melović, B., Dabić, M., Jeganathan, K., & Kundi, G. S. (2021). Information Technology and Gen Z: The Role of Teachers, the Internet, and Technology in the Education of young people. *Technology in Society*, *65*, 101565.

Taagepera, M., & Noori, S. (2000). Mapping students' thinking patterns in learning organic chemistry by the use of knowledge space theory. *Journal of Chemical Education*, *77*(9), 1224.

Taber, K. S. (2013). Revisiting the chemistry triplet: drawing upon the nature of chemical knowledge and the psychology of learning to inform chemistry education. *Chemistry Education Research and Practice*, *14*(2), 156-168.

Talanquer, V. (2014). Chemistry education: ten heuristics to tame. *Journal of Chemical Education*, *91*(8), 1091-1097.

Talib, O., Matthews, R., & Secombe, M. (2005). Computer-Animated Instruction and Students' Conceptual Change in Electrochemistry: Preliminary Qualitative Analysis. *International Education Journal*, *5*(5), 29-42.

Tareef, A. B. (2014). The effects of computer-assisted learning on the achievement and problem-solving skills of the educational statistics students. *European Scientific Journal, 10* (28). The Theoretical and Research Foundations of Multimedia.

Treboukhina, N., Goncharova, Y., Bickenbach, N., Melikyan, A., & Moysova, O. (2023, February). *The Challenges of Language Learning in a New Reality: Reflecting*

Uce, M., & Ceyhan, I. (2019). Misconception in chemistry education and practices to eliminate them: Literature analysis. *Journal of Education and Training Studies, 7*(3), 202-208. https://doi.org/ 10.11114/jets. v7i3.3990

Udoh, C. O. & Ajala, J. A. (2005). *Mental and social health*. Maybes Publications.

Ugwuanyi, C. S., & Okeke, C. I. (2020). Enhancing University Students' Achievement in Physics Using Computer-Assisted Instruction. *International Journal of Higher Education*, *9*(5), 115-124.

Ugwuanyi, C. S., Okeke, C. I., Nworgu, B. G., Agwagah, U. V., Ugwuanyi, C. C., ... & Okeke, A. O. (2020). Evaluation of the impact of computer-assisted instruction on mathematics and physics students' achievement: implication for industrial technical education. *International Journal of Engineering Research and Technology*, *13*(7), 1786-1794. University of Nigeria.

Von Aufschnaiter, C., & Rogge, C. (2010). Misconceptions or missing conceptions? *Eurasia Journal of Mathematics, Science and Technology Education*, *6*(1), 3-18.

Von Stumm, S., Hell, B., & Chamorro-Premuzic, T. (2011). The hungry mind: Intellectual curiosity is the third pillar of academic performance. *Perspectives on Psychological Science*, *6*(6), 574-588.

University of Education,Winneba http://ir.uew.edu.gh

Walson, O. B. A., & Okanu-Igwela, J. N. B. (2019). Issues, challenges and prospects in the use of educational technology for instructional delivery in the management of 21st university education in Nigeria. *ADECT 2019 Proceedings*.

Watson, B., & Kopnicek, R. (1990). Unterricht für und durch „conceptual change ": Auseinandersetzung mit kindlichen Konzepten in Lernprozessen. *Phi Delta Kappan*, 680-684.

Williams, J. P. (2002). Reading comprehension strategies and teacher preparation. *What research has to say about reading instruction*, *3*, 243-260.

Williamson, V. M., & Abraham, M. R. (1995). The effects of computer animation on the particulate mental models of college chemistry students. *Journal of Research in Science Teaching*, *32*(5), 521-534.

Wilson, L., & Corpus, D. (2005). The effects of reward systems on academic performance. Middle School Journal Research Articles. Retrieved February 13, 2005, from http://www.nmsa.org/rese

Wishart, J. (2002). Students and Teacher's Motivation and Learning through Use of CD – ROMs. *Journal of Multimedia and Hypermedia, 9*(4), 333-47.

Woldeamanuel, M. M., Atagana, H., & Engida, T. (2014). What makes chemistry difficult? *African Journal of Chemical Education*, *4*(2), 31-43.

Wu, H. K., & Shah, P. (2004). Exploring visuospatial thinking in chemistry learning. *Science Education*, *88*(3), 465-492.

