EFFECT OF COMPUTER-ASSISTED INSTRUCTION ON STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMICAL BONDING IN SCIENCE SECONDARY SCHOOLS, KANO STATE- NIGERIA

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DECLARATION

I declare that this research dissertation was carried out by me, (BINTA IBRAHIM KHALIFA), SPS/13/MST/00024 and submitted to the Department of Science and Technology Education, Bayero University Kano, in Partial fulfillment of the requirement for the award of Masters in Science Education (M.Sc. (Ed) Chemistry.

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CERTIFICATION

This is to certify that Binta Ibrahim Khalifa, with registration number SPS/13/MST/00024 conducted this research dissertation under the supervision of Dr. Suwaiba S. Ahmad in the Department of Science and Technology Education, Faculty of Education, Bayero University Kano.

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DEDICATION

This research work is dedicated to my father Alhaji Ibrahim Khalifa and my late mother Haj. Halimatu Sadiya Auwal. May her gentle soul rest in perfect peace.

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OPERATIONAL DEFINITION OF TERMS

COMPUTER: Is an electronic machine operated under the control of instructions stored in its own memory that can input data, process data according to specified rules, produce output and store the results for future use.

CHEMISTRY: Is the study of matter and its interactions with other matter and energy.

CHEMICAL BONDING: A chemical bond is a strong attraction between two or more atoms. Bonds hold atoms in molecules and crystals together.

ELECTRONEGATIVITY: Describes the tendency of an atom to gain an electron.

COMPUTER SIMULATIONS: Is an attempt to model a real-life or hypothetical situation on a computer so that it can be studied to see how the system works.

ICT: Are technologies used for the collection, process, storage, manipulation and communication of information.

TRADITIONAL TEACHING: Is a teacher controlled learning environment where power and responsibility are held by the teacher and he/she plays the role of instructor.

COMPUTER-ASSISTED INSTRUCTION (CAI): Is an interaction between a student, a computer and a software programme guided by the teacher for the purpose of enhancing learning outcomes.

PRETEST: Is the test administered to the subjects before the treatment.

POSTTEST: Is the test administered to the subjects after the treatment.

ABBREVIATIONS

CAI:	Computer Assisted Instruction
CBAT:	Chemical Bonding Achievement Test
CBE:	Computer- Based Education
CBT:	Computer- Based Training
ICT:	Information and Communication Technology
NECO:	National Examination Council
SSCE:	Senior School Certificate Examination
WAEC:	West African Examination Council
WASSCE:	West African Secondary School Certificates Examination

ABSTRACT

This study examined the Effect of Computer Assisted Instruction on students' academic achievement in Chemical Bonding in Science Secondary Schools in Kano State. The main objective is to determine the effect of Computer Assisted Instruction on the academic achievement of chemistry students. The study made use of Quasi- experimental pre-test and post-test group design where students from SSII classes were involved. Stratified random sampling technique was used to select 2 male and 2 female science secondary schools. The sample selected for this study consists of two hundred and ten (210) senior secondary year two (SSII) chemistry students drawn from four (4) out of seven (7) Government owned science secondary schools in Kano State, comprising of 110 males and 100 females. The instrument that was used for this study is a Standardized Chemical Bonding Achievement Test (CBAT) which contained thirty items of multiple-choice questions type. The instrument was made to undergo content and face validation by some chosen experts. Split half method was used to establish the internal consistency and Spearman Rank Order Correlation was used to calculate the reliability coefficients at a value of 0.93. These research questions were put forward, among which is; What is the effect of Computer Assisted Instruction on the Academic Achievement of Chemistry Students in Science Secondary Schools in Kano State? Three null hypotheses were developed to include; there is no significant difference between the Academic Achievement of Chemistry Students exposed to Computer Assisted Instruction and those exposed to Traditional method of teaching in Science Secondary Schools in Kano State. Data was analysed using SPSS statistical package for calculating mean, standard deviation, paired sample test and independent sample t-test. From the findings, the experimental groups showed higher mean scores than control groups indicating a slight effect of CAI on academic achievement of chemistry students, it also revealed that CAI has no significant impact on the academic achievement of chemistry students. Therefore, necessary attention should be accorded to computer literacy in secondary schools and relevant computer assisted instructional packages should be developed for use within the Nigerian school systems. Further empirical studies should be carried out on the use of computer for instructional purposes on multiple subjects and at different levels to provide sound basis for the integration of computer in Nigerian secondary schools.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In the pursuit of a society in which individuals are prepared to make informed decisions about their health, welfare and the environment in which they live, science education is considered to be of critical importance (Glenn, 2000). At secondary school level in particular, success in science classes is seen as opening doors to science careers, as well as promoting scientific literacy. Science is often poorly taught, and students lose interest, choosing only the least number of required science courses (Jan, Ruth Catherine, Bruce, Elizabeth, Florrie and Juan, 2012).

