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DEPARTMENT OF SCIENCE EDUCATION

THE EFFECT OF COMPUTER ASSISTED INSTRUCTION (CAI) ON STUDENTS' ATTITUDE AND COGNITIVE ACHIEVEMENT IN CHEMICAL BONDING.

BY

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DECLARATION

CANDIDATE'S DECLARATION

I, NOMOLOX SOLOMON KOFI ADHERR, declare that this thesis, with the exception of quotations and references contained in published work which have been identified and duly acknowledged, is entirely my 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 thesis was supervised by me in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

SUPERVISOR'S NAME: Dr. E. K. OPPONG

SIGNATURE………………………………….....

DATE.……………………………………………

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DEDICATION

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ABSTRACT

The study investigated the effect of Computer Assisted Instruction (CAI) on the attitude and cognitive achievement of students in chemical bonding. The study compared the effect of CAI and a Traditional Method of Teaching (TMT) on the cognitive achievement of students in chemical bonding.

The study was conducted in the Kwahu East District of the Eastern Region of Ghana. Schools that offered chemistry as an elective subject were the target population. The total accessible population for the study comprised of forty-six (46) students; twenty-two (22) in the experimental group and twenty-four (24) in the control group.

A researcher designed Chemical Bonding Achievement Test (CBAT) containing twenty (20) multiple choice questions and Chemical Bonding Attitude Scale (CBAS) containing thirty (30) questions were used in the collection of data. The experimental and control groups were taught with CAI and TMT respectively and the data collected analysed descriptively and inferentially.

The results of the study revealed that CAI materials significantly enhanced the achievement of students taught chemical bonding than those taught with TMT. The results also showed that CAI improved the achievement of low cognitive students in a chemical bonding class. A t-test conducted gave a $p = 0.00$, which showed a significant difference between the pre-test and post-test CBAT scores of the experimental group.

Additionally, the study showed that integrating animation with text and narration in the learning environment of students changed their attitude due to its motivational effect.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter includes the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, limitations and delimitations of the study, and the operational definition of terms. Finally, the organisation of this whole five-chapter thesis is outlined.

1.1 Background to the study

Chemical bonding is one of the difficult topics (Okorie & Ezeh, 2016), in the chemistry syllabus for Senior High Schools (SHS) in Ghana due to its abstract and conceptual nature. A difficult chemistry concept is one which students find difficult to understand and teachers find difficult to teach. Students usually complain that concepts under chemical bonding pose a challenge to them and that they do not understand what they are taught in class due to the methodologies employed by teachers to deliver lessons.

Teachers using the traditional teaching method find it difficult to communicate the concept of chemical bonding to their students, making it difficult for students to understand. In this regard the difficulties that students have in understanding chemical bonding; and the inability of teachers to explain its concepts may be the factors leading to the bad performance of students recorded in chemistry over the past years. The WAEC Chief Examiner's report (2010), for instance showed that candidates who wrote its chemistry examination performed poorly on chemical bonding questions, the report stated that students were unable for instance 'to correctly distinguish between dative bond and covalent bond'. The abstract nature of the concept of chemical bonding and the pedagogical approach adopted by teachers in presenting the concept to the students have often been blamed for students' difficulty in understanding and the under achievement in this particular concept and chemistry in general.

To overcome such problems associated with chemistry teaching and learning, researchers have proposed improvements to the chemistry curriculum including attending to course content sequencing, staff/student relationship, students' social and cultural background, learning styles, use of technology and alternative explanations (Abiola & Dhindsa, 2012; Taber, 2011). The researcher also believes, that, teaching chemical bonding would be productive and motivating when there are available, sufficient, and strategically designed Teaching and Learning Materials (TLMs) suited for the students in this era of Information Communication Technologies (ICTs). This research therefore concentrates on investigating the use of CAI in teaching chemical bonding and the attitudinal and academic achievements that it can bring to students.

1.2 Statement of the problem

The current methods used by most SHS teachers in Ghana to teach chemical bonding may be considered inadequate in ensuring that students are able to visualize its abstract concepts to facilitate meaningful learning. This is a worrying observation because even though most chemistry teachers in Ghana are well vest in the use of computers and the internet and can easily download free multimedia and visualization tools from the internet, teachers are either unaware or simply prefer to stay unconcerned to the influence of ICT in the delivery of education.

According to Aladejana (2013), classrooms in the past were a cycle of memorization, repetition, and note copying, but now, the world's education is increasingly shaped by ICT. In the 21st century, students have endless access to the television right from childhood, with it they watch cartoons and play games. This is to say that technology has become an integral part of our everyday lives; at home learners come in contact with mobile phones, television, computers, internet, and games. The conflict then arises when such students get to the classroom and are expected to listen, write and regurgitate, (Aladejana, 2011). Thus according to Sowunmi and Aladejana (2013), the 21st Century classroom must be matched with the 21^{st} Century education which should be flexible, creative, challenging, and complex.

The rippling effect of an education that requires students to learn by rote ("Chew, Pour, Pass, forget") without gaining any in-depth understanding is that, these students become less motivated during lessons, exhibit absenteeism, develop negative attitude and elicit low cognitive achievements. This revolutionary turn around in education around the world points out that, compared to other teaching methodologies, the old traditional method of teaching chemical bonding is plagued with many disadvantages which needs to be remedied.

1.3 Purpose of the study

The primary purpose of this study was to investigate the effect of CAI on the cognitive achievements of students in chemical bonding and to compare the effective change in students' attitude and achievement in chemical bonding by the use of CAI and TMT. Additionally, the study sought to find out and to make recommendations on the use of CAI relative to TMT in the Ghanaian educational context.

1.4 Research objectives

The guiding objectives of this study were, to:

1. Determine the attitude of students towards the study of chemical bonding before and after the use of CAI.
2. Determine the cognitive achievements of students in chemical bonding before and after the use of CAI.

3. Compare the effectiveness of both CAI and TMT on the cognitive achievements of students in chemical bonding.
4. Determine the effect of using CAI on the achievement of low cognitive students in chemical bonding.

1.5 Research questions

Based on the objectives of the study above the researcher formulated the following questions and designed the research to answer them:

1. What is the attitude of students towards the study of chemical bonding before and after the use of CAI?
2. What is the cognitive achievement of students in chemical bonding before and after the use of CAI?
3. What is the difference in cognitive achievements of the experimental and the control group in chemical bonding using CAI and TMT respectively?
4. What is the effect of using CAI on the achievement of low cognitive students in chemical bonding?

1.6 Null hypothesis

Based on the above specific objectives, the null hypothesis below was formulated and tested:

Ho_1: There is no significant difference between the pre-test and post-test CBAT scores of the experimental group.

1.7 Significance of the study

It is the hope of the researcher that the results of this study would become a source of information for teachers who would endeavour to integrate multimedia and visualization materials (CAI) into the delivery of their lessons especially in teaching chemical bonding. This research would also serve as a reference to ascertain the influence of CAI on student motivation, attitude and cognitive achievement in chemical bonding.

Additionally, this study would serve the purpose of becoming a reference for further research into the effects of using CAI on students' attitude and cognitive achievement in chemical bonding in the Ghanaian classroom and even the world at large. Finally, the study would help stakeholders in chemistry education especially the Ghana Education Service (GES), Ghana Association of Science Teachers (GAST) and Curriculum Research Development Division (CRDD) to make an informed decision on the integration of ICTs into aspects of the science curriculum especially in teaching chemical bonding.

1.8.1 Limitations of the study

Time required for the completion of this study was one of the limitation of the study. This caused the researcher to limited the study to only two schools in the Kwahu East District of Ghana though it was designed to cover all schools that offered chemistry in the ten (10) regions of Ghana. Another limitation was that the number of lessons conducted during the study on both the experimental and control groups were eight (8). Some of the students of both groups repeatedly absented themselves from class due to the annual inter-schools' sports competition and their inability to pay their fees and this could have an effect on their performance in the teaching approaches adopted for the study. Additionally, based on the number of periods allocated to chemistry in a week in the selected schools, the researcher could only teach both groups; bonding and the types of interatomic bonds.

1.8.2 Delimitation of the study

The primary purpose of this study was to investigate the effect of using CAI on students' achievements and attitude towards chemical bonding. In the measurement of achievements, the researcher restricted it to only cognitive achievements based on written tests and the variables used in accessing attitudes of the students were behaviours, interest, perceptions and motivations. Finally, the CAI materials used in the study were all downloaded freely from the internet for the purpose of the study.

1.8.3 Definition of terms

The following terms were used with these operational definitions throughout the study.

Traditional Methods of Teaching

It refers to teaching students with only prepared lesson notes and teacher prepared notes only.

Control Group

It refers to the students taught by Traditional Methods of Teaching.

Experimental Group

It refers to the students taught using Computer Assisted Instruction with prepared lesson notes and teacher prepared notes.

Chemical Bond Achievement Pre-Test

A test given to students of both the control and experimental group before exposing them to teaching methods to measure achievement.

Chemical Bond Achievement Post-Test

A test given to students of both the control and experimental group after exposing them to teaching methods to measure achievement.

Chemistry Attitude Scale Pre-Test

A questionnaire administered to students of the experimental group to determine their attitude towards chemistry before exposing them to teaching methods.

Chemistry Attitude Scale Post Test

A questionnaire administered to students of the experimental group to determine their attitude towards chemistry after exposing them to teaching methods.

CAI Material

This include all software, animations, applets, videos, pictures etc. used during the CAI to aid in visualizing concepts.

Cognitive Achievement

Performance of a student in a particular activity involving the use of the cognitive domain of the brain.

1.8.4 Abbreviations and acronyms

WAEC	-	West African Examinations Council.
WASSCE	-	West African Secondary School Certificate Examination.
GES	-	Ghana Education Service
CBAT	-	Chemical Bonding Achievements Test
CBAS	-	Chemical Bonding Attitude Scale
EG	-	Experimental Group
CG	-	Control Group
CAI	-	Computer Assisted Instruction
TMT	-	Traditional Teaching Methods
GAST	-	Ghana Association of Science Teachers
SHS	-	Senior High School
CRDD	-	Curriculum Research Development Division

1.9.1 Organization of the thesis

This thesis write-up is segmented under five chapter headings, namely introduction, review of related literature, research methodology, data analysis and discussion of results, and conclusion and recommendations. The introductory chapter, captioned as chapter one provides detailed information on the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, limitations and delimitations of the study. Chapter two of this thesis consists of a review of related and relevant literature from sources like books, journals, abstracts and online resources relevant to the topic.

Chapter three provides detailed information on the conduct of the study, under the following headings; research design, population, sample and sampling technique, research instruments, reliability of the instrument, validation of the instrument, data collection procedure and data analysis procedure. The fourth chapter presents the data collected, their appropriate analysis and discussion of results by research questions whiles the fifth and final chapter presents the summary of the results of the study, conclusions arrived at, recommendations and suggestions for further study made by the researcher.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Overview

This chapter includes the literature reviewed under the following heading: Misconceptions about chemical bonding, the implications of misconceptions in chemical bonding for teaching, student's attitude towards chemistry, ICT in teaching and learning (education), computer assisted instruction (CAI) and the review of studies on CAI.

2.1.0 Misconceptions about chemical bonding

According to Tu¨may (2016), identifying students' misconceptions and learning difficulties and finding effective ways of addressing them has been one of the major concerns in chemistry education. It is particularly argued that one of the fundamental sources of learning difficulties and chemical misconceptions is learners' failure to understand the emergent nature of chemical entities, their properties, and interactions. Additionally, according to Tu¨may, studies on students' conceptions have revealed that many students at all levels of education have misconceptions about basic chemical concepts, even after years of instruction.

Bergqvist, Drechsler, Jongb and Rundgrena (2013) posits that models play an important and central role in science education and that chemical bonding is one of the most important topics in secondary school chemistry, and this topic is dominated by the use of models. Nahum , Mamlok-Naaman and Hofstein, (2008) also added their view to this by stating that chemical bonding is one of the most important topics taught in chemistry at upper secondary school level as well as the foundation for other topics in the subject. According to Bergqvist, Drechsler, Jongb and Rundgrena (2013), chemical bonding is a topic that students find difficult, and therefore develop a wide range of alternative conceptions.

In science education, it is considered useful if students have knowledge of different states of models and recognize their functions and limitations as well as the fact that a concept can be explained by several models (Bergqvist, Drechsler, Jongb & Rundgrena, 2013) and therefore helps students gain a better understanding of scientific knowledge and the nature of science (Drechsler & Van Driel , 2008). The representations of chemical bonding models are divided into three modes of representation: verbal, symbolic, and visual modes, according to (Gilbert, 2007).

Chemical bonding has been classified into a series of three target systems; metallic, ionic, and covalent bonding. In literature of science education, there have been numerous studies to determine students' understanding and misconceptions about metallic, ionic, and covalent bonding. Some of these misconceptions according to Gericke et al (2012) are sourced from teachers and textbooks.

Studies have revealed prevalent and consistent misconceptions across a range of ages and cultural settings. According to Nicoll (as cited by Bergqvist et al , 2013) students don't provide correct explanation for bonding phenomena and they don't understand why bonding occurs. Nicoll also showed that some students tried to explain chemical bonding in terms of electrons attracting one another. A number of students, according to Nicoll, believed that molecules, atoms and electrons did not move within bonds. When students in the same study done by Nicoll mentioned the motion of electrons, they described the motion as strictly between two atoms.

Additional alternative conceptions reported are that the ionic lattice or ionic compounds are composed of discrete molecules or ion pairs seen as molecules of the ionic compound, which seems to be quite widespread and is referred to in several studies from several countries (Othman, Treagust , & Chandrasegaran , 2008; Taber , Tsaparlis , & Nakibogˇlu , 2012)

Additionally, from the literature students thought that covalent bonds are weak compared to ionic bonds and so break more easily. Students reasoned that hydrogen chloride exists as discrete molecules in acid solution and when metal is added a bond is being formed between the metal and the chlorine atom, swapping patterns with the hydrogen.