Wu, H. K., Krajcik, J. S., & Soloway, E. (2001). Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *38*(7), 821-842.

Yara, P.O. &Tunde – Yara, B.A. (2010). Broken Homes and Academic Performance of Adolescent in Secondary Schools in Ibadan Nigeria. *The Journal of International Social Research, 3.*

Yu, Z. (2021). The effects of gender, educational level, and personality on online learning outcomes during the COVID-19 pandemic. *International Journal of Educational Technology in Higher Education*, *18*(1), 14.

Yushau, B., Mji, A., & Wessels, D. C. J. (2003). Creativity and computer in the teaching and learning of Mathematics. Retrieved from 239 www.kfupm.edu.sa/math /UPLOAD/Tech_Reports/311.pdf [Accessed 27 June 2015].

Yusuf, A. J. (2012). Poor academic performance among adolescents with epilepsy in Kaduna, Northern Nigeria: A case-control study. *South African Journal of Child Health*, *6*(4), 132-134.

University of Education,Winneba http://ir.uew.edu.gh

Yusuf, M. O., & Afolabi, A. O. (2010). Effects of Computer Assisted Instruction (CAI) on Secondary School Students' Performance in Biology. *Turkish Online Journal of Educational Technology-TOJET*, *9*(1), 62-69.

Zacharia, Z. (2003). Beliefs, attitudes, and intentions of science teachers regarding the educational use of computer simulations and inquiry-based experiments in physics. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *40*(8), 792-823.

Zengin, M., & Arslan, H. (2017). Elementary school science teachers' views on laboratory activities. *Eurasia Journal of Mathematics, Science & Technology Education, 13*(1), 243-256.

University of Education,Winneba http://ir.uew.edu.gh

APPENDIX A

STUDENTS' QUESTIONNAIRE

The purpose of this questionnaire is to collect data to answer question on students' prior conceptions of nomenclature of cyclic hydrocarbons.

NOTE: The researcher assures you that the information gathered will be treated with utmost confidentiality and for academic purposes only. Do not write your name anywhere in this questionnaire. Please *tick (√) in the box that most accurately reflects your opinions on each of the questionnaire's items.*

Gender: Male [ ] Female [ ]

Age: ___________

1. I am familiar with the properties of hydrocarbons.
   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
   Strongly Disagree [ ]
2. All organic compounds contain carbon and hydrogen.
   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
   Strongly Disagree [ ]
3. Substituents are not named in alphabetical order in naming hydrocarbons.
   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
   Strongly Disagree [ ]
4. I can differentiate between structural isomers and name them correctly.
   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
   Strongly Disagree [ ]
5. In naming hydrocarbons, the end of the name is given by the number of bonds between carbon atoms.
   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
   Strongly Disagree [ ]
6. I am comfortable with naming hydrocarbons containing functional groups. (Alcohols. Ethers).
   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
   Strongly Disagree [ ]
7. Identification of single, double and triple bonds in hydrocarbons structures are difficult.

University of Education,Winneba http://ir.uew.edu.gh

Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
Strongly Disagree [ ]

8. I struggle to grasp the nomenclature of branch chain hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
   Strongly Disagree [ ]

9. I find the nomenclature of hydrocarbons to be confusing and difficult to understand.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
   Strongly Disagree [ ]

10. Rules in naming hydrocarbons are difficult to understanding.

    Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]
    Strongly Disagree [ ]

University of Education,Winneba http://ir.uew.edu.gh

APPENDIX B

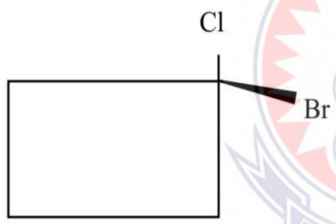
PRE-INTERVENTION TEST

Answer all questions **Duration: 1hour** Test items on IUPAC nomenclature on cyclic hydrocarbons. Do not write your name anywhere in this paper. Please tick (√) where appropriate or fill in the required as guided.

1. What is the IUPAC name of the cyclic hydrocarbon with six carbon atoms and a double bond?
   a. Cyclopentane
   b. Cyclopentyne
   c. Cyclohexene
   d. Cyclohexane

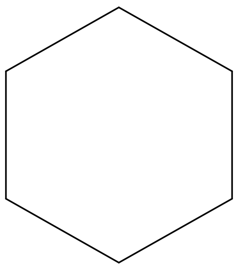
Give the IUPAC name for the structures below:

2.