Chemistry education is a potent tool that focuses on achieving economic growth and development for nation's sustainable goals. It is the vehicle through which chemical knowledge and skills reach the people who are in need of capacities and potentials for development (Emmanuel, 2013). Chemistry education is aimed at equipping learners with diverse basic scientific skills, competencies and creativity needed to provide opportunities for wealth creation (Adedayo, 2011). These aims will remain a mirage if teachers of chemistry do not have the pre-requisite qualification and experience needed for an engaged chemistry interactive classroom to enhance their productivity (Akpan, 2012). Chemistry is a practical-oriented course that needs appropriate qualification and experiences to teach.

Chemistry is one of the most important subjects in science. It contains a number of abstract concepts many of which are not obviously applicable outside the classroom (Stieff and Wilensky, 2003). The role of Chemistry in the development of the scientific base of a country cannot be over emphasized (Oloyede, 2010). It is one of the core science subjects that students are required to pass in order to qualify for admission into tertiary institutions to pursue science-based programmes (Njoku, 2007). In spite of this important position of chemistry among other science and science related disciplines, students' academic achievement has consistently been below expectation and unimpressive (Jegede, 2010; Oloyede, 2010).

Studies in Nigeria have shown that factors such as student factor, teacher factor and societal factors are the causes of students' poor performance in science courses of which teacher factor is identified as the major cause of students' failure (Oloyede, 2008). Zayum (2008) notes that instructional format provided by the teacher seems to be the medium of effective learning and that good teaching makes learning more meaningful. Zayum argues that while good teaching helps the learner more quantitatively, poor teaching would lead to poor learning and poor performance.

Research findings at all levels of schooling to determine students' ideas about the concepts of chemical bonding suggest that students who did not acquire a satisfactory understanding of scientific conceptions occurred as a result of traditional teaching methods such as simple lecturing. Such teaching method does not engage students actively in learning (Morgil, Oskay, Yavuz, and Arda, 2005). In such a traditional teacher-centred classroom, the students become listeners, and the teacher gives out the facts and defines important ideas. Students' participation is often limited to listening to the teacher and perhaps raising their hands to answer questions (Muir-Herzig, 2004). This leads to poor performance as apparent in research findings in Nigeria.

Kiboss, Ndirangu, and Wekesa, (2004) reports that traditional teaching methods when used in teaching science means that students may understand the subject, but only at a 'knowledge level' that involves them memorizing concepts without achieving in-depth understanding. Similarly, highly teacher-centred teaching methods may negatively affect the students' beliefs about science, leading them to perceive science learning as a simple accumulation of facts, and science as uninteresting (Williams, Linn, Ammon, and Gearhart, 2004). These pedagogical approaches may then influence students' attitudes, cognitive development and achievement in science education (Cepni, Tas and Kose, 2006). For this reason, science and chemistry teachers may need to consider alternative teaching approaches, particularly for difficult and abstract science concepts.

Chemical Bonding is taught as part of a general chemistry course to second year senior students in Nigerian Secondary Schools. It is an abstract concept as students do not experience bonding visibly in their daily lives. Yet, Chemical Bonding is one of the fundamental key concepts in chemistry. It is also one of the areas in the physical sciences where understanding is developed through diverse models and where learners are expected to interpret a wide unrelated range of symbolic representations of Chemical Bonds (Taber and Coll, 2002).