The conceptions that atoms are present in ionic compounds and that these atoms become ions when the compound melts are shown by Othman et al (2008). The authors also identified the conception that free electrons are produced when an ionic compound is dissolved in water, hence making aqueous ionic compounds capable of conducting electricity but not solid ionic compounds. Treagust (as cited by Bergqvist et al , 2013) claimed that secondary school learners' preferred model for explaining covalent bonding is the octet rule, i.e. a shared electron pair holds atoms together because they consequently obtain octets of electrons. Further alternative conceptions reported are that the covalent bond is weak, and the difference in states of substances is due to the difference in strength of the covalent bonds instead of the inter-molecular bonds (Othman et al., 2008).

2.1.1 Implications of misconceptions in teaching chemical bonding for teaching

Teaching is effective when the approach used brings about a desirable change in the behaviour of the learner. If learning strategies and students' achievement have to improve, then the students have to be introduced to more effective, efficient and appropriate teaching approaches (Jack, 2013).

Due to the fact that chemistry is a science containing abstract topics and concepts (Burrows & Mooring, 2015), students have difficulty in understanding its concepts and principles. A strong positive link should exist between the quantity and quality of instructional materials improvised by a teacher for teaching of chemistry concept. The major function of the school is teaching as claimed by Popoola and Olarewaju (2010). According to Furo (2015), effective teaching and good performance is possible if the necessary instructional teaching facilities are made available. Research works in the field of learning psychology reveal that the use of instructional materials in chemistry has several advantage mainly because of two senses (seeing and hearing) involved and all learning is based on perception. Furo further stated that instructional materials are the medium by which the senses gain information from environment.

Izzet and Ozkan (2008) added that the use of good and appropriate materials in science application makes lessons more interesting, encouraging and makes the difficult science concepts learnt easily understood in a more effective way. If it is taken into account that students especially at the age of primary school have difficulty in learning abstract concept, it is important to make these concepts physical and present them carefully, Izzet and Ozkan revealed.

Engel and Reid (2006) stated that the chemical bond is at the heart of chemistry and bonding between atoms is the essence of chemistry. In other words, understanding chemical bonding and the nature of bonds is very fundamental in the study of chemistry (Okorie, 2014). For example, a good understanding of bonding and the nature of bonds makes it easy for chemistry students to predict the overall energy change in a chemical reaction (Boo as cited in Okorie, 2014).

An understanding of the concept of bonding is fundamental to subsequent learning of various topics in chemistry, including chemical equilibrium, thermodynamics, molecular structure, and chemical reactions. An understanding of molecular structure based on atomic structure and bonding is crucial to subsequent understanding of chemical reactions in the chemistry syllabus.

A considerable amount of research has pointed out that the process of knowledge construction involves replacing or reorganizing the student's conceptual framework. However, from the literature on concepts, such as chemical bonding, chemical equilibrium, acids and bases, students still have difficulty changing their initial perceptions of the concepts. The literature showed that abstract concepts encountered in the course of the student's study of chemistry provide increased opportunity for the development of formal misconceptions. Sometimes students have such strong misconceptions that even after learning the correct concepts in the classrooms, they resist modifying their pre-existing ideas, instead, they try to interpret the new acquired knowledge using their preconceptions (Khalid, 2003).

Nicoll suggests that teachers need to emphasize the transitions between the symbolic, macroscopic, and microscopic worlds so that students will develop their own mental models of bonding on these three levels to facilitate better understanding. When the teachers were less knowledgeable, they were more likely to rely upon low-level questions and to give their students less opportunities to speak.

Additionally, constructivist literature emphasizes that the teacher always has to teach from where the students are rather than where the teacher would like them to be, or where the curriculum suggests they should be (Taber, 2000).

Teichert and Stacy (2002) reported that many instructors agree that one of the best ways to measure student understanding is to assess how well they can explain a concept to someone else. This however is made difficult for students because majority of teachers and even professors use teacher-centred teaching strategies to teach science (Yip, 2001) and this therefore makes students only successful in examinations because this method trains the students to be good at retrieving factual information and the rote application of algorithms. These traditional teaching strategies provide conceptual information to the students who learn the material, memorize it, and reproduce it on the day of examination (Khalid, 2003). According to constructivist view of learning, meaningful learning occurs when the learners actively construct their own knowledge by using existing knowledge to make sense of newly gained experiences. Taber (2000) has stated that the first step in a constructivist learning approach is to make the teacher and student aware of the learner's current ideas. Teaching can then be planned to challenge misconceptions, and provides students with the opportunities to learn.

2.2.0 Students' attitude towards chemistry

Chemistry is one of the most important branches of the Sciences that enables students to understand what happens around them. Ahiakwo (as cited in Babalola & Hafsatu, 2015) defined chemistry as the mother and centre of all the sciences due to its confluence and influence and its curriculum. According to Nwahunanya (2011) chemical bonding is a difficult chemical concept which according to literature is because it incorporates many abstract concepts, which are central to furthering of studies in chemistry and other sciences. This observation according to Sirhan (2007) repels students from continuing studies of the subject.

The brain is not the passive consumer of information and to learn with understanding, a learner must actively construct meaning of what is to be learned. A revelation by Yunus and Ali (2012) show that students have negative attitudes towards chemistry because they lack interest in the subject and its syllabus. According to Koballa and Glynn (2007), attitudes are often used interchangeably with terms such as interest, beliefs, curiosity, opinions, and other commonly used affective-related variables. Cheung (2009) reported that there is a correlation between attitude and academic achievements of students. There is also a significant relationship between students' attitude towards chemistry and the perception of their teacher method of teaching chemistry (Anglena & Ugwuegbulan, 2011). With respect to this statement, Salta and Tzougraki (as cited in Khan & Ali, 2012) revealed that the correlation between high school students' achievements in chemistry and their attitudes toward Chemistry was calculated to be in the range from 0.24 to 0.41.

According to Glasman and Albarracín (2006) it is very important to help students develop positive attitude towards the study of chemistry since that could be used to predict a student's behaviour in its lessons. Cheung supports this by stating that the development of positive attitude by students is necessary because attitude is linked with academic achievement.

2.2.1 Factors causing negative attitudes towards chemistry

According to Aladejana (as cited by Sowunmi and Aladejana, 2013), science teaching at various levels still retains the old conservative approach with the teacher, in most cases, acting as the repertoire of knowledge and the students the dormant recipient. There is over-reliance on textbooks with only occasional demonstrations and experimental classes. In an average classroom, one finds a teacher at the blackboard jotting down important facts, students furiously copying all that is written and said, expected to memorize the facts and spit them out in an examination.

Studies by Jegede (2007) geared towards probing students' attitudes toward chemistry, indicated a low level of student motivation to engage in chemistry learning. Nbina (2012) pointed out that too much pressure and critical remarks by teachers could sometimes lead to students' failure and dislike of chemistry, and encourages lukewarm attitudes in them. Understanding of students' attitude in chemistry is important in fostering their achievements and interest. Students attitude towards science have been extensively studied by Dhindsa and Cheung (as cited in Khan & Ali, 2012), their studies identified many factors that could be contributory to student's attitude towards studying chemistry; these factors include age, career interest, social view of science and scientists, social implications of chemistry or cognitive styles of students. Adesoji (2008) also identified teaching methods, teacher's attitude, influence of parents, gender, age, cognitive style of pupils, career interest, and social implication of chemistry and achievement. The above identified factors of students' attitudes towards chemistry were categorised by Salta and Koulougliotis (2012) as;

- Teaching approaches
- Educational tools
- Non-formal educational material and activities

A number of factors have been identified as related to student's attitude towards chemistry, such factors include teaching methods, teacher attitude, influence of parents, gender, age, cognitive style of pupils, career interest, and social implication of chemistry and achievement, Adesoji, (2008) concluded. Olatoye (as cited in Khan & Ali, 2012) found that students' attitude towards chemistry have significant direct effect on students' achievement in the subject, students' attitude towards chemistry have significant direct effect on students' achievement in the subject, reported by Abulude, (2009).

Students also develop negative attitude towards the chemistry lessons due to the constant interplay between the symbolic, microscopic and macroscopic levels. The macroscopic level includes observable substances, processes or phenomena; the microscopic level includes unobservable entities such as atoms, molecules and ions that are conceptualized to explain macroscopic observations; and the symbolic level includes symbols, formulas, and equations that represent macroscopic or microscopic entities and processes. Infact, Johnstone's macroscopic, microscopic, and symbolic levels framework has been the most impressive discipline-specific paradigm in chemistry education research (Gilbert and Treagust, 2009; Talanquer, 2011; Taber, 2013).

When this difficulty of the abstract and conceptual nature of chemistry is not addressed, students may be forced to think chemistry concepts are always confined to the four corners of the classroom. According to Yara (2009) teachers' feelings and attitudes about science could also affect their students' feelings and attitudes in a very massive way and thereof contribute to low academic achievement. There are many problems regarding the way science is taught in schools, especially if consideration is given to non-science-oriented students as an important target population. Many countries for instance have ventured to give students a taste of an assortment of facts considered as important by the scientific community. This approach is based on the apparent reason that if students have access to knowledge in the science subjects, they would be able to cope with the modern world as well develop positive attitude towards science.

Jegede (2007) and Edomwonyi-otu and Avaa (2011), reporting on students' views reported that chemistry was too broad to be learnt in a short time and therefore found it difficult to learn. Other available literature also suggest that the nature of the curriculum could be the cause of the negative attitude (Eilks, Marks & Feierabend, 2008). In many countries, the science curricula are described as being overloaded with content (Gilbert 2006) the weak linkage between real life and scientific knowledge (Demirciog˘lu, Demirciog˘lu, & Calik, 2009), students' difficulties in transferring chemical knowledge to different contexts (Gilbert 2006), a failure to see the reasons for studying chemistry (Stolk , Bulte , de Jong , & Pilot , 2009b), chemistry curricula that are isolated from society and the learner (Stolk , Bulte , de Jong , & Pilot , 2009a), the passive involvement of students in the learning process (Stolk , Bulte , de Jong , & Pilot , 2009a), the failure to inculcate scientific literacy between students who will not continue to study the subject (Gilbert, 2006), and a predominantly traditional chemistry education emphasizing the memorization of facts, theories and rules (Stolk , Bulte , de Jong , & Pilot , 2009a).

In conclusion, the theoretical way by which chemistry (chemical bonding) is taught (without hands on activities and practice) in most schools could be the cause the development of negative attitudes by students. This is supported by the sense derived from literature that, the content and pedagogy of science education have repeatedly been scrutinized by science researchers in education and several attempts have been made to re-orient science education in a meaningful, authentic, relevant, and contextualized direction.

2.2.2 Creating a positive attitude towards chemistry

According to Festus (2007), contend that performance appears generally to be the fundamental goal behind every life struggle, but a positive platform has consequential effects of improving the worth of students and can only be achieved through acquisition of positive learning attitudes. Attitudes can distort the perception of information and affect the degree of their retention (Festus & Ekpete, 2012).

According to Abulude, (2009) attitudes and academic achievements are related in so many ways, such that a negative or positive attitude could play substantial role in a student's decision to study science now or in the future. To help student exhibit proper disposition towards chemistry calls for an active participation by every science teacher in the life of the student, in and out of the classroom. According to Yara (2009), teacher, attitude and his method of teaching can greatly have influenced the students' attitude. There is therefore the call for each and every teacher to reconsider the way by which lessons in chemistry are taught to students. Teachers are entreated to present lessons such that they satisfy the students learning scenarios and also meet their criteria so that the science teaching would merit a more relevant position in the students' life. The teacher is additionally called on to support the development of cognitive and meta-cognitive strategies, as well as emotional and motivational dispositions in an interesting environment with relevance to future life in a contemporary society and or in prospective careers.

When students feel that the content that they learn is relevant to their daily life and to the society in which they operate, there is a good chance that they will develop positive attitudes towards the subject. A collaborative effort from all stakeholder; curriculum developers, teachers and parents is needed to ink hands and ideas to overcome these challenges of negative attitude toward learning chemistry in the educational system. According to Adesoji and Olatunbosun (2008), chemistry teaching is supposed to be result oriented and students centered, and this can only be achieved when students are willing and teachers are favorably disposed, using the appropriate methods and resources in teaching the students.

2.3.0 ICT in Teaching and Learning

According to Okorie (2014) teachers using traditional lecture method find it difficult to communicate the concept of chemical bonding to students; and students find it difficult to learn the concept. The trend in the 21st century learning is the use of computer and software packages to facilitate teaching-learning process. Siddiqui and Khatoon (2013) opined that although good teaching can facilitate the process of developing proficiency in science, developing a conceptual understanding of science is difficult and time consuming if not performed with the help of ICT. ICTs have the potential to innovate, accelerate, enrich, and deepen skills, to motivate and engage students, to help relate school experience to work practices, create economic viability for tomorrow's workers, as well as strengthening teaching and helping schools to change.

According to Furo (2015) the use of computers in schools seems to help people to be creative in problem solving thereby developing positive interest in their studies. The author further revealed that computer as instructional material has made a significant contribution to a wide range of group-learning activities. They can, for example, be used to manage or structure a group-learning process, by guiding the group through a simulation exercise of some sort. This can provide a vehicle through or with which a group of learners interact, and gain access to information, investigate simulated situation, which can lead to creativity indeed, virtual all these are ways in which computers can be used to determine pupils interest in learning. It can also be used in group-learning situations. Learners in groups thus, do not only benefit from feedback they receive from the computer, but also from the feedback they receive from one another.

kucukahmet (as cited by Furo, 2015) supported that 75% of learning achievement is resulted from seeing, hearing 13%, smelling 6%, touching 3% and tasting 3%. This shows that, the more senses are considered during the information dissemination; the easier it is to retain knowledge and enhance learning. To him therefore, instructional material make instruction more beneficial, lasting and pleasurable thereby creating conducive atmosphere for children by increasing their level of attention on the subject, understanding the lesson and developing interest on the subject

In Falvo's (2008) view animated visualizations that show both structures and processes help teachers convey important scientific concepts in chemistry and molecular biology. There are a lot of important reasons for using computers and the World Wide Web in chemistry education in this technological and globalised world. There is a great deal of research that have proven the benefits of ICT to the quality of education (Al-Ansari 2006).