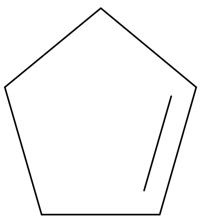
....

3.



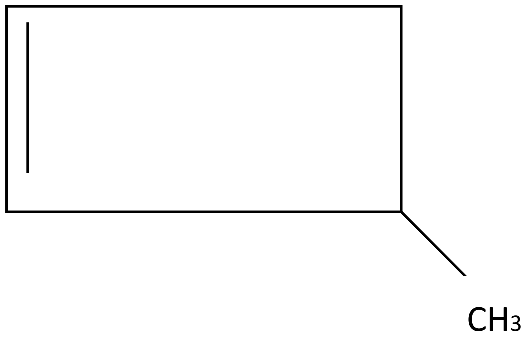
....

4.



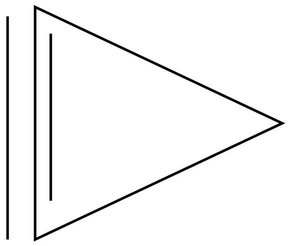
....

5.



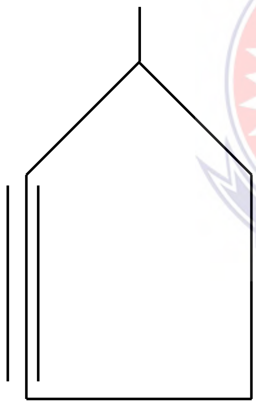
……………………………

6.



………..…………………………………………..

7.



……………………………………………………...

8. What is the correct name of the cyclic hydrocarbon with the molecular formular C_3H_6? a. Cyclobutane
   b. Cyclopentane
   c. Cyclopropane
   d. Cyclopropyne

University of Education,Winneba http://ir.uew.edu.gh

Draw the structural formula for each of the following compounds.

9. Cycloheptyne

10. 1,2-dimethylcyclopropane

11. 4-bromocyclohexene

12. Cyclononane

13. 3-Chlorocyclopentene

14. 3-methylcyclobutyne

15. What is the name of the cyclic hydrocarbon with four carbon atoms and a triple bond? a) Cyclobutyne

   b. Butene

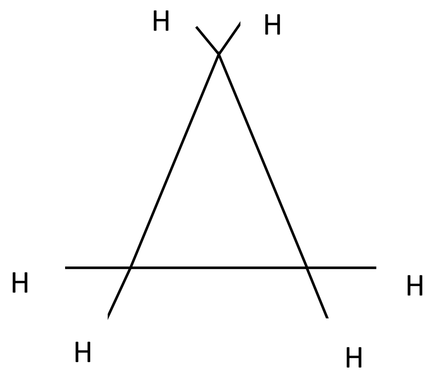
   c. 1,4-butadiene

   d. Cyclobutane

University of Education,Winneba http://ir.uew.edu.gh

16. What is the structural formula of 3,4-dimethylcyclohexene?

17. Give the IUPAC name of the structure below.



………………………………………………………..

18. Give the IUPAC name of a cyclic hydrocarbon with the formula C_6H_8?

19. What is the correct name of the cyclic hydrocarbon with the seven carbon atoms and a double bond?

20. The correct IUPAC name of a cyclic hydrocarbon with ten carbon atoms is
    a) Cyclopentene
    b) Cyclodecane
    c) Cyclohexene
    d) Cyclobutane

University of Education,Winneba http://ir.uew.edu.gh

APPENDIX C

POST-INTERVENTION TEST

Answer all questions **Duration: 1 hour**

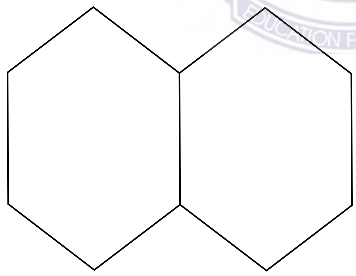
Test items on IUPAC nomenclature on cyclic hydrocarbons. Do not write your name anywhere in this paper. Please tick (√) where appropriate or fill in the required as guided.

Write the molecular formula for the following compounds.