Learning about Chemical Bonding allows the learner to make predictions and give explanations about physical and chemical properties of substances. According to Taber and Coll (2002), many students have difficulty in understanding these concepts, so there is the tendency for them to form alternative concepts. Chemical Bonding is regarded as difficult and abstract concept, because both the atoms, which take part in a chemical combination to form the bonds, the bonds themselves, and their process of formation, are not concrete objects that can be seen with the naked eyes. They can only be conceptualised and imagined.

Chemistry teachers in secondary schools find it difficult to teach Chemical Bonding, because they failed to devise necessary tools that will enable them help their students to visualise the bonding process. Mastery of the concept of Chemical Bonding is fundamental to the study of chemistry as Engel and Reid (2006) rightly asserts, the Chemical Bond is ‘at the heart of Chemistry and Bonding between atoms is the essence of Chemistry’.

The advancement of civilization is making learning even much easier through utilization of electronic devices. Amongst these are the computers and its accessories (Landu, 2003). The computer has many functions, one of which is to assist in classroom instruction (Wodi and Dokubo, 2006). It is possible to use computer to deliver instruction in the classroom either partially or totally. According to Wodi and Dokubo (2006), Information and Communication Technology (ICT) based learning intervention can either be used to enhance practical investigation or as a virtual alternative to real practical work.

Interesting and well designed programmes can be motivational and students can spend more time on tasks, assessment, diagnostics and remediation can be built into programmes to help learners achieve mastery of the concepts taught (Olele, 2008). In most Nigerian schools where materials and apparatus for practical are either unavailable or insufficient, the dominant mode of teaching large classes is traditional (Njoku, 2004); the use of computer in teaching and learning therefore holds much promise (Ogunsola, 2002).

Computer Assisted Teaching is an interactive technique whereby computer is used to present instruction. It uses a combination of texts, sound, video and graphics in the learning process. It is a multimedia instruction which according to Mayer and Moreno (2003), can be defined as presenting both words and pictures that are intended to foster learning. To Mayer and Moreno (2003), the words can be printed on screen or spoken as narration. The picture can be static, for example (illustrations, graphs, charts, photos, or maps) or dynamic such as animation.

Zacharia (2003) reports that Computer Assisted Instruction also provides opportunities for inquiry-based approaches to teaching and discourages rote memorization and algorithmic problem-solving while encouraging conceptual understanding and critical thinking. For this reason, many educators now advocate the use of computers in chemistry classrooms. Computer Assisted learning environments attempt to make explicit the information embedded in traditional molecular representations as well as provide a visual representation of molecular interactions for students (Voska and Heikkinen, 2000). Such an approach is in contrast to traditional chemistry teaching that rely almost entirely on verbal explanation of concepts, meaning that students have little opportunity to observe molecular interactions (Stieff and Wilensky, 2003).

Worldwide multimedia is now permeating the educational system as a tool for effective teaching and learning (Adegoke, 2010). There are a lot of important reasons for using computer in chemistry education. Educators not only can gather many materials from various centers, but they can also get text, graph, audio, video, and picture animation in the same media to students (Sanger, Phelphs and Fienhold, 2000). Many studies also support the idea that Computer Assisted Instruction has positive effect on students' achievements and attitudes. Weiss, Knowlton and Morrison (2000) for instance mentioned gaining attention, motivation, extra information and elucidation of complex knowledge or complex phenomena as potential roles of Computer Assisted Instruction.

Globally, many students experience difficulties in understanding chemistry concepts because of the manner in which they are taught. As a result, students form misconceptions in this regard (Özmen, 2009). In order to curtail these misconceptions, Computer Assisted Teaching is employed in science education (Akpan and Andre 2000; Özmen, 2009). Studies from developed countries have mainly addressed three areas: conceptual change, skills development and content (Tversky, 2001). Little is known about the effectiveness of Computer Assisted Teaching in developing countries.

Visualizations, when effectively designed and used help to assure adequate perception and comprehension in the real-world context of student's learning (Tversky, 2001; Tasker, 2004). Students receiving Computer Assisted Instructions also enjoy their classes more and have better attitudes towards computer (Falvo, 2008). Teachers using computer Assisted Instruction can generally achieve the following results in more student-centred teaching: less lecturing, increased individual instruction, more time spent coaching and advising students, more interest in teaching and increased productivity (Leahy and Sweller, 2004).