However, various barriers to ICT use in Africa schools have been identified to include: poor infrastructure; epileptic power supply; lack of electricity; lack of trained personnel; poverty; inadequate funding and limited or no internet access (Aladejana as cited by Sowunmi & Aladejana, 2013). Advocating a total shift to technology-assisted classroom might be unrealistic in most secondary schools. Blended learning can however be a better alternative, which is the combination of multiple approaches to learning.

2.3.1 Computer assisted instruction (CAI)

Computer Assisted Instruction (CAI) is a program of instructional material that is presented by means of a computer or by a group of computer systems. CAI is a type of educational program designed to serve as a teaching tool in which a teacher uses computers at different times and spaces according to the characteristics of the subject matter, the students and the available software and hardware.

Furo (2015) explained that computer assisted instruction (CAI) refer to instruction or remediation presented on a computer. It is the use computers as an interactive instructional technique whereby a computer is used to present the instructional materials and monitor the learning that take place. It is assisted learning because it allows the learner to interact with instructional techniques whereby a computer is used to present the instruction and monitor the learning that takes place. It uses a combination of text, graphics (animation), sound and video in the learning process.

Most recent literature suggest that CAI software integrates features that encompasses activities beyond the simple drill-and-practice but include simulations, graphing and even modelling (Barot, 2009; Yusuf & Afolabi 2010).

In elaboration, Andrews (as cited in Chaudhary, 2013) states that CAI consist of 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 analysis). According to Barot (2009) the use of computer provides immediate feedback letting students know of their achievements when using a CAI. Computer programs are interactive and can illustrate a concept through attractive animation, sound and demonstration. They allow students to progress at their own pace and work individually or problem solving in a group (Furo, 2015).

According to Sowunmi and Aladejana, (2013) reserach has found that CAI allows learners to progress at their own paces and work individually or solve problem in a group, computers provide immediate feedback, letting students know whether selected answers are correct. If the answer is incorrect, the programme shows students how to correctly answer the question. Computers, offer a different type of activity and could offer a change of pace from teacher-led to group instruction. CAI improves instruction for pupils to receive immediate feedback. Computer programmes can present instruction at the learner's pace and keep track of the learner's errors and progress. Computers capture the learners' attention because the programmes are interactive and engage the learners' spirit of competitiveness to increase their scores.

The usage of CAI could be repetition, evaluation, exercises and presentation (Eskandari & Ebrahimi, 2013). CAI and its various modes of use such as computer simulations, animations and games can support the new, inquiry-based approaches to science instruction, providing virtual laboratories or field learning experiences that overcome practical and logistical constraints to student investigations. These modes of CAI can allow students to visualize, explore, and formulate scientific explanations for scientific phenomena that would otherwise be impossible to observe and manipulate. They can help students mentally link abstract representations of a scientific phenomenon (for example, equations) with the invisible processes underlying the phenomenon and the student's own observations (Linn, Chang, Chiu, Zhang & McElhaney, 2010).

2.3.2 Various terms used for computer delivered instruction

The usage of computers and technologies in education is usually defined by different terms depending on the context in which it is used, some of these terms include;

- Computer Based Education (CBE) and Computer Based Instruction (CBI) are the broadest of all the terms and can refer to virtually any kind of computer use in educational settings, including drill and practice, tutorials, simulations, instructional management, supplementary exercises, programming, database development, writing using word processors, and other applications. These terms may refer either to stand-alone computer learning activities or to computer activities, which reinforce material introduced and taught by teachers. According to Jeffs, Evmenova, Warren, & Rider (2006), CBE and CBI often refer to the general use of computers in the classroom setting and such uses involve many facets of instruction and can utilize a variety of computer technologies such as databases, drill and practice, web quests.

- Computer Managed Instruction (CMI) usually refers to either the use of computers by school staff to organize students' data and make instructional decisions or activities, in which the computer evaluates students' test performance, guides them to appropriate instructional resources, and keeps records of their progress.
- Computer Enriched Instruction (CEI) is the term used to define a learning activities in which computers; generate data at the students' request to illustrate relationships in models of social or physical reality, execute programmes developed by the students, or provide general enrichment in relatively unstructured exercises designed to stimulate and motivate students.
- Computer Aided Language Learning or Computer Assisted Language Learning (CALL) is a relatively new and rapidly evolving academic field of computer delivered instruction. It explores the role of information and communication technologies in language learning and teaching, CALL activities exploit improved technology to produce highly interactive learning environments, providing effective support for the acquisition of listening, speaking, reading, and writing skills.
- Computer Assisted (Aided) Learning (CAL) and Computer Assisted (Aided) Instruction (CAI) is the term used when computers are used in teaching and

learning process. Computer Assisted (Aided) Learning (Instruction) is concerned with the use of computers to mediate the flow of information in the teaching and learning process in the classroom. With CAI or CAL information is stored in the computer and is made available to the student rapidly and readily. According to Cotton (as cited in Jeffs et al, 2006), CAI is used more specific in applications such as drill and practice, tutorials or simulation activities offered as a stand-alone activity or supplemental activities to enhance teacher-directed instruction.

2.3.3 Types of computer assisted instruction (CAI)

There are many types of Computer Assisted Programs. Each of the CAI program is appropriate under different instructional circumstances and therefore takes a different pedagogical approach. Although the beginning of CAI was through a presentation of programmed instruction by the use of computers, the initial forms of CAI; tutorials, drill and practice and games were oriented to behaviourist theories of learning, but with the advancement of the computer technology and software no type of CAI is solely associated with any specific learning theory.

2.3.4 Advantages of computer-assisted instruction

Computer-Assisted Instruction (CAI) is diverse and a rapidly expanding spectrum of computer technologies that seeks to facilitate the teaching and learning process. It also seeks to use computer to visualize complex objects, and to facilitate communication between students and teachers during teaching and learning. It is obvious that there is a current trend of research all over the world in the use of computer facilities and resources in enhancing students' learning and for that matter, the potentials of CAI cannot be underestimated in the quest to help students in this regard. There is a plethora of established findings on the instructional importance of computers and its associated technologies all across the globe especially in the advanced countries. The use of CAI adds variety and novelty to teaching and learning, and also has the potential of using vivid and animated graphics enabling three-dimensional aspects, and other features to be viewed more realistically by the students. According to Yenice (2006), Computer Assisted Instruction (CAI) is an instruction illustrates concepts through attractive animation, sound, and demonstration students can interact directly with lessons programmed into the computer system, (Roblyer, as cited in Sowunmi & Aladejana, 2013).

Among the several benefits of CAI include; the ability to enable students proceed at a pace appropriate for their individual learning levels and skills. Self-pacing can help teachers individualise instruction for students and also allow student to choose their own pace. With this student can learn the content as per their capacity and can repeat the task if they do not understand (Barot, 2009). This is perhaps the most widely accepted advantage of CAI since it involves the active participation of students in the learning process.

Another advantage of CAI is the flexibility to access teaching material at a wide range of time or locations. Using the computer offer a flexible way by which resources are made available to students and the process of accessing the information. Literature have supported this by stating that CAI's flexibility is in terms of time, space and pace (Yusuf & Afolabi, 2010). The computer in a simulation mode permits students to explore time and space, to mix explosive chemicals together in a simulated laboratory without destroying themselves and the laboratory, and to investigate complex problems using instruments and methodology which would be excessively costly or not possible at all without the computer. With this level of flexibility offered by CAI there is a greater chance of been able to deal with increased and diverse population of students. CAI offers students who do not learn with a particular approach with material using entirely different and unique approach thereby helping both brilliant students as well as slow student.

Immediate feedback provided by the use of CAI motivates student and gives direction to the student if an answer given by the student is wrong and then provides the help to correct the mistake (Barot, 2009). Reinforcement of learning in such situations is immediate and systematized, which results in a more effective learning, according to established theories of instruction.

Individualization is also an advantage offered by the use of CAI in education. A computer has the ability to provide multiple paths in the delivery of lessons; every student proceeds according to their own needs, that is according to their previous knowledge, their ability, their interests and their intellectual capacity. In this light scientific concept can be presented in tutorials with the aid of illustrative animation, dynamically creating illustration with interesting verbal explanations. When CAI uses simulation, it can provide new insights into relationship, or experiences that would otherwise not have been possible. With this sort of individualisation there is the possibility of continuous interaction (Barot, 2009) between the student and the CAI materials.

Graphical representations play an important role in instruction of students in an educational setting. In addition to pictures, computer graphics used in CAI could also include the use of screen formatting feature such as arrows, boxes and other icons to emphasize concepts in the classroom. This non-verbal mode of instruction could help build comprehension in areas that are difficult to teach by other non-visual instructional techniques. Sound can prompt, focus or reinforce students and thus enhance instruction.

2.4.0 Review of studies on the effectiveness of Computer-Assisted Instruction

Computer-Assisted Instruction is one of the multimedia instructions that has been empirically proved to enhance students' performance, arouse their interest, and reduce the boring and abstract nature of mathematics (Adegoke, 2010). Computer Assisted Instruction (CAI) has been reported to be one of the most effective instructional strategies for developing interest, positive attitude, promoting retention ability of the students and improving the achievements of students (Yusuf & Afolabi, 2010)

The general line of orientation in research have fuelled a debate whether or not CAI is an effective means of improving student achievements and interest. There have been various studies on the use of CAI and sometimes conflicting results have been reported. Some studies show that the use of CAI can increase student achievements and overcome misconceptions while some others mention no difference between traditional and CAI. The researcher seeks to review some of the studies that have been conducted across the globe in a quest to reveal both sides of the augment and to fill in the gaps by the conduct of this research.

Students' comprehensions could be enhanced with the addition of visual forms of teaching (Serin, 2011) and the use of CAI significantly increases the academic achievements of students (Gravitt, 2010; Yusuf & Afolabi, 2010). The findings by (Owusu, Monney, Appiah, & Wilmont, 2010) however provided a contradictory report on the use of CAI by reporting that students who were instructed by the conventional or other approaches performed better on the post-test than those instructed by the use of CAI. Furo (2015) also reported that the use of CAI in education contributed significantly to higher students’ performance in schools.

Over the past fifteen years there have been research reports that have focused on the relationship between CAI and achievements in many different subject areas, such as Mathematics (Erkfritz - Gay, 2009; Kao, 2009; Tucker, 2009), Algebra (Moosavi, 2009; Gravitt, 2010), Physics (Kannan, 2007), Biology (Owusu et al.,2010; Yusuf & Afolabi, 2010) and Computer Science (Kausar, Choudhry, & Gujjar, 2008). These studies have shown that the amount of benefit a student receives from CAI appears to be related to the age or level of the students under study. Among the several reviewed studies, those conducted at the primary school level reported a positive effect on the students (Kao, 2009; Tucker, 2009). Those studies conducted at the secondary school levels (Owusu et al., 2010; Yusuf & Afolabi, 2010), the college level (Moosavi, 2009) and tertiary level (Kannan, 2007) found a significant effect of the use of CAI on students. Yusuf (2010) also found and reported a significant difference in the performance of students taught with CAI but Bayraktar (2008) could not found any significant difference between the students exposed to CAI and those exposed to traditional method. Safo, Ezenwa and Wushishi (2013) also reported Computer Assisted Instruction enhanced the achievement and retention in geometry. Akram, Athar and Ali (2011) also reported a significant influence of CAI on student's achievement in chemistry at higher secondary level in government and private schools. There were also studies conducted that sought to compare the difference in achievements of students using animation and the traditional teaching methods; from the reports computer animation technique enabled higher academic achievements in comparison to traditional teaching methods (Frailich, Kesner & Hofstein, 2009; Karaçöp, 2010; Özmen, Demircioğlu & Demircioğlu, 2009). Yen, Lee and Chen (2012) also reported that students taught with animation with narration performed significantly better than those in a control group he used. The Akengin (2011) also reported that CAI was significantly improves retention and therefore also contributes to attainment of better scores.

The motivational benefits of using CAI as a tool for improvement of general achievements are discussed under this paragraph. Advocates of CAI (Owusu et al, 2010) claim that using CAI enhances learning through the overall positive motivational factors associated with technology integration into the curriculum. These CAI supporters indicated that CAI improves achievements through increased motivation.

Computer-Assisted Instruction according to them increases motivation by providing a context for the student that is enriching, challenging and stimulates curiosity. Activities that are intrinsically motivating also carry other significant advantages such as an overall improvement in interest, providing students with choice over their own learning. Increased motivation in turn increases student learning (Owusu et al, 2010), success in academic gains in reading and mathematics and an overwhelming positive student attitude towards Computer-Assisted Instruction and learning.

Adegoke (2010) also reporting on the use of CAI found that multimedia based instruction involving animation with narration results in a more significant learning outcome than animation with onscreen text. Computer-Assisted learning can be an efficient teaching and learning procedure for different student population because according to Owusu et al., (2010) the performance of low achievers improved when they were instructed by CAI.

Rivers and Vockell (2007) investigated the problem solving skills of high school biology students by using computer simulations. Simulations were administered to the students of experimental group with and without guidance, whereas control group was not administered by the simulation. The student's performance was assessed by post-tests, scientific thinking tests and critical thinking tests. The results showed that the students who were guided through simulations could achieve better in results of the post-tests, scientific and critical thinking tests.

A well planned and successive presentation of the topic using animation could draw students' attention to topics, enhancing students' levels of perception, efficiency of the lessons and presentation of different information to students (Hakverdi-Can & Dana, 2012). From the studies of (Karaçöp, 2010; Marbach-Ad, Rotbain, & Stavy, 2008) it was shown that the use of animation enabled students to show a difference in their achievement.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This Chapter includes the research design, the study population, sample and sampling techniques, research instrument, reliability and validation of the instruments used in the study, data collection procedure and the data analysis procedure used in the study.

3.1 Research Design

The design adopted by the researcher for this study was a quasi – experimental design, implemented by a pre-test post-test control group containing intact and non-equivalent groups of students. The subjects of the study were assigned into two groups by a non-random sampling technique, which was based on the results of an administered pre-test before the commencement of the treatments. The groups were categorised into Control Group (CG) and Experimental Group (EG) and treated with non-randomised teaching approaches, CAI and TMT respectively.