1. Cyclooctane…………………………………………………………………………..
2. Cyclopentyne…………………………………………………………………...
3. Cycloheptene………………………………………………………………………
4. Cyclononane………………………………………………………………………
5. Which of the following is a cyclic hydrocarbon?
   a. Heptane
   b. Ethane
   c. Cycloheptane
   d. Propyne

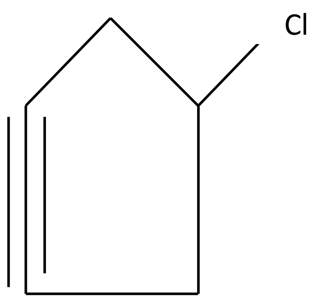
Name the following structures

6.



……………………………………………………..

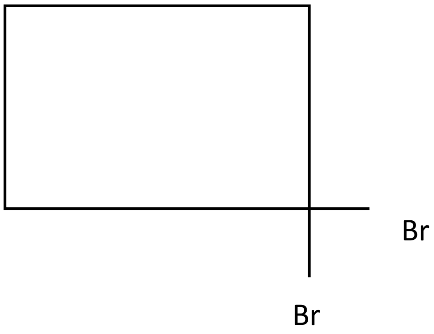
7.



……………………………………

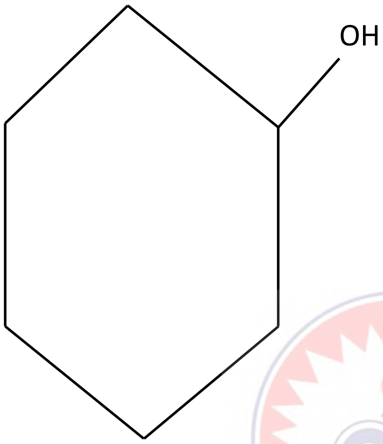
University of Education,Winneba http://ir.uew.edu.gh

8.



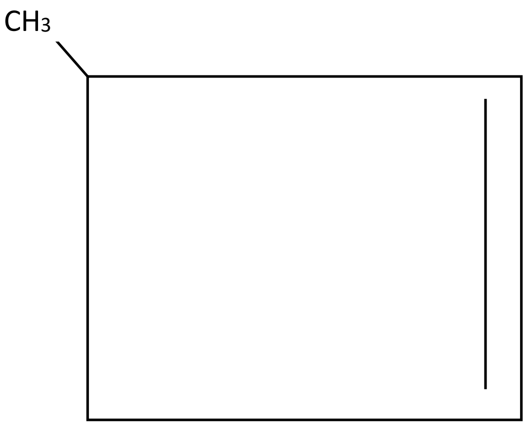
....

9.



....

10.



....

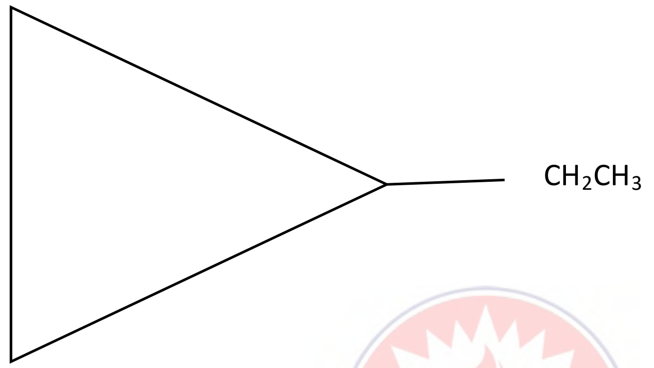
11. What is the IUPAC name of the cyclic hydrocarbon with the formula C_6H_{10}?

University of Education,Winneba http://ir.uew.edu.gh

12. The IUPAC name for a cyclic hydrocarbon with eight carbon atoms and a methyl group is called …

    a. Methylcyclooctane
    b. Cyclobutane
    c. Methylcyclopentene
    d. Cyclononane

13. What is the IUPAC name for this compound.



……………………………….

Draw the structural formula of the following compounds.

14. 1-chloro-4-iodocylohexane

15. 1, 2, 4 - triethylcyclopentane

16. Cyclooctene

University of Education,Winneba http://ir.uew.edu.gh

17. 3-methylcyclohexene

18. 1, 2, - dimethylcycloheptane

19. Ethylcyclobutane

20. Cyclopentyne

University of Education,Winneba http://ir.uew.edu.gh

APPENDIX D

STUDENTS' QUESTIONNAIRE

The purpose of this questionnaire is to collect data to answer question to assess students' attitude towards CAI for the teaching and learning in nomenclature of cyclic hydrocarbons.