Several capabilities of computers, such as providing individualized instruction, practice, revision, teaching and problem- solving, simulations during the applications and immediate feedback, make computers useful instructional devices for developing desired learning outcomes. An additional benefit is that the teacher can use computers at different times and places according to the characteristics of the subject matter, the students, and available software and hardware (Morgil, Yavuz, Oskay and Arda, 2005).

For some years now, advances in computer-based educational environments have been accompanied by great hopes for their ability to foster interest and improve learning in courses. In recent years, benefits have been derived from Information and Communication Technologies (ICT) in attempting to overcome the difficulties encountered in the conceptual learning of chemistry (Abdullah and Shariff, 2008). One of the goals of the Chemistry-Teaching Community is to develop more effective and logically aligned strategies to teach secondary school students the key concept of Chemical Bonding (Teichert and Stacy, 2002). This attempt is motivated by studies conducted worldwide that revealed that the traditional approach of teaching Bonding is problematic. Specifically, during the last two decades, researchers have found that students lack deep conceptual understanding of the key concepts regarding the Bonding concept (Taber, 2001).

In recent years there has been a call to shift from more teacher-centred learning activities to learning activities that make the learners more responsible for their own learning (Froyd and Simpson, 2010) as endorsed by constructivist theory: the theoretical framework on which this research is based. Therefore this study examined the effect of Computer Assisted Instruction in teaching Chemical Bonding to science secondary school students in Kano State.

1.2 Statement of the Problem

Chemical bonding is a central concept in chemistry teaching, and therefore a comprehensive understanding of it is essential for understanding almost every other topic in chemistry such as polymers, acids and bases, chemical energy, and thermodynamic (Hurst, 2002). Research reports (Njoku, 2004) on the status of science education in Nigerian secondary schools shows that science classroom activities are still dominated by teacher-centred methods, such as lecture and teacher demonstration methods, which have been found to be ineffective in promoting science learning at the primary and secondary school levels. This could be the reason why students have been performing poorly in standard examinations such as the Senior School

Certificate Examination (SSCE) conducted by West African Examination Council (WAEC), and the National Examination Council (NECO). According to West African Examinations Council's, examiners reports low enrolment and poor achievement of secondary school students in chemistry subject (WAEC, 2012).

According to Olorukooba (2007) and Jegede (2007), students consider chemistry to be a difficult field of study. The students' inability to comprehend and remember what has been learnt is mostly caused by teacher-centred approach that makes learners passive listeners.

Several studies have been carried out on Computer-Assisted Instruction (CAI) and academic achievement in science. Kolawole (2003) observes that Computer-Assisted Instruction (CAI) enhanced students' achievement in the sciences, where students exposed to Computer-Assisted Instruction (CAI) strategy performed better than those who were exposed to analogies instructional strategy while those exposed to expository teaching method performed the least. Orisebiyi (2007), who investigated the effect of computer assisted package on student's achievement and retention in biology found CAI to be effective on students' achievement and retention in Integrated Science. Cotton (2009) concluded, among others, that the use of CAI as a supplement to conventional instruction produces higher achievement than the use of conventional instruction alone. Research is inconclusive regarding the comparative effectiveness of conventional instruction and CAI alone, and that computer-based education (CAI and other computer applications) produce higher achievement than conventional instruction alone.

In Nigerian schools where chemical bonding in organic chemistry is arbitrarily taught or teachings are insufficient, the use of Computer-Assisted Instruction could be a welcomed idea. Therefore, the present study examined the Effect of Computer-Assisted Instruction on Students' Academic Achievement in Chemical Bonding in Science Secondary Schools in Kano State.

1.3 Objectives of the Study

1. To investigate the difference between the academic achievements of chemistry students exposed to Computer Assisted Instruction and those exposed to traditional method of teaching in science secondary schools in Kano State.

2. To examine urban and rural difference in academic achievement of chemistry students exposed to Computer Assisted Instruction in science secondary schools in Kano State.

3. To examine gender difference in academic achievement of chemistry students exposed to Computer Assisted Instruction in science secondary schools in Kano State.

1.4 Research Questions

1. What is the difference between the academic achievement of chemistry students exposed to Computer Assisted Instruction and those exposed to traditional method of teaching?