The study was guided by the research questions and the hypothesis that were formulated by the researcher in chapter one. These research questions were to compare the effect of CAI and TMT on cognitive achievements of students and the impact of CAI on the attitude of students towards the study of chemical bonding. The CAI material for the EG were downloaded, sorted and organised based on curriculum materials, misconceptions, views of students, and that of teachers. The treatments given to the EG and CG were only different in the sense that the EG were taught with the TMT interspaced with computer visualizations and multimedia on a projected screen for students' visualization and intermittent interaction. The groups were taught the same selected concepts of chemical bonding. The notes for students, lesson plans, textbook recommendations and assignments for the groups were also the same to prevent biases in the conduct of the study. All lessons were taught by the researcher (the same teacher) to minimise teacher differences in the study. The treatment and collection of data in the course of the study lasted four (4) weeks.

3.2 Population

The targeted population for this study were all science students in all Senior High Schools in the Eastern Region of Ghana. However, the accessible population comprised elective chemistry students in two senior high schools in the Kwahu East District in the Eastern Region of Ghana.

3.3 Sample and sampling techniques

The sample for this study was made up of third year science students in two (2) senior high schools in the Kwahu East District of Ghana. The researcher chose to conduct the study with third year students because chemical bonding was supposed to have been taught in the first or second year of their study of chemistry according to the GES syllabus.

The total number of subjects in the accessible sample was forty-six (46) students, made up of thirty-three (33) male students and twelve (13) female students. For the sake of anonymity of the selected schools, they were represented throughout the study with the codes; School A and School B. Schools A and B were classified into EG and CG based on the average test score obtained by each group in a pre-test conducted. The school which recorded a lower average test score was assigned the EG (school A) whiles the school with a higher average test score was assigned CG (school B). The sample size of the EG was twenty-two (22) students made up of seventeen (17) male students and five (5) female students, the CG was also made up of twenty-four (24) students made up of sixteen (16) male students and seven (8) female students.

3.4.0 Research instruments

The study was implemented by the use of two instruments; Chemical Bonding Achievements Test (CBAT) and Chemical Bonding Attitude Scale (CBAS).

3.4.1 Chemical bonding achievements test (CBAT)

The researcher developed the CBAT to measure students' cognitive achievement in chemical bonding both for the EG and CG before and after the implementation of the CAI and TMT treatments respectively. The instrument was designed based on the MoESS syllabus, WAEC syllabus and the lessons planned for the study structured in such a way that it enabled the achievements of the objectives of the study. Majority of the questions items used for the CBAT were extracted from WASSCE past questions in Chemistry from 1993 to 2015. The CBAT was designated $CBAT_1$ and $CBAT_2$ for pre-test and post-test respectively. Even though $CBAT_1$ and $CBAT_2$ contained the same kind of questions, questions of $CBAT_1$ were edited by rearrangement of questions and changes in the answers and administered as $CBAT_2$. The $CBAT_1$ and $CBAT_2$ were administered to determine students' pre-knowledge and post-knowledge on the selected concepts in chemical bonding.

The CBAT contained twenty (20) multiple-choice test items with four (4) options each from which student were to select the correct option. The scoring developed for the CBAT multiple choice items was that each correct answer merited one (1) mark and a wrong answer merited zero (0). Based on this scoring scheme the maximum score expected from a student was 20 marks whiles the zero (0) marks was the minimum.

3.4.2 Chemical bonding attitude scale (CBAS)

This questionnaire was also developed by the researcher. The CBAS was edited after the comments from a pilot study and the criticism of the supervisor of the study. The questions on the attitude of students was made up of thirty (30) statements. The thirty

(30) questions were structured to access the attitudes of students towards chemical bonding and the teaching methods employed by their teachers to teach the topic. This instrument used a 4-point likert - scale with the following scoring options: strongly agree (SA) for four (4) points, agree (A) for three (3) points, disagree (D) for two (2) points and strongly disagree (SD) for one (1) for positively cued items and strongly disagree (SD) for four (4) points, disagree (D) for three (3) points, agree (A) for two (2) points, strongly Agree (SA) for one (1) points for negatively cued items.

A score of 2.0 or above is accepted, and taken that a student agreed with the opinion and therefore had a positive attitude towards the given item; scores below 2.0 indicate disagreement with the item of the instrument and so not positive attitude towards the specific attitude criterion tested. The potential scores from the CBAS was therefore in the range of thirty (30) to hundred and fifty (120) points.

Students were required to indicate their degree of agreement or disagreement with the statements by a tick (√) in the appropriate column. Scores were evaluated separately and then the mean attitude score determined for each student for both pre-test and post-test. In the structuring of the Chemistry Attitude Scale, particular precautions were taken to validate them to prevent unambiguous and irrelevancy.

The CBAS consisted of 13 positive cued questions and 17 negatively cued questions.

3.5 Preparation of CAI materials

The materials used for the CAI included animations, simulation and PowerPoint presentations. To ensure their appropriateness, the researcher went through the following processes by examining some chemistry textbooks, curriculum materials, syllabi and past questions to identify key concepts in chemical bonding. The researcher also reviewed related literature to determine student's alternative concepts in chemical bonding. The views of some chemistry teachers and students were sought to find out the difficulties encountered during the teaching and learning of the concepts of chemical bonding. The researcher's supervisor and the researcher finally examined the suitability of the animations, simulation and the PowerPoint presentation. Based on these consultations the CAI materials downloaded from the internet, were sorted and used for the EG treatment as an add-on.

3.6.0 Reliability of instruments

To ensure the reliability of the CBAT developed for the study, the researcher carefully selected, analysed and modified WAEC chemistry past questions on chemical bonding from 1993 to 2015. The selection of questions from WAEC past chemistry questions was to ensure that they met the standards of WAEC in accessing students in chemical bonding. To further ensure that the CBAT was reliable the time allocation was sufficient for students to answer the question. The reliability coefficient of 0.82 was calculated for the CBAT using the Kuder - Richardson - 20 method.

3.6.1 Validation of instruments

The researcher constructed the test items of the CBAT based on the selected topics taught, which were face-validated by the researcher's supervisor, two other lectures in the department of Science Education, Winneba and an experienced chemistry teacher in a senior high schools. Based on their criticisms the necessary corrections were made to ensure the adequacy and appropriateness of the instrument.

The draft CBAS was also shown to the researcher's supervisor for scrutiny to ensure a construct and content validity. Corrections were made to the questionnaire based on the comments and suggestions of the researcher's supervisor.

3.7.0 Data collection procedure

In implementing the design of the study, permission was first of all sought from the heads of the selected schools. After the permissions were granted, the researcher visited the selected schools on separate days to familiarise with the chemistry teachers and the subjects (the students). The familiarisation was to enable the researcher settle well into the school climate of the selected schools and to brief students about the study, however, the researcher did not observe any classes in the schools so that the conduct of the study was devoid of the halo effect. Students were not also made aware that they were in the study with another school to prevent the John Henry effect of compelling them to work harder than they would have on a normal day. The familiarisation was also used by the researcher to assign numbers to each subject which was to act as a code to identify the work done by students.

After the familiarization, the researcher with the help of the chemistry teachers in the selected schools conducted a pre-test using the Chemical Bonding Achievements pre-test ($CBAT_1$) for both groups and the Chemical Bonding Attitude Scale pre-test ($CBAS_1$) for only the EG on the days the study commenced in the respective schools. The pre-test lasted about one hour 30 minutes to minimise pressure on the subjects (1 hour for $CBAT_1$ and 30 minutes for $CBAS_1$).

The researcher then collected the $CBAS_1$ and $CBAT_1$ with the help of the teachers. To ensure a high questionnaire response rate, all collected CBAS were verified by reading through to see if all items were answered. The performance of the students in the $CBAT_1$ helped the researcher assign the schools into CG and EG.

The study then commenced with the use of the two teaching approaches. The study was completed in four (4) weeks with the administration of the Chemical Bonding Achievements post-test ($CBAT_2$) for both groups and Chemical Bonding Attitude Scale post-test ($CBAS_2$) for only the EG. The scripts of the post-test were marked and the marks collated, the questionnaire were also collected and collated. The results of all the CBAT and CBAS were analysed appropriately. In answering all the pre-test and post-test students were asked to write the assigned numbers by the researcher on their sheets.

3.7.1 Teaching with computer assisted instruction (CAI)

The concepts treated under the study were from the topic, chemical bonding. These concepts were centred around bonding and the types of interatomic bond. The lessons were delivered by the use of pictures, animations, PowerPoint presentation and simulations projected from a laptop onto a screen. During the courses of the lessons, incomprehensible animations and simulations were repeated. The lessons ended with class discussions and at times students asked to interact with the animation by clicking to change some variable.

3.7.2 Teaching with the traditional teaching method (TMT)

In the class designated CG, the condition of the EG were all similar expect that in the CG class, all the lessons were taught using the TMT only. The researcher explained concepts whiles students listen and with intermittent questions from the teacher to the students and students to the teacher.

In both teaching methods students continued their studies out of the class through the researcher's recommended textbooks and notes. During the lessons for each group, students were asked questions at certain times and feedbacks were given according to the answers. Students were also given homework to help with studies of the topics out of the classroom. Students were also asked to read on concepts of the next lessons.

3.8.0 Data Analysis Procedure

The data that were collected from the post-tests and pre-tests were sorted, collated and analysed. In the analysis of the chemical bonding attitude scale, the score of each student for the thirty questions were computed and the mean attitude score of each student determined. The scores of the $CBAS_1$ and $CBAS_2$ were compared and discussed descriptively. The data was also analysed using simple percentages and represented graphically.

The scores of the subjects for both pre-tests were compared. Independent t-test at 0.05 level of significance was conducted to test for significance in the pre-test and post-test CBAT of the EG. The mark differences of the subject's achievements were also determined by subtracting the pre-test marks from the post-test and compared. These were also graphically represented. The analysis of the $CBAT_1$ and $CBAT_2$ of low achievers was also carried out. All the data collected in the study were analysed using Statistical Package for Social Sciences (SPSS) version 22.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter deals with the results of the analysis of the data gathered in the course of the study and their appropriate interpretation and discussions. Forty-six (46) students were used as subjects in the study. Twenty-two (22) formed the experimental group whiles twenty-four (24) composed the control group. The experimental group was taught using CAI whiles the control was taught with the TMT.

The analysis of the data took two forms; descriptive and inferential analysis of data. Statistical Package for Social Sciences (SPSS) version 22 was used for both the descriptive and inferential data analysis. The data gathered were analysed under the headings of the four research questions and one hypothesis formulated to guide the study in chapter one. These research questions were:

1. What is the attitude of students towards the study of chemical bonding before and after the use of CAI?
2. What is the cognitive achievements of students in chemical bonding before and after the use of CAI?
3. What is the difference in cognitive achievements of the experimental and the control group in chemical bonding using CAI and TMT respectively?
4. What is the effect of using CAI on the achievement of low cognitive students in chemical bonding?

Below is the hypothesis that was tested:

Ho_1: There is no significant difference between the pre-test and post-test CBAT scores of the experimental group.

4.1.1 Research question 1

What is the attitude of Students' towards the study of chemical bonding before and after the use of CAI?

This question was posed by the researcher to determine the outcome of using computer assisted instruction on the attitude of students towards the study of chemical bonding. This question was posed only to the experimental group who were taught using the CAI. The researcher therefore posed this question to the students to determine if the attitude of students towards chemical bonding changed negatively or positively or remain the same after they were exposed to the use of the CAI.

This question was answered by the analysis of data gathered from an attitude scale (CBAS) which was developed by the researcher. The attitude scale contained thirty (30) items containing both positive and negative statements. Students were required to select their level of agreement or disagreement to these items based on a four (4) likert - scale. To ascertain the attitude of the students before and after the CAI was introduced to the students, the attitude scale was administered as a pre-test and post-test and the mean attitude score of both tests of all twenty-two (22) students were collated and compared.

Table 1

Pre-test Mean Attitude Scores of Twenty-two (22) Students in the Experimental Group with Their Corresponding Percentages.

Students by numbers	Pre-test mean attitude score	Percentage of score
1	2.13	53%
2	2.00	50%
3	1.93	48%
4	1.87	47%
5	1.97	49%
6	1.90	48%
7	1.87	47%
8	1.70	43%
9	1.83	46%
10	1.97	49%
11	2.07	52%
12	1.80	45%
13	1.57	39%
14	2.00	50%
15	2.13	53%
16	1.97	49%
17	1.93	48%
18	2.03	51%
19	1.97	49%
20	2.07	52%
21	1.93	48%
22	2.07	52%

Table 2

Post-test Mean Attitude Scores of Twenty-two (22) Students in the Experimental Group with Their Corresponding Percentage.