NOTE: The researcher assures you that the information gathered will be treated with utmost confidentiality and for academic purposes only. Do not write your name anywhere in this questionnaire. Please *tick (√) in the box that most accurately reflects your opinions on each of the questionnaire's item.*

Gender: Male [ ] Female [ ]

Age: ____________

1. Using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons is an effective way to learn.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]

   Strongly Disagree [ ]

2. I enjoy using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]

   Strongly Disagree [ ]

3. Computer-assisted instruction helps me understand the nomenclature of cyclic hydrocarbons better.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]

   Strongly Disagree [ ]

4. Using computer-assisted instruction makes learning the nomenclature of cyclic hydrocarbons easier.

University of Education,Winneba http://ir.uew.edu.gh

Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ] 5. I am confident in my ability to learn the nomenclature of cyclic hydrocarbons using computer-assisted instruction.

Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

6. I would recommend using computer-assisted instruction to others for learning the nomenclature of cyclic hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

7. I find using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons to be confusing.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

8. Computer-assisted instruction makes learning the nomenclature of cyclic hydrocarbons more difficult for me.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

9. I get frustrated when using computer-assisted instruction to learn the nomenclature of cyclic hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

10. I find it difficult to concentrate when using computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons.

    Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree[ ]

University of Education,Winneba http://ir.uew.edu.gh

11. I feel like I'm not learning as much when using computer-assisted instruction to learn the nomenclature of cyclic hydrocarbons.

    Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]

    Strongly Disagree [ ]

12. I would rather use traditional methods for learning the nomenclature of cyclic hydrocarbons than computer-assisted instruction.

    Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]

    Strongly Disagree [ ]

13. Computer-assisted instruction for learning the nomenclature of cyclic hydrocarbons is boring.

    Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]

    Strongly Disagree [ ]

14. I don't feel like I'm making progress when using computer-assisted instruction to learn the nomenclature of cyclic hydrocarbons.

    Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ]

    Strongly Disagree [ ]

University of Education,Winneba http://ir.uew.edu.gh

APPENDIX E

STUDENTS' QUESTIONNAIRE

The purpose of this questionnaire is to collect data to answer question to explore the role of CAI as a tool for promoting active learning and enhancing students' engagement in the nomenclature of cyclic hydrocarbons.

NOTE: The researcher assures you that the information gathered will be treated with utmost confidentiality and for academic purposes only. Do not write your name anywhere in this questionnaire. Please *tick (√) in the box that most accurately reflects your opinions on each of the questionnaire's item.*

Gender: Male [ ] Female [ ]

Age: ___________

Instruction: *Tick* ***[√]*** *in the box that most accurately reflects your opinions on each of the questionnaire's items.*

1. I found the use of CAI to be distracting and unhelpful in learning the nomenclature of cyclic hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

2. I found it difficult to stay focused during CAI sessions for learning the nomenclature of cyclic hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

3. I found that CAI allowed for more interaction and engagement with the material compared to traditional teaching methods for learning the nomenclature of cyclic hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

University of Education,Winneba http://ir.uew.edu.gh

4. I enjoyed the flexibility and convenience of using CAI for learning the nomenclature of cyclic hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

5. CAI helped me to apply my knowledge of cyclic hydrocarbons to solve problems.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

6. CAI encouraged me to take a more active role in my learning about cyclic hydrocarbons. Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

7. I was satisfied with the level of feedback provided by CAI while learning about cyclic hydrocarbons.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

8. The pace of CAI was too slow for my learning style.

   Strongly Agree [ ] Agree [ ] Undecided [ ] Disagree [ ] Strongly Disagree [ ]

University of Education,Winneba http://ir.uew.edu.gh

APPENDIX F

PRE-INTERVENTION TEST

Answer all questions **Duration: 1 hour**

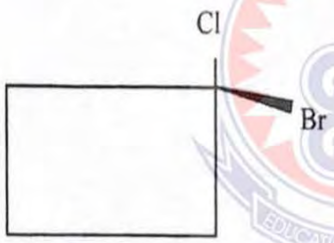
Test items on IUPAC nomenclature on cyclic hydrocarbons. Do not write your name anywhere in this paper. Please tick (√) where appropriate or fill in the required as guided.