2. Is there any difference in academic achievement between urban and rural school chemistry students exposed to Computer Assisted Instruction?

3. Is there any difference in academic achievement between male and female chemistry students exposed to Computer Assisted Instruction?

1.5 Null Hypotheses

1. There is no significant difference between the academic achievement of chemistry students exposed to Computer-Assisted Instruction and those exposed to traditional method of teaching in science secondary schools in Kano State.

2. There is no significant difference between the academic achievement of urban and rural school chemistry students exposed to Computer -Assisted Instruction in science secondary schools in Kano State.

3. There is no significant difference between the academic achievement of male and female chemistry students exposed to Computer -Assisted Instruction in science secondary schools in Kano State.

1.6 Significance of the Study

At the end of this study, it is hoped that literature will be added to the use of Information and Communication Technology (ICT) in Teaching and Learning of Science. Policy makers would be enlightened about the effectiveness of CAI in facilitating Understanding, Comprehension and Retention of knowledge.

Curriculum Planners and stakeholders will be acquainted with the role of CAI as an effective Instructional Technique that facilitates interaction between students and computers which displays well planned learning materials along with pictures, graphs and visual effects that makes learning interesting. Hence, Curriculum Planners can incorporate CAI into the curriculum as a method of instruction right from Primary, Secondary and Tertiary levels of education. It will stimulate the curriculum developers and administrators to encourage teachers in all subject areas to acquire skills and attitude for developing CAI instructional materials for teaching, it will also enable administrators of higher institutions to organize and sponsor workshops, seminars and in-service trainings for their lecturers with a view to making use of CAI as one of the methods of teaching.

Computer Assisted Instruction will provide room for teachers and instructors to engage and motivate learners to a greater degree. It will enable teachers to show experiments that would otherwise not be possible. By using computer to teach, quicker and more accurate data collection will be provided to the teacher, saving lesson time and giving better quality results.

For science students, using Computer Assisted Instruction will make teaching and learning more interesting, authentic and relevant. It will give time for observation, discussion and analysis as well as increase opportunities for communications. Visual modes of presentation will aid understanding of chemical concepts and processes, give opportunities for independent self-directed learning and provide opportunities for collaboration with peers. Computer Assisted Instruction will help in reducing the mechanical aspect of practical work making learners to concentrate on interpretation and analyses of data. Students will be able to see for themselves how bonds are formed and so on. It will call for more attention towards using CAI to teach chemistry lessons.

1.7 Scope of the Study

The research study examined the effect of Computer-Assisted Instruction in chemical bonding. The study made use of two basic tools such as microsoft power point and multimedia package as Computer Assisted Instructional tools. The study was limited and conducted only at Government Science Secondary Schools in Kano State comprising of SSII students who have the basic knowledge of chemistry from SSI and are not engaged with examination preparation in SS III. The topic Chemical Bonding was chosen among other chemistry topics due to the fact that bonding is a central concept in chemistry and it is perceived by students as a difficult concept (Coll and Taylor, 2002). The researcher concentrated mainly on atoms and elements, molecules and compounds, bond types, electronegativity, bond polarity, hydrogen bonding and van der Waals forces.

1.8 Assumption of the Study

1. Students in the study sample have had effective instruction to chemistry through traditional method of teaching such as lecture method but are not exposed to Computer Assisted Instruction.
2. Students will understand and interpret each item in the research instrument and make dependable response to the items.
3. The choice of the topic and concepts used for the study are appropriate to the level of the students used for the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This study seeks to find out the Effect of Computer Assisted Instruction on Students' Academic Achievement in Teaching and Learning of Chemical Bonding. In this Chapter, literature relevant to the study were reviewed and organised in the following subheadings:

- Theoretical Framework.
- Conceptual Framework.
- Computer Assisted Instruction
- Chemistry and Chemical Bonding
- Chemistry Education.
- Nature and Teaching of Chemistry at Secondary Schools.
- Gender and Chemistry Teaching in Nigeria.
- Academic Achievement and Chemistry Teaching.
- Use of ICT in Teaching and Learning of Chemistry at Secondary School level.
- Advantages of using ICT to teach.
- Challenges to the use of ICT in Teaching
- Computer Assisted Instruction in Chemistry Teaching.
- Background to Chemical Bonding.
- Review of Empirical Studies.
- Implication of Literature Reviewed.