Students by numbers	Post-test mean attitude score	Percentage of score
1	2.47	62%
2	1.93	48%
3	2.23	56%
4	1.97	49%
5	2.03	51%
6	1.50	38%
7	2.23	56%
8	2.40	60%
9	2.07	52%
10	2.23	56%
11	2.17	54%
12	2.13	53%
13	1.60	40%
14	2.20	55%
15	1.77	44%
16	2.00	50%
17	2.43	61%
18	1.87	47%
19	2.03	51%
20	2.00	50%
21	2.30	58%
22	2.27	57%

49

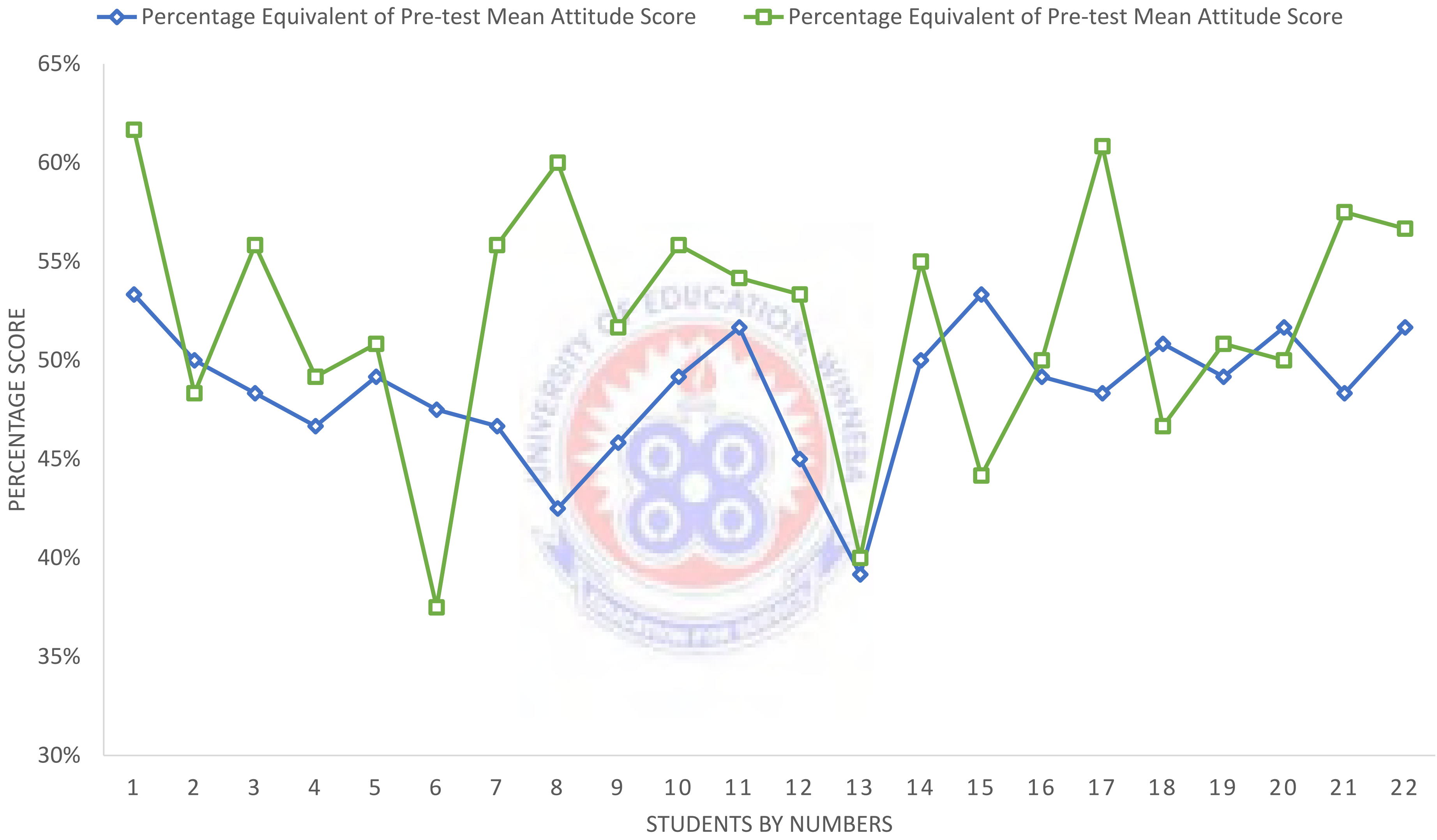

Figure 1. Comparison of the Percentage of the Pre-test and Post-test Mean Reponses Scores for the twenty-four (22) Students in the Experimental Group

Analysis of Pre-test and Post-test Mean Attitude Score of the Experimental Group.

From Table 1, the mean pre-test results of the experimental group indicated that the minimum mean, 1.57 representing (39%) was scored by student 13. The maximum mean score was also found to be 2.13 signifying (53%) was scored by students numbered 1 and 15. Additionally, observing from Table 1, two students (2 and 14) scored a mean of 2.00 which represent 50% of the total score expected to be scored on the attitude scale to show a positive attitude. A mean of 1.93 thus (48%) was scored by students 3,17 and 21. Students 4 and 7 accrued a mean of 1.87 (47%) whiles four (4) students (5,10,16,19) had a mean attitude score of 1.97 showing (49%) of the total marks.

The following means,1.57 (39%), 1.70 (43%), 1.80 (45%), 1.83 (46%), 1.90 (48%), 2.03(51%) with a frequency of one (1) each were scored by students 13, 8, 12, 9, 6 and 8 respectively. Finally, students 11, 20, 22 scored means of 2.07 (52%).

From the table of pre-test scores of the twenty-two (22) students of the experimental group it was revealed that only 8 students representing 36.36% of the total population had means on the scale above 2.00 (50%). However, the post-test means of the same group (Table 2) indicated an improvement in the attitude of most of the students on the attitude scale with respect to the mean attitude score. This low score in attitude at the beginning shows clearly that students lack interest in the chemistry (chemical bonding) and its syllabus (Yunus and Ali, 2012).

The maximum of the group on the post-test table showed an increase in the maximum mean from 2.13 (53%) to 2.47 (62%) in the post-test and the minimum mean shifting from 1.57 (39%) to 1.50 (38%). From table 2, 72.73% of the students scored means on the attitude scale that were above 2.00 (50%) of the overall 4.00 (100%). Results by Krnel & Bajd (2009) supports the result of this question by saying that CAI increases the interest and motivate of students in the teaching learning process.

On the whole, the following five (5) students were the only ones amongst the members of the group who had their mean attitude scores lowered; For student 2, the mean score moved from 2.00

(50%) in the pre-test to 1.93 (48%) in the post test, for student 6, the pre-test moved from 1.90 (48%) to 1.50 (38%). There was also an observation in student 15,18 and 20 who had their pre-test dropped from 2.13 (53%), 2.03 (51%), 2.07 (52%) to 1.77 (44%), 1.87 (47%), 2.00 (50%) in the post-test respectively. This could be as a result of the stress that students encountered from the inter-schools' sports competitions that was organised in the course of the study as well as the inability for students to pay fees and as such were frequently sent home for fees. The lukewarm attitudes recorded in figures by these students could be as a result of too much pressure and critical remarks by teachers (Nbina, 2012).

The line graph in figure 1 above provides the graphical view of the comparison between the mean pre-test and post-test on the attitude scale of all students in the experimental group who were taught using CAI.

4.1.2 Research question 2

What is the cognitive achievements of students in chemical bonding before and after the use of CAI?

This question was posed by the researcher to enable the comparison of the pre-test and post-test scores of the experimental group to ascertain if there was improvement in the cognitive achievement of students or not after the CAI was administered to the twenty-two students of the experimental group. The CBAT was administered as both pre-test and post-test to collect data to answer this question.

The total number of questions that was answered by the students was 20 multiple choice questions self-prepared by the researcher. The total marks expected to be scored by students to gain the maximum marks was 20 marks. Tables 3, 4, 5 and 6 provides a summary of the pre-test and post-test marks of the students while figure 2 give a comparative graphical view of the difference in the cognitive achievement of student.

Table 3

Marks Obtained by Experimental Group Before Exposure to CAI

18	11	13	9	10	8
10	10	10	8	7	15
10	9	11	12	5	
12	11	10	9	9	

Table 4

Marks Obtained by Experimental Group After Exposure to CAI

19	18	15	12	14	13
16	17	14	12	8	20
14	13	19	18	15	
18	17	12	15	11	

Table 5

Pre-test and Post-test Marks Obtained by the Experimental Group Showing the Difference in Marks and Percentage of Difference

Students by numbers	Pre-test marks	Post-test marks	Marks difference	Percentage of difference
1	18	19	1	6%
2	10	16	6	60%
3	10	14	4	40%
4	12	18	6	50%
5	11	18	7	64%
6	10	17	7	70%
7	9	13	4	44%
8	11	17	6	55%
9	13	15	2	15%
10	10	14	4	40%
11	11	19	8	73%
12	10	12	2	20%
13	9	12	3	33%
14	8	12	4	50%
15	12	18	6	50%
16	9	15	6	67%
17	10	14	4	40%
18	7	8	1	14%
19	5	15	10	200%
20	9	11	2	22%
21	8	13	5	63%
22	15	20	5	33%

Table 6

Pre-test and Post-test Marks Obtained by the Experimental Group by Frequency and Percentage.

Scores Obtained	Frequency (Pre - test)	Percentage of students (%)	Frequency (Post- test)	Percentage of students (%)
0 - 5	1	5%	0	0%
6 - 10	13	59%	1	5%
11 - 15	7	32%	12	55%
16 - 20	1	5%	9	41%
Total	**22**	**100%**	**22**	**100%**

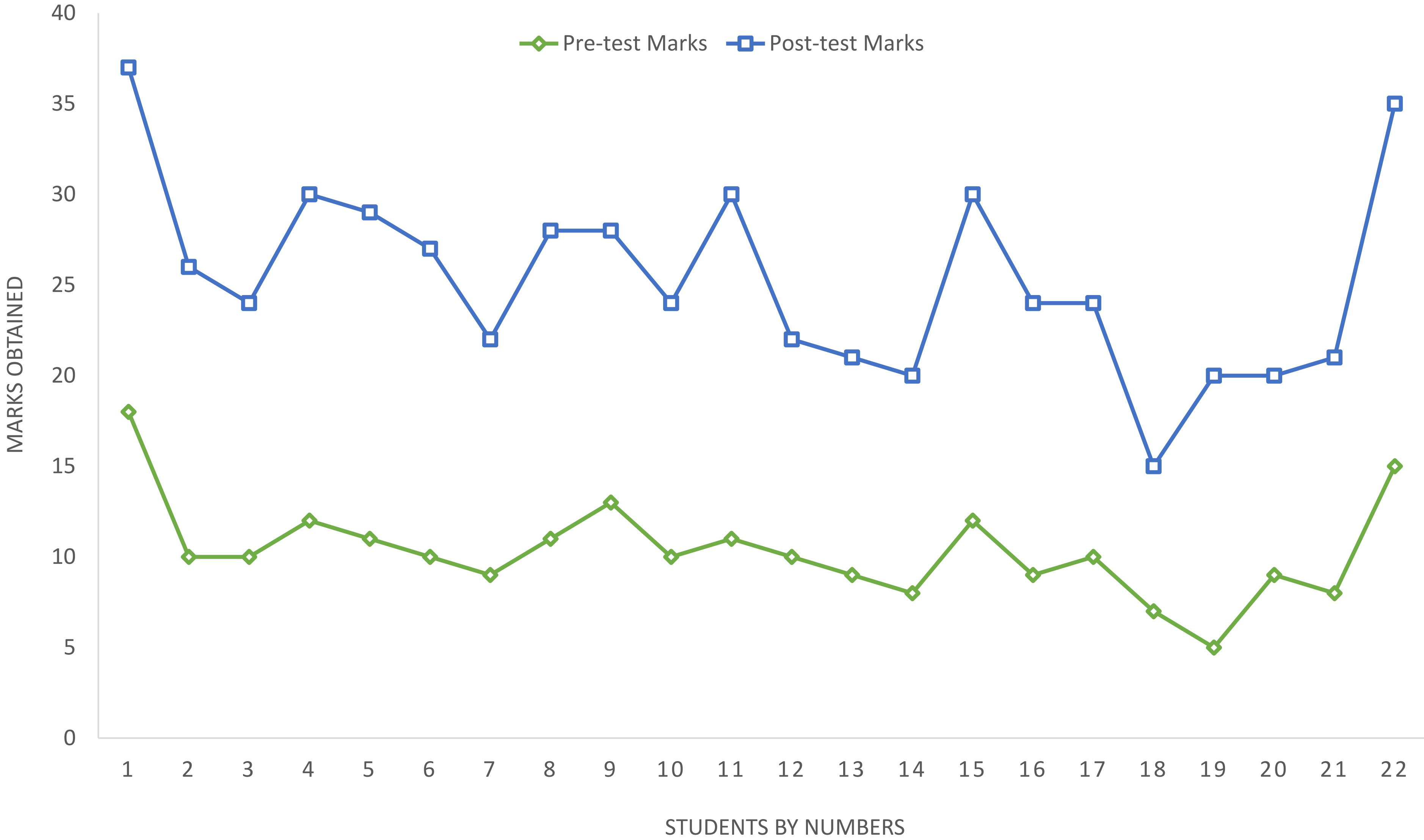

Figure 2. Marks obtained by students before and after exposure to CAI

Analysis of Pre-test and Post-test Scores of the Experimental Group on the Chemical Bonding Achievement Test.

From Table 6 it was seen that the pre-test scores of the experimental group showed only 1 student representing 5% of the groups population scoring marks in the range of 0 - 5. However, 13 students representing 59% of the population of the experimental group scored between 6 - 10 marks. Seven (7) students had marks in the range of 11-15 and finally only one (1) student had between 16 to 20 marks. By observation from the tables (3, 4, 5, 6), 14 students representing 64% of the students had marks less than half of the maximum marks of twenty (20) for the pre-test CBAT. With this low level of achievement of the experimental group who initially also scored low marks on the attitude scale it goes to support the view of Abulude (2009) and Cheung (2009) that attitudes and academic achievements are related in so many ways, such that a negative or positive attitude could play substantial role in a student's decision to study science now or in the future.

In observing the marks of students after exposure to the CAI, it was realised that the number of students who had marks in the range of 0 - 5 reduced drastically to zero (0) showing an improvement in that regard. Additionally, only one (1) student (5%) had marks in the range of 6 - 10. The number of students who had marks between 11-15 was observed to be twelve (12) representing 55% of the students in the experimental group. 41% (9) of the students scored marks in the range of 16 - 20. Critically observing table 3, 4, 5, 6 showed that only one (1) student each had 20 marks and 19 marks in the post-test but three (3) students had 18 marks.

Table 5 shows the difference in the pre-test marks and post-test marks of students. The minimum difference in the marks that was observed is one (1) whiles the maximum difference in marks of the students was 10 (ten) marks. From the table a maximum percentage increase in the pre-test marks of the students was observes to be 200%, that is from 5 marks in the pre-test to 15 marks in the post test.

In comparison based on the values in table 3, 4, 5, 6, 96% (21 students) had marks from 11 - 20, as compared to 37% (8 students) in the pre-test of the CBAT. This shows an improvement in the cognitive achievement of the students after exposure to CAI which buttresses the results of Saka (2011) which also showed that the use of CAI significantly increases the academic achievements of students.

Figure 2 above gives a graphical representation of the difference in performances of the experimental groups in the pre-test and post-test of the CBAT.

4.1.3 Research question 3

What is the difference in cognitive achievements in chemical bonding of the Experimental and the Control group using CAI and TMT respectively?