1. What is the IUPAC name of the cyclic hydrocarbon with six carbon atoms and a double bond?

a. Cyclopentane
b. Cyclopentyne
c. Cyclohexene
d. Cyclohexane

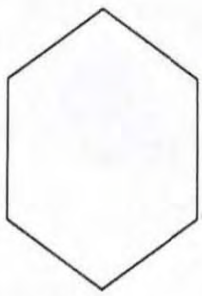
Give the IUPAC name for the structures below:

2.



1-bromo-1-chlorobutane

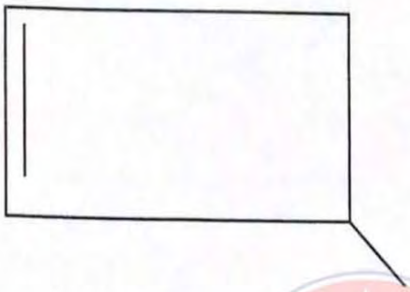
3.



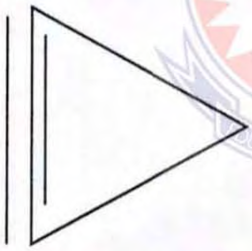
Benzene

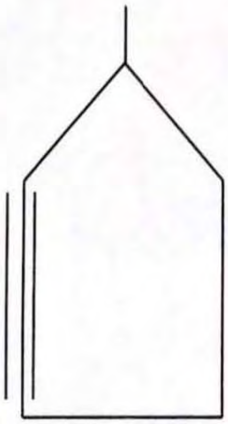
University of Education,Winneba http://ir.uew.edu.gh

4.  ......1 - Cyclopentene......

5. 

CH$_3$ ......3 - methyl......

6.  ......Cyclopropyne......

7.  ......Cyclopentyne......

University of Education,Winneba http://ir.uew.edu.gh

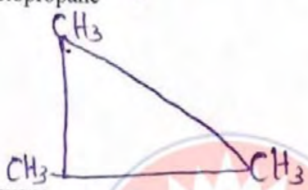
8. What is the correct name of the cyclic hydrocarbon with the molecular formular C_3H_6?

a. Cyclobutane
b. Cyclopentane
c. Cyclopropane
d. Cyclopropyne

Draw the structural formula for each of the following compounds.

9. Cycloheptyne

10. 1,2-dimethylcyclopropane

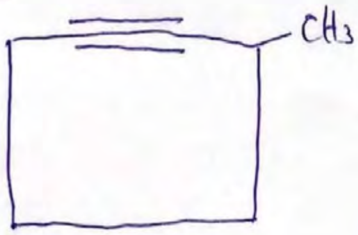


11. 4-bromocyclohexene

12. Cyclononane

13. 3-Chlorocyclopentene

14. 3-methylcyclobutyne

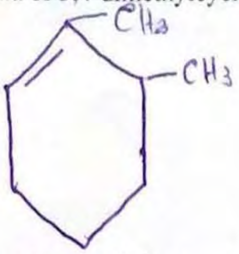


University of Education,Winneba http://ir.uew.edu.gh

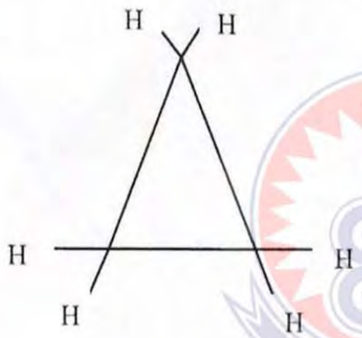
15. What is the name of the cyclic hydrocarbon with four carbon atoms and a triple bond?

a) Cyclobutyne
b) Butene
c) 1,4-butadiene
d) Cyclobutane

16. What is the structural formula of 3,4-dimethylcyclohexene?



17. Give the IUPAC name of the structure below.



........Cyclopropane......................................

18.Give the IUPAC name of a cyclic hydrocarbon with the formula C_6H_8?

Cyclohexene

19. What is the correct name of the cyclic hydrocarbon with the seven carbon atoms and a double bond? Cyclohexyne

20. The correct IUPAC name of a cyclic hydrocarbon with ten carbon atoms is

a) Cyclopentene
b) Cyclodecane
c) Cyclohexene
d) Cyclobutane

6/20