2.2 Theoretical Framework

The Theoretical framework of this study is based on Constructivism.

2.2.1 Constructivism Theory

Constructivism as a pedagogy signifies the idea of intellectual independence. It says that people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences (Christie, 2005). Constructivism as an instructional strategy encourages instructors to provide for each student preferred learning style, rate of learning and personal interactions with other learners. Therefore, Constructivism supports Computer Assisted Instruction as a means of enhancing students' learning.

Accepted teaching and learning practices have undergone changes of revolutionary proportions in recent years. These changes are evident in situations as diverse as early childhood teaching, college teaching and workplace training. They have been underpinned by shifts in psychological and pedagogical theory, the most recent of which fit broadly under the heading of constructivism. These different interpretations of constructivism have been labelled by Dalgarno, (2001) as endogenous, exogenous and dialectic, as follows: Endogenous constructivism: This emphasises the individual nature of each learner's knowledge construction process, and sees the role of the teacher as being merely to facilitate disequilibrium occurring by providing appropriate experiences. The application of Computer-Assisted Instruction is consistent with the endogenous interpretation of constructivism, which highlights for the learner the discovery of knowledge through their interaction with the environment rather than from direct instruction. The simulations can provide a realistic framework in which learners can explore and experiment, with these explorations allowing the learner to construct his or her own mental model of the environment. The interactivity inherent allows learners to see immediate results as they create models or try out their theories about the concepts modelled. Exogenous constructivism: This is of the view that formal instruction can help learners to form knowledge representations which they can later accommodate to their subsequent experiences and emphasizes the role of direct instruction to help the learner to form his or her own mental model of the ideas to be learned, supported by activities that allow the learner to test and further modify his or her knowledge representation. These activities could be carried out using Computer-Assisted Instruction, which simulates part of the knowledge area. Dialectic constructivism: This is of the view that learning occurs through realistic experience, but that learners require scaffolding provided by teachers or experts as well as collaboration with peers working together and developing their understanding of concepts through a social learning process supported by the deployment of Computer-Assisted Instruction.

2.2.2 Activity Theory

Activity theory which falls under Constructivism defines the use of computer by the teacher to create an environment that will help learners to reach their level of potential development which Vygotsky's (1978) work suggested can be reached with the help of a teacher or a more capable peer. Activity theory is today a global multidisciplinary research approach which is progressively more oriented towards the study of work and technologies (Engestrom, 2005). Activity theory is a powerful and clarifying descriptive tool rather than a strongly predictive theory. The object of activity theory is to understand the unity of consciousness and activity. Activity theory incorporates strong notions of intentionality, history, mediation, collaboration and development in constructing consciousness (Spasser, 2002).

Therefore, to infuse Activity theory into the context of this study, using the classical meditational triangle, the subjects are the students and the object (objective) is to learn about Chemical Bonding. The tools are the computer and the non-ICT tools (instructions) that mediate the interactions between the subjects and the object. The students are part of the community who are mediated by rules and division of labour. Rules may be explicit or implicit. Division of labour refers to the explicit and implicit organisation of the community involved in the activity.