The researcher posed this question with the aim of determining whether the difference in the marks that were scored by the subjects in both the experimental and control groups during their pre-test and post-test had any differences, and if they were different find out the level of difference between the two groups. In the analysis the researcher determined the difference in the marks obtained by the subjects by subtracting the pre-test marks from the post-test marks to ascertain the gain or loss in marks by the students.

With these differences arrived at, the researcher then compared the experimental marks difference with that of the control group to check which group showed a more positive increase in marks. Table 7 presents the pre-test and post-test marks of both the experimental and control group with their appropriate differences calculated.

Table 7

Pre-Test, Post-Test Marks with Their Corresponding Difference of both the Experimental and Control Groups.

Control group			Experimental group		
Pre-test	Post-test	Difference (post – pre)	Pre-test	Post-test	Difference (post –pre)
16	14	-2	18	19	1
14	17	3	10	16	6
11	12	1	10	14	4
11	14	3	12	18	6
8	10	2	11	18	7
7	8	1	10	17	7
7	6	-1	9	13	4
7	7	0	11	17	6
11	13	2	13	15	2
9	15	6	10	14	4
9	13	4	11	19	8
11	14	3	10	12	2
8	6	-2	9	12	3
7	13	6	8	12	4
11	12	1	12	18	6
11	8	-3	9	15	6
8	9	1	10	14	4
10	11	1	7	8	1
11	14	3	5	15	10
9	9	0	9	11	2
15	15	0	8	13	5
12	14	2	15	20	5
12	13	1			
17	14	-3			

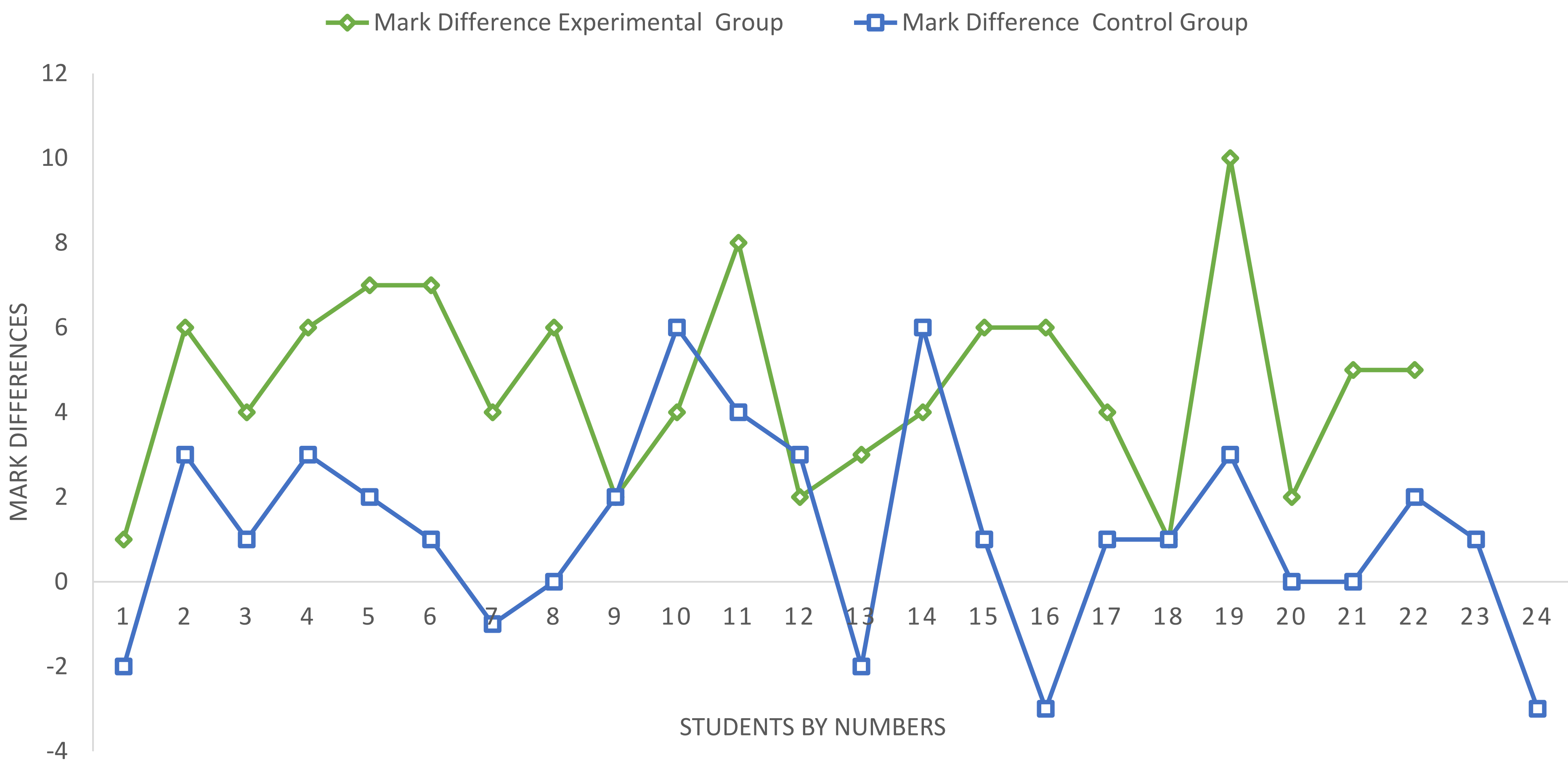

Figure 3. Comparison of Mark Differences of both the Experimental and Control Groups.

Table 8

Pair sample test showing mean, standard deviation and standard error of the pre-test and post-test marks of the experimental group.

	Mean	N	Std. deviation	Std. error mean
Pretest - EG	10.3182	22	2.69720	0.57505
Posttest - EG	15.0000	22	3.05505	0.65134

Table 9

Pair sample test showing mean, standard deviation and standard error of the pre-test and post-test marks of the control group.

	Mean	N	Std. deviation	Std. error mean
Pretest - CG	10.5000	24	2.84376	0.58048
Posttest - CG	11.7083	24	3.09950	0.63268

From Table 7 the difference in the marks obtained by students comparing the pre-test and their post - test showed that for the experimental group the maximum and minimum mark difference is 10 and 1 respectively. Also from the same table the control group mark difference showed that the maximum mark difference is six (6) whereas the minimum mark difference is found to be negative three (– 3). This revelation showed that some students of the control group decline in their cognitive achievement. The difference could be attributed to the well planned and successive presentation of the topic for the experimental group using animation. This according to Hakverdi-Can and Dana (2012) could draw students' attention to topics, enhancing students' levels of perception, efficiency of the lessons and presentation of different information to students. From the studies of (Karaçöp, 2010) there is the confirmation that the use of animation enabled students to show a difference in their achievement.

Commenting on tables 8 and 9 the means of the two groups for the post-test which is the interest of this question showed that, the experimental group had a mean of 15.00 whiles that of the control stood at 11.7083. Based on these values it can be deduced that the mean of the experimental was greater than that of the control. Additionally, the experimental could be deduced to have performed better than the control because the sample size of the experimental group was twenty-two (22) whiles that of the control group was twenty – four (24) revealing that the use of CAI increases the interest of the students and also increases enjoyment and motivation (Wang, Wu, Lu, Fan, & Lo, 2012).

This may be the reason for the observation that for the experimental group the students generally improved in their post-test as compared to the control group. Figure 3 above show the graphical representation of the mark difference of the two groups.

4.1.4 Research question 4

What is the effect of using CAI on the achievement of low cognitive students in chemical bonding?

This question was posed by the researcher to ascertain if the introduction of the CAI had any special influence on the achievement of low cognitive students of the experimental group. The data for this question was from the pre-test and protest of the CBAT.

The low achievers of the group were defined by the researcher as students with pre-test marks of less than 10. The marks of such students were monitored to extract their post-test marks so as to gain an insight in the performance of these subjects in the group. Below is a table (Table 10) giving the pre-test, post-test and their difference.

Table 10

Pre-Test, Post-Test Marks with Their Corresponding Mark Differences for low achievers of the experimental group.

Student By numbers	Pre-test	Post-test	Difference (Post –Pre)	Percentage
7	9	13	4	44%
13	9	12	3	33%
16	9	15	6	67%
20	9	11	2	22%
14	8	12	4	50%
21	8	13	5	63%
18	7	8	1	14%
19	5	15	10	200%

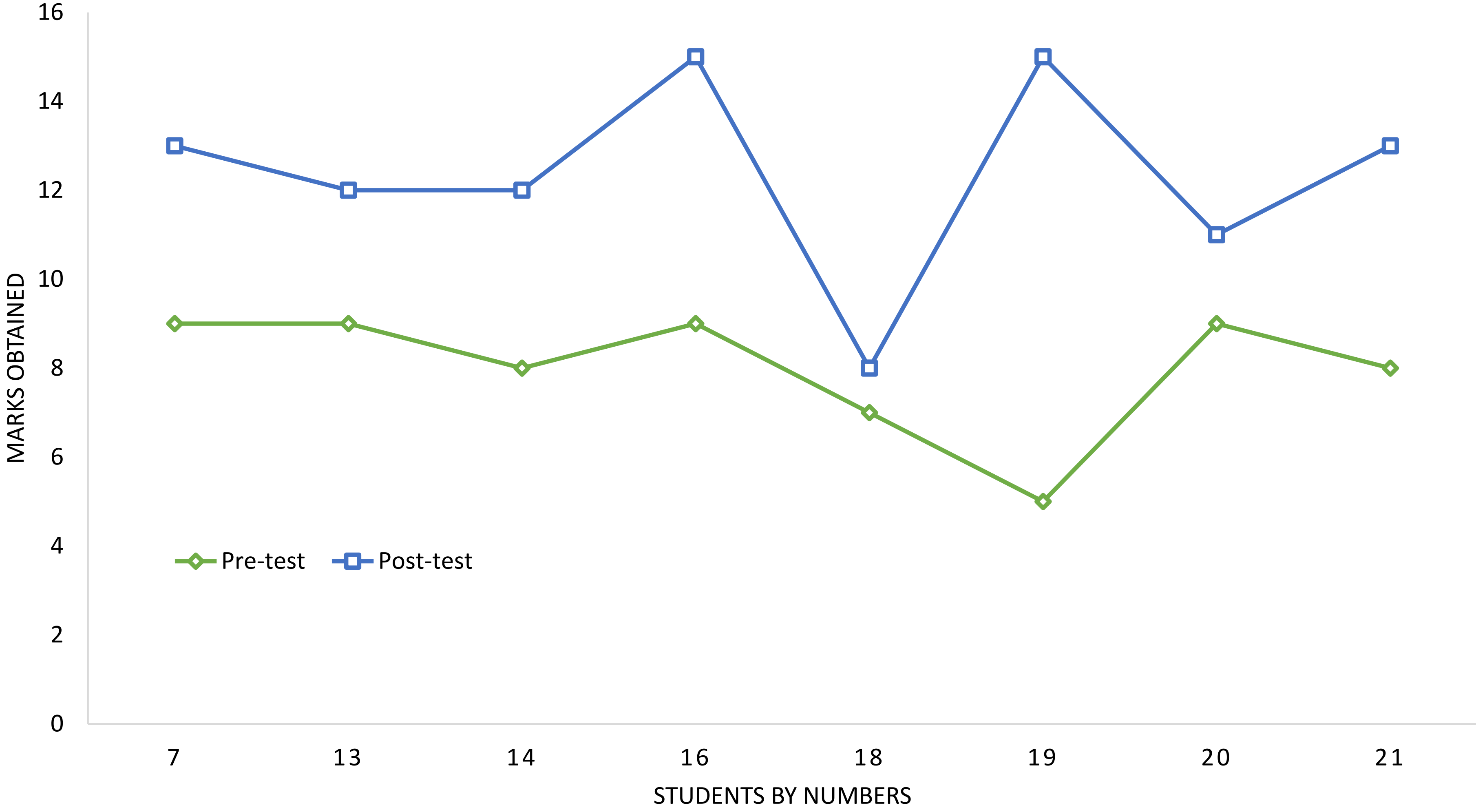

Figure 4. Comparison of Pre-test and Post-test scores of low achievers of the experimental group.

From Table 10 student 19, shows a significant increase in achievement by recording a whopping 200% increase in test scores. Before the introduction of the CAI the pre-test of the student stood at 5 but this score showed a rapid increase to 15 marks after the treatment with the CAI.

In general, the scores of the students deem as low cognitive students (7,13,16,20,14,21,18 and 19) showed an abrupt increase which goes to prove that the use of CAI is every effective for increasing the cognitive achievement of low achievers in a class. This find is no different form from the findings of that of Owusu et al., (2010), who also revealed an increase in achievement for low achievers when they were instructed by CAI.

4.2.0 Testing of Hypothesis

Null Hypothesis, H_o: There is no significant difference between the pre-test and post-test CBAT scores of the experimental group at $\alpha = 0.05$ significance level ($p < 0.05$).

$H_o: \mu_1 = \mu_2$

Null Hypothesis, H_a: There is significant difference between the pre-test and post-test CBAT scores of the experimental group at $\alpha = 0.05$ significance level ($p < 0.05$).

$$H_a : \mu_1 \neq \mu_2$$

Table 11

Pair sample test of pre-test and post-test marks of the experimental group

				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	p-value
PRETEST EG POSTTEST EG	-4.68182	2.31735	0.49406	-5.70928	-3.65436	-9.476	21	0.000

Decision on T-test: The result from the statistical test for the hypothesis from Table 4.6 yielded a value for p as p = 0.000, which indicated that the difference in the means was significant and not by chance. The test statistic was set at $p < 0.05$ and since p is less than 0.05 (level of significance), we reject the Null Hypothesis and accordingly accept the Alternate Hypothesis.

From the test statistic therefore it is appropriate to conclude that there is a significant difference between the pre – test scores and that of the post – test of the experimental group in favour of the post – test.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter includes the summary of the findings and conclusion of the study made by the researcher. Also the chapter looks at recommendations made by the researcher that should be looked at by stakeholders of science education in general, chemistry as a course and chemical bonding in particular and suggestions for further research to add to the world of knowledge.