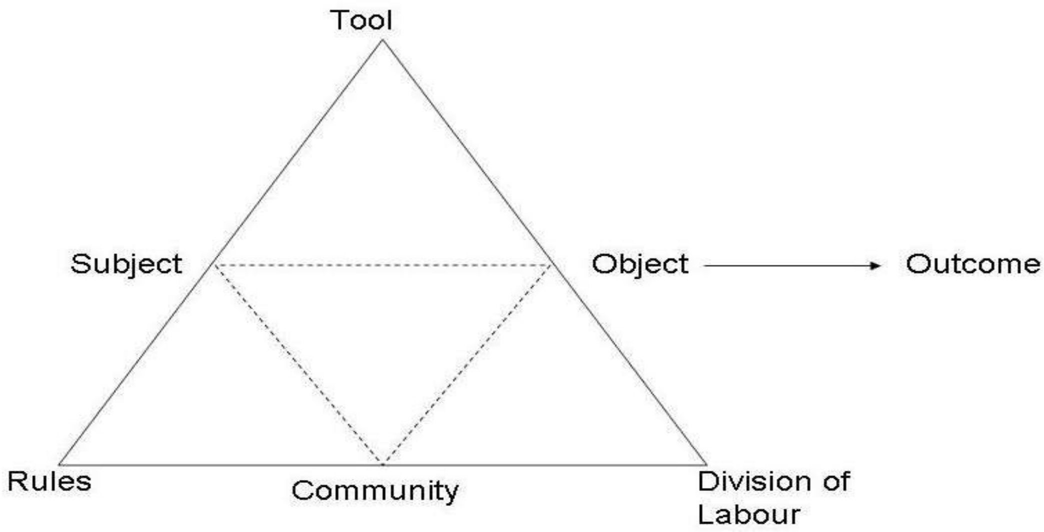


Figure 2.1: Engestrom's Activity Theory Diagram adapted from Mwanza and Engestrom (2003)

It has been observed that practical lessons in science permit learners to share their understanding in such a way that they are able to discuss their understanding and conception in the classroom. This actually can aid general understanding and the construction of knowledge as supported by (Jimoyiannis and Komis, 2001). Therefore, using Computer-Assisted Instruction can help learners to discuss in a collaborative way in the classroom. This study therefore sought to ascertain if Computer Assisted Instruction can effectively affect students' understanding of Chemical Bonding in Chemistry.

2.3 Conceptual Framework

2.3.1 Computer Assisted Instruction

Computer Assisted Instruction (CAI) refers 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 takes place (Umaru, 2003). Jenk and Springer (2005) opines that how CAI is delivered can affect its effectiveness, and that new studies are needed to clarify the effect of CAI in contemporary student environment. Instructional material and strategies have been found to aid academic achievement and retention such strategy as Computer Assisted Instruction. It uses a combination of text, graphics (animation), sound and video in the learning process. Venkataiah (2004) observed that Computer-Assisted Instruction (CAI) is an interaction between a student, a computer and a software programme guided by the teacher for the purpose of enhancing learning outcomes. Even though CAI was expensive and mechanical, it was considered to be a better teaching machine because of its flexibility and versatility. Furthermore, it provided integrated experiences which varied from abstract to concrete; helped the teacher to reduce repetition of words; improved students manipulative skills; improved visual perceptions and retention of information by the learner.

2.3.2 Chemistry and Chemical Bonding

Chemistry is one of the most important subjects in science and contains a number of abstract concepts requiring complex concepts many of which are not obviously applicable outside the classroom (Stieff and Wilensky, 2003). For this reason, students view chemistry as one of the most difficult subjects to study at all levels of schooling. Many researchers have reported on students' conceptions of fundamental, underlying chemistry concepts saying that when fundamental concepts are not constructed adequately, more advanced concepts that build upon the fundamentals are not fully understood. Chemistry knowledge is represented by scientists at three levels; the macroscopic, the sub-microscopic and the symbolic (Raviola, 2001). Because interactions between molecules and atoms occur at a sub-microscopic level, chemists refer to the objects and processes which they cannot observe directly at a symbolic level (Stieff and Wilensky, 2003). To understand chemistry at a sophisticated level necessitates students being able to make connection or relations among the levels. However, research suggests that students have difficulties in understanding the sub-microscopic and symbolic levels. Concepts such as the particulate nature of matter, physical and chemical change, chemical equilibrium, solutions, acids and bases, chemical bonding, and conservation of mass are topics that students have difficulties in visualizing at sub microscopic level. Over the last two decades a great deal of educational research has been conducted to determine students' alternative conceptions and difficulties in chemistry. Some current research has sought to investigate the underlying causes of difficulties students have when dealing with complex topics, and this research also seeks to develop curricula to help students overcoming these difficulties (Voska and Heikkinen, 2000).