5.2 Summary of the findings

The main reason for the conduct of this research was to ascertain the effectiveness of using CAI in teaching chemical bonding. The study sought to determine the effect of CAI on attitude and cognitive achievement of the experimental group and the effect of the TMT on the achievement of students in the control group.

The study was conducted in the Kwahu East District of the Eastern Region of Ghana. It was conducted with two schools that offered chemistry as an elective subject. The total accessible population for the study was forty-six (46) students taught some selected concepts under the topic chemical bonding. The students of the two schools were taught using two teaching methods (CAI and TMT). The duration for the study was four (4) weeks.

The finding from the study showed a positive improvement in the attitude of students towards the study of chemical bonding when they were introduced to the use of CAI. This conclusion was based on the difference in the mean attitude score of the twenty-two (22) students (Figure 1) who participated in answering the CBAS questionnaire. From the study, it was revealed that with the CAI students became more motivated, paid more attention in class and were frequent in class as compared to the usual trends in classes taught using the TMT.

Additionally, from the study's finding it came out that there was a correlation between the attitude of students and their achievement in chemical bonding. This was evident in the high scores of the experimental groups who initially scored low in the pre-test of the CBAT and CBAS (Table 2 and table 5). This improvement in the EG achievement shows that CAI enhances learning through an overall positive motivational factor associated with the integration of technology into the teaching of chemical bonding. The use of CAI also revealed its ability to help students in the retention of facts and ideas of chemical bonding. This fact was detected from the results of the t-test statistics of the hypothesis tested.

5.3 Conclusion

In conclusion, it could be said that this study has opened the eyes of the researcher and in fact that of the stakeholders of chemistry on the enormous benefits that could be derived from the use of ICT in teaching chemical bonding. The study revealed that the use of CAI materials improved the achievement of students in chemical bonding. The better achievement of students in chemical bonding could be as a result of the effectiveness of the CAI material downloaded by the researcher for the study.

Also, the CAI materials significantly enhanced the retention and achievement of students taught chemical bonding than those taught with TMT. Table 7 shows that students in the computer assisted group were more successful academically as compared to those in the TMT class. This meant that CAI was better at enhancing the interest and achievement of students in the teaching and learning of chemical bonding than the TMT.

In table 11 the t-value computed at a p - value less than 0.05 showed that the hypothesis that was tested to determine whether to accept or reject the claim that there was no significant difference between the pre-test and post-test CBAT scores of the experimental group was rejected in support of the existence of a significant difference. Conducting this study has showed that integrating animation with text and narration in a learning environment enhanced students' learning outcome in chemical bonding.

To conclude finally, this study reveals an immediate need for the use of visualization tools as teaching aids during instruction, since this leads to motivation, retention of facts, creates positive attitude and an overall improvement in cognitive achievement in chemical bonding.

5.4 Recommendations

Based on the findings of the study the following recommendations were made:

1. Computer-Assisted Instruction should be encouraged for the teaching and learning of chemical bonding (chemistry).
2. Computers should be used as motivational tool to motivate low cognitive achievers especially in chemical bonding (chemistry).
3. Computers should be provided and adequately programmed with variety of computer-assisted instructional materials by teachers to help in the delivery of chemistry lessons especially in chemical bonding.
4. Necessary attention should be accorded computer literacy and operation in the senior high schools by the organisation of seminars, workshops and conferences, and relevant computer assisted instructional packages should be developed or downloaded for use within the Ghanaian school systems.
5. In addition, Ghanaian schools should be equipped with the necessary ICT facilities to leverage the potentials of ICT in its schools.
6. All schools in Ghana should have a computer laboratory or better still a computer and projector that can be used to support the traditional teaching methods.
7. During the use of CAI teachers should always link their computer visuals to the actual classroom curriculum, beside this they should create learning environment that allows student creativity and participation.
8. National chemistry curriculum and textbooks should be revised based on the novelties in educational technologies and computer technologies to facilitate understanding.

5.5 Suggestions for Further Research

The results of this study suggest that the use of multimedia computer assisted instruction can be beneficial in the teaching of chemical bonding particularly in teaching concepts and principles of abstract nature. However due to some limitation and delimitation of the study stated in chapter one, the following suggestion are made by the researcher to enable further research into this crucial topic.

1. First of all, the researcher suggests the replication of the study with more variables, including attitudes towards using computers, attitudes towards other science fields, and teacher's motivation to use CAI.
2. The study should also be conducted in all parts of the country to find out the effectiveness of CAI compared to the TMT in teaching chemical bonding.
3. Future studies should be carried out for different subjects to investigate the effectiveness of CAI in education in general.
4. Further research needs to be conducted to address the effectiveness of CAI among different periods of instructional times in terms of weeks.
5. Since random assignment was not possible for sampling, a quasi-experimental method was used for this research study. Further studies should be conducted with random assignment of subjects.
6. A follow-up study should be conducted to assess the students' gains in performance after the second and third years of CAI implementation.
7. Additional studies should also be conducted with the students using different amounts of CAI activities.
8. Further research studies can be carried out to examine whether or not there is a relationship between gender and the effectiveness of CAI.

9. This study should be replicated in other school settings such as colleges, universities and private schools nationally. This would reveal the effectiveness of computer-assisted instruction in different student population.
10. Further empirical studies should be carried out on the use of computer for instructional purposes, on different topics, subjects and at different levels to provide sound basis for the integration of computer in Ghanaian schools.

5.6 Contributions of the study to Chemistry Education

The strength of this study lies in its contribution to chemistry and science education in Ghana in general. Stakeholders in chemistry curriculum development will acquire useful information from this study that can serve as a basis for incorporating CAI materials and activities in the curriculum especially in teaching chemical bonding whenever there is a change or review of methods of teaching chemical bonding (chemistry).

Chemistry teachers will use the information gained from the study to involve their students in the teaching and learning of chemical bonding.

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APPENDICES

Appendix A - Chemical Bonding Achievement Test 1 ($CBAT_1$)

Duration: 1 hour

*Each question in test is followed by options lettered A to D. Find the correct option for **each** question and circle it on the question paper. Give only **one** answer to **each** question. Do all rough work on this paper.*

Students Number (Provided by researcher):……………………………

1. The delocalised electrons present in metals are responsible for which of the following properties of the metal?

   (a) High melting point (b) Hardness

   (c) Electrical conductivity (d) High boiling point

2. Which of the following occurs in an ionic bond?

   (a) Oppositely charged ions attract.

   (b) Two atoms share two electrons.

   (c) Two atoms share more than two electrons.

   (d) Like-charged ions attract.

3. Why do atoms share electrons in covalent bonds?

   (a) To become ions and attract each other

   (b) To attain a noble-gas electron configuration

   (c) To become more polar

   (d) To increase their atomic numbers

4. Which of the following covalent bonds is the most polar?

   (a) H-F (b) H-H (c) H-C (d) H-N

5. The C=O bond is much more polar than the C=C bond because

   (a) of the electronegativity difference between C and O

   (b) carbonyl compounds are acidic

   (c) carbonyl compounds are basic

   (d) the C=O bond is electrophilic

6. How do atoms achieve noble-gas electron configurations in single covalent bonds?

   (a) One atom completely loses two electrons to the other atom in the bond.

   (b) Two atoms share two pairs of electrons.

(c) Two atoms share two electrons.

(d) Two atoms share one electron.

7. Which of the following pairs of elements is most likely to form an ionic compound?

(a) Magnesium and Fluorine (b) Oxygen and Chlorine

(c) Nitrogen and Sulphur (d) Sodium and Aluminium

8. Which of the following statements is correct

(a) A pi-bond is stronger than a sigma bond

(b) A pi-bond is more reactive than a sigma bond

(c) A pi-bond is formed by the head-on overlap of two atomic orbitals

(d) A triple bond consists of two sigma bonds and one pi-bond.

9. The strength of metallic bonds depends on the

(a) Charge density of the atoms (b) Number of valence electrons

(c) Position of the metals on the periodic table (d) Total number of electrons in the atoms

10. Which of the following factors favours formation of covalent bonds

I. High ionization energy of bonding atoms

II. Small electronegativity difference between bonding atoms

III. Low electron affinity of bonding atoms

(a) I only (b) II only (c) I and II only (d) I, II and III

11. The bond formed between sodium and chlorine atoms to produce sodium chloride crystal is ionic because

(a) Sodium metal has low first ionization energy and chlorine atom has high electron affinity value

(b) Sodium atom accepts two electrons from the chlorine atom

(c) Sodium metal has a high first ionization energy and chlorine atom has a low electron affinity value

(d) An electron pair is shared between the sodium atom and chlorine atom.

12. Which of the following statements about polarization of bonds is true?

(a) It induces covalent character in ionic compounds

(b) It is increased by small and highly charged cations in ionic bonds

(c) It is increased by small and highly charged anions in ionic bonds

(d) It is increased by large and highly charged cations in ionic bonds

13. The polarizing power of a cation is enhanced by its

(a) High charge and large size (b) High charge and small size

(c) High ionization energy (d) Small charge and small size

14. Which of the following activities results in the formation of a pi bond?
    (a) Side by side overlap of two p-orbitals (b) Head-on overlap of two p-orbitals
    (c) Overlap of two s-orbitals (d) Overlap of an s-orbitals and p-orbital
15. Which of the following compounds is most ionic?
    (a) $AlBr_3$ (b) AlI_3 (c) BeI_2 (d) CsF
16. The polarizability of an anion is enhanced by its
    (a) Small nuclear charge and large size
    (b) High ionization energy and low electron affinity
    (c) Small nuclear charge and small size
    (d) High nuclear charge and small size
17. The bond in LiI has more covalent character than that in NaI because
    (a) The charge density of Na^+ is greater than that in Li^+
    (b) The polarizing power of Li^+ is greater than that of Na^+
    (c) The Li^+ ion is larger than that of Na^+
    (d) Electrons are shared in forming the bonds in LiI
18. The metallic bonding potassium is weaker than that in sodium because potassium has a
    (a) Larger atomic size (c) Smaller atomic size
    (b) Greater number of valence electrons (d) Higher melting point
19. Which of the following elements can form diatomic molecules held together by triple covalent bonds?
    (a) Carbon (b) Fluorine (c) Oxygen (d) Nitrogen
20. Which of the following bonds is formed as a result of the tendency of atoms to attain a noble gas configuration.
    (a) Covalent (b) Van der Waal forces (c) Hydrogen bond (d) Metallic bond

Appendix B - Marking Scheme for Post –Test ($CBAT_2$)

1. C	2. A	3. B	4. A	5. A	6. C	7. A	8. B	9. B	10. D
11. A	12. A	13. B	14.A	15. D	16. A	17. B	18. A	19. D	20. A

Appendix C - Chemical Bonding Achievement Test 2 ($CBAT_2$)

Duration: 1 hour

Each question in test is followed by options lettered A to D. Find the correct option for ***each*** *question and circle it on the question paper. Give only* ***one*** *answer to* ***each*** *question. Do all rough work on this paper.*

Students Number (Provided by researcher):……………………………

1. The delocalised electrons present in metals are responsible for which of the following properties of the metal?

   (a) High melting point (b) Electrical conductivity

   (c) Hardness (d) High boiling point

2. Which of the following occurs in an ionic bond?

   (a) Oppositely charged ions attract.

   (b) Two atoms share more than two electrons.

   (c) Like-charged ions attract.

   (d) Two atoms share two electrons

3. Why do atoms share electrons in covalent bonds?

   (a) To become ions and attract each other

   (b) To become more polar

   (c) To attain a noble-gas electron configuration

   (d) To increase their atomic numbers

4. Which of the following covalent bonds is the most polar?

   (a) H-H (b) H-F (c) H-C (d) H-N

5. The C=O bond is much more polar than the C=C bond because

   (c) of the electronegativity difference between C and O

   (d) the C=O bond is electrophilic

   (c) carbonyl compounds are basic

   (d) carbonyl compounds are acidic

6. How do atoms achieve noble-gas electron configurations in single covalent bonds?

   (a) One atom completely loses two electrons to the other atom in the bond.

   (b) Two atoms share two pairs of electrons.

   (c) Two atoms share one electron.

   (d) Two atoms share two electrons.

7. Which of the following pairs of elements is most likely to form an ionic compound?
   (a) Magnesium and Fluorine (b) Sodium and Aluminium
   (c) Nitrogen and Boron (d) Oxygen and Chlorine
8. Which of the following statements is correct
   (a) A pi-bond is formed by the head-on overlap of two atomic orbitals
   (b) A triple bond consists of two sigma bonds and one pi-bond.
   (c) A pi-bond is stronger than a sigma bond
   (d) A pi-bond is more reactive than a sigma bond
9. The strength of metallic bonds depends on the
   (b) Charge density of the atoms (b) Number of valence electrons
   (c) Position of the metals on the periodic table (d) Total number of electrons in the atoms
10. Which of the following factors favours formation of covalent bonds
    I. Low ionization energy of bonding
    II. Low electron affinity of bonding atoms
    III. Small electronegativity difference between bonding atoms
    (b) I only (b) II only (c) I and II only (d) II and III only
11. The bond formed between sodium and chlorine atoms to produce sodium chloride crystal is ionic because
    (a) Sodium metal has a high first ionization energy and chlorine atom has a low electron affinity value
    (b) An electron pair is shared between the sodium atom and chlorine atom.
    (c) Sodium metal has low first ionization energy and chlorine atom has high electron affinity value
    (d) Sodium atom accepts an electron from the chlorine atom
12. Which of the following statements about polarization of bonds are true?
    (a) It induces covalent character in ionic compounds
    (b) It is increased by large and highly charged cations in ionic bonds
    (c) It is increased by small and highly charged cations in ionic bonds
    (d) It is increased by small and highly charged anions in ionic bonds
13. The polarizing power of a cation is enhanced by its
    (a) High charge and large size (b) High charge and small size
    (c) High ionization energy (d) Small charge and small size
14. Which of the following activities results in the formation of a pi bond?
    (a) Side by side overlap of two p-orbitals (b) Head-on overlap of two p-orbitals

(c) Overlap of two s-orbitals (d) Overlap of an s-orbitals and p-orbital

15. Which of the following compounds is most ionic?

(a) $AlBr_3$ (b) BeI_2 (c) CsF (d) AlI_3

16. The polarising power of a cation is enhanced by its

(a) High nuclear charge and large size

(b) High ionization energy and low electron affinity

(c) Small nuclear charge and small size

(d) High nuclear charge and small size

17. The bond in LiI has more covalent character than that in NaI because

2. The charge density of Na^+ is greater than that in NaI because
3. The polarizing power of Li^+ is greater than that of Na^+
4. The Li^+ ion is larger than that of Na^+
5. Electrons are shared in forming the bonds in LiI

18. The metallic bonding potassium is weaker than that in sodium because potassium has a

(c) Larger atomic size (c) Smaller atomic size

(d) Greater number of valence electrons (d) Higher melting point

19. Which of the following elements can form diatomic molecules held together by triple covalent bonds?

(a) Carbon (b) Fluorine (c) Oxygen (d) Nitrogen

20. Which of the following bonds is formed as a result of the tendency of atoms to attain gas configuration.

(a) Covalent (b) Ionic bond (c) Hydrogen bond (d) Metallic bond

Appendix D - Marking Scheme for Post –Test ($CBAT_2$)

1. B	2. D	3. C	4. B	5. C	6. D	7. A	8. D	9. B	10.D
11. C	12. A	13.B	14.A	15. C	16. A	17. B	18. A	19. D	20.A

Appendix E – Chemical Bonding Attitude Scale (CBAS)

This is not an examination. Its purpose is to find out the attitude of students towards the study of chemical bonding and the teaching methods employed by teachers in teaching chemical bonding in senior high schools in Ghana, which affects the cognitive achievements in the topic.

You are kindly requested to complete this questionnaire as frankly as possible. The confidentially of your responses are assured.

SECTION ONE

Demographic information of students

Please provide the responses for the items under this section. Please tick where necessary and write where it is necessary.

Students Number (Provided by researcher):………………………………………………….……….

SECTION TWO

For each of the items on the opposite pages, please tick a number from the scale of 1 – 5 in the right of the items to indicate your level of agreement or disagreement with the statement in each item. The meaning of the scale is as follows; for positive statements;

4 = Strongly Agree (SA), 3 = Agree (A), 2 = Disagree (D), 1= Strongly Disagree (SD).

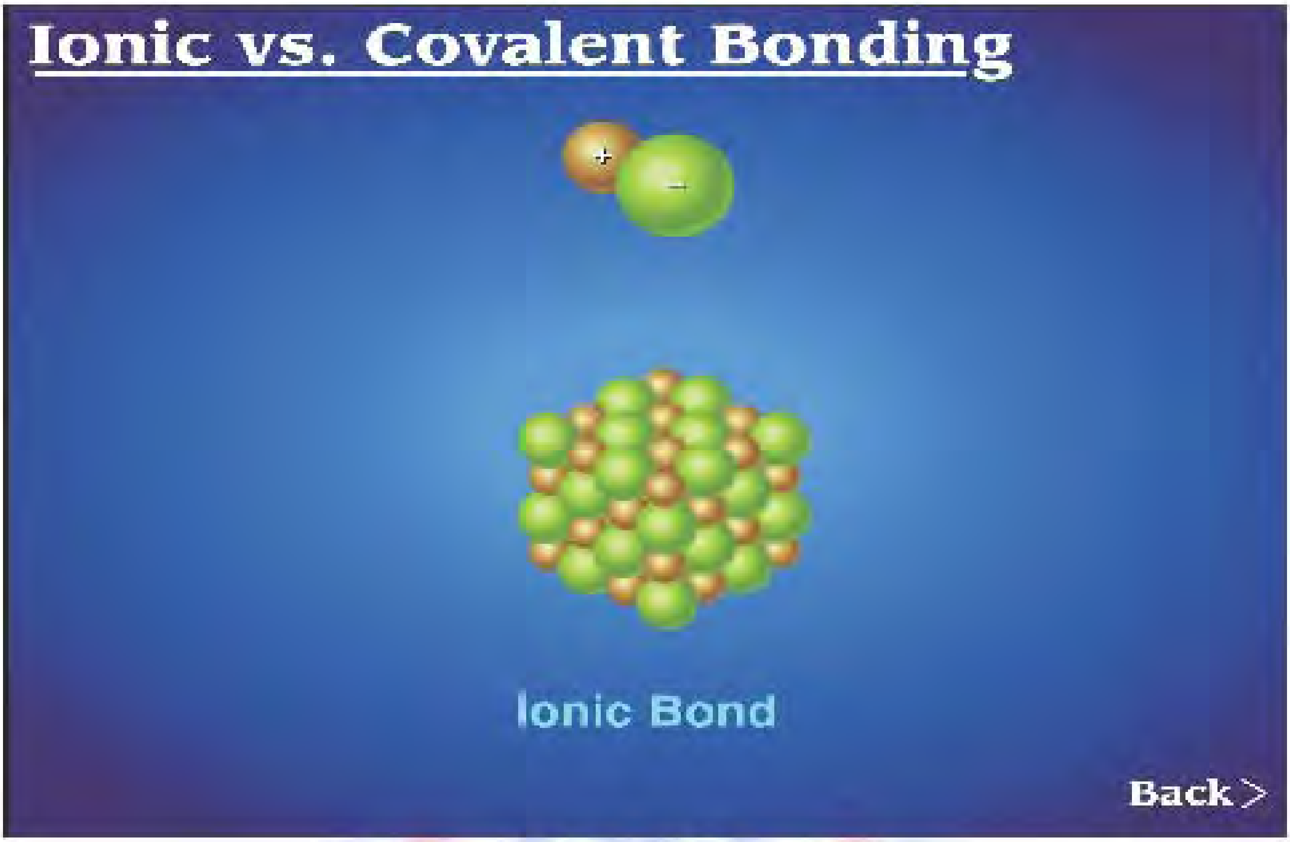
For negative statements;

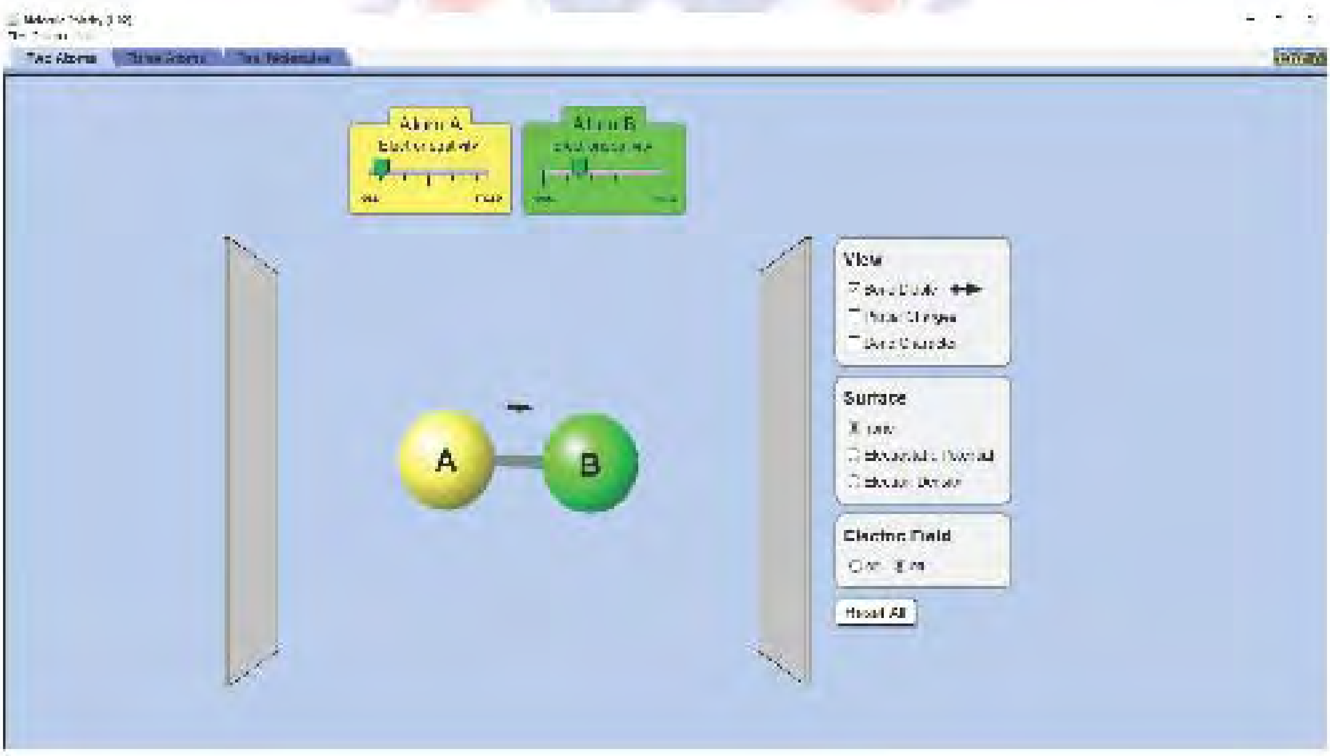
4 = Strongly Disagree (SD), 3 = Disagree (D), 2 = Agree (A), 1= Strongly Agree (SA).

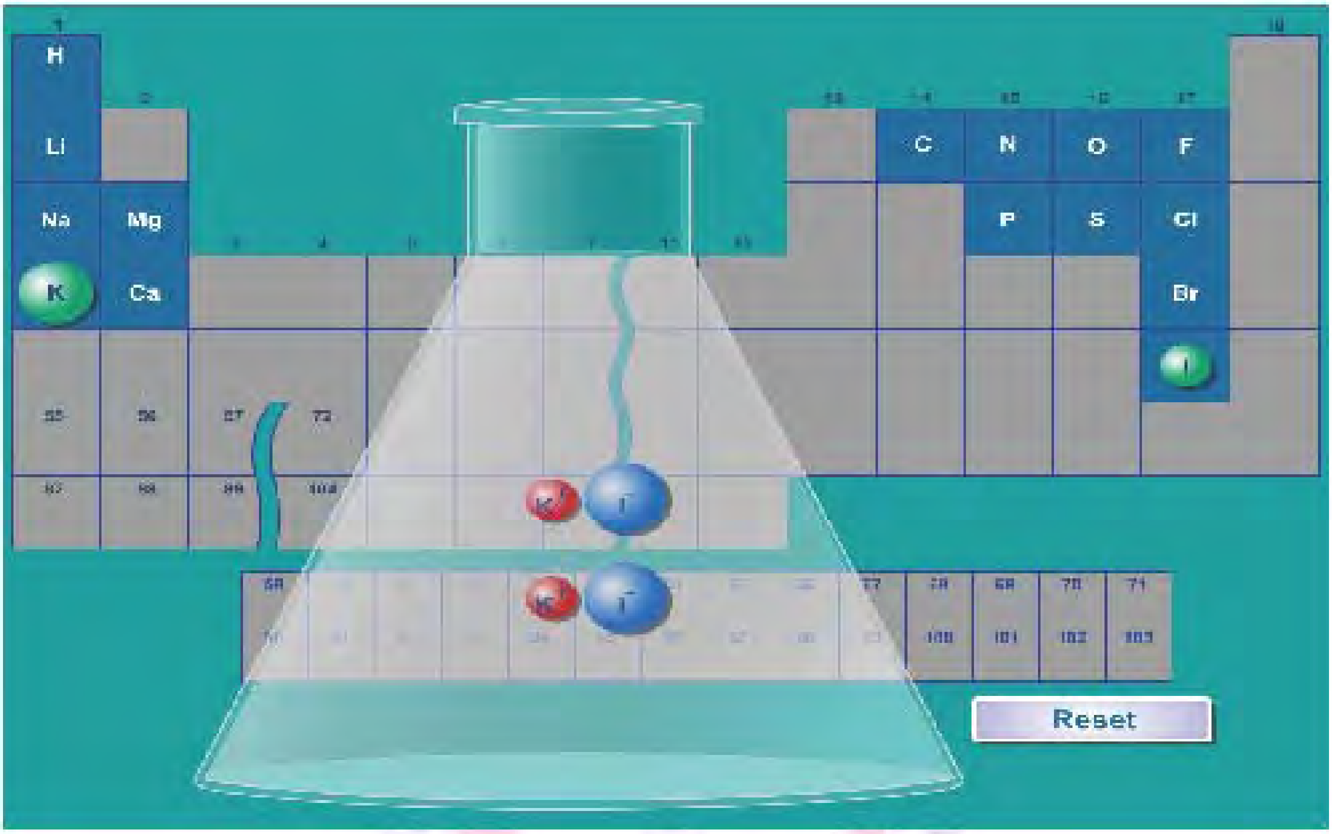
ITEMS	SA	A	D	SD
I believe chemical bonding would help me further chemistry studies.				
Studying chemistry is a waste of my time				
I wish chemical bonding is cancelled from the syllabus				
Chemical bonding is a difficult topic				
Chemical bonding is not my favourite topic in chemistry				
Chemistry plays an important role in my life				
I understand chemical bonding				
I intend to further my education in chemistry				
I am unable to visualise chemical bonding concepts				
Chemical bonding is a topic for clever students only				

I feel bored when I study chemical bonding				
My chemistry teacher is highly motivating				
My teacher encourages me to study chemistry				
My chemistry teacher avoids me when I ask questions				
I have a good personal relationship with my chemistry teacher				
My chemistry teacher stimulates understanding				
My teacher makes chemistry difficult				
My chemistry teacher does not teach with teaching aids				
I dislike my chemistry teacher's teaching method				
My chemistry teacher makes learning chemical bonding boring				
My teacher makes chemical bonding understandable				
Teaching skills of my chemistry teacher are outmoded				
My chemistry teacher teaches in an enjoyable way				
I love my chemistry teacher's teaching method				
I do not understand when my chemistry teacher teaches				
I usually ask many questions during chemical bonding lessons				
I frequently absent myself from chemical bonding lessons				
I am passive during chemical bonding lessons				
I hate chemistry chemical bonding lessons				
I enjoy chemistry chemical bonding lessons				

Appendix F - Screenshot of some of the CAI material used for the study






H
Li
C
N
O
F
Na
Mg
P
S
Cl
K
Ca
Br
Reset