Despite much research and curriculum development, it seems students still do not adequately learn many chemistry concepts (Tyson and Treagust, 1999). The effectiveness of new and alternative teaching methods of teaching chemistry concepts has been the subject of intensive investigation and ever since educators first began to use computers in the classroom, researchers have tried to evaluate whether the use of educational technology had a significant impact on student achievement (Papanastasiou, Zembylas and Vrasidas, 2003). In the chemistry education literature, there have been numerous studies reporting positive effects of the use of computers on student achievement. Therefore, the position of chemistry makes it necessary for the use of innovative pedagogical strategy that will enable teachers meet the challenges of teaching and learning of the subject especially in this era of information age. Several researches have shown that using Computer-Assisted Instruction (CAI) has a positive effect on students achievement compared to traditional methods. Computer has been used in both junior and senior secondary schools to teach various subjects (Nwobi and Uwandu, 2007). According to Ezeliora (2000), the use of CAI provides the learner with different backgrounds and characteristics. Using teaching software such as CAI, concepts are presented to the students in such a well-organized manner that makes for greater clarity and easier understanding. Okoro and Etukudo (2001) found CAI for teaching chemistry, Paul and Babaworo (2006) in technical education courses; they all confirmed that CAI seen to be effective in enhancing students' performance in other subjects than the conventional classroom instruction.

Chemical bonding has always been a crucial and fundamental topic which forms a basis for the learning of other topics in the secondary chemistry curriculum. From a constructivist perspective, meaningful learning requires a strong basis of prior knowledge, so that new knowledge could be scaffold based upon it. However, literatures have reported numerous alternative conceptions about chemical bonding, which are prevalent across different age groups and cultural settings (Coll and Taylor, 2002; Taber, 2002; Coll and Treagust, 2003; Ozmen, 2004). Chemical bonding is defined as any interaction that account for the association of atoms into molecules, ions, crystals, and other stable species that make up the familiar substances of the everyday world. When atoms approach one another, their nuclei and electrons interact and tend to distribute themselves in space in such a way that the total energy is lower than it would be in any alternative arrangement. If the total energy of a group of atoms is lower than the sum of the energies of the component atoms, they then bond together and the energy lowering is the bonding energy (Atkins and Beran, 1992).

The ideas that helped to establish the nature of chemical bonding came to fruition during the early 20th century, after the electron had been discovered and quantum mechanics had provided a language for the description of the behaviour of electrons in atoms. However, even though chemists need quantum mechanics to attain a detailed quantitative understanding of bond formation, much of their pragmatic understanding of bonds is expressed in simple intuitive models. These models treat bonds as primarily of two kinds namely, ionic and covalent. The type of bond that is most likely to occur between two atoms can be predicted on the basis of the location of the elements in the periodic table, and to some extent the properties of the substances so formed can be related to the type of bonding. A key concept in chemical bonding is the molecule. Molecules are the smallest units of compounds that can exist. One feature of molecules that can be predicted with reasonable success is their shape. Molecular shapes are of considerable importance for understanding the reactions that compounds can undergo, and so the link between chemical bonding and chemical reactivity (Atkins and Beran, 1992; John and Morrison, 1993).

2.3.3 Chemistry Education

Chemistry is the study of matter and its interactions with other matter and energy (Kelder, 2008). It is one of the most essential subjects that permeate every scope of activity including Agriculture, Biotechnology, Engineering, Environment and Medicine. Furthermore, chemistry has contributed enormously to improve the quality and comfort of human life in the present day world (Memije-Cruz, 2010). It is therefore, vital that the teaching of chemistry be done in such a fashion to lay a strong foundation on which future careers are built upon.

The understanding of key concepts in chemistry has become easier with the advancement of Science and Technology, making the learning of chemistry to be interesting and rewarding (Wiegand, 2003). Basic chemistry is relevant hence one can choose to take a course in chemistry and even make a career out of it. Therefore, the purpose of every chemistry teacher is to assist learners to understand scientific ideas and chemical phenomena (Dori and Barak, 2000).

One way to achieve this is to have students engaged in information processing and problem solving activities that emphasize the real-world experience, and daily-life chemistry (Dori and Hameiri, 2003). Students who wish to become Chemists, Doctors, Geologists, Nurses, Nutritionists, Pharmacists, and Physicists ought to study chemistry. The importance of chemistry will not be diminished over time, so it will remain a promising career path (Wieman, 2007).

2.3.4 Nature and Teaching of Chemistry at Secondary Schools

Scientific and technological literacy are widely considered as important goals for education (Hodson, 2003). As part of scientific literacy, the nature of science is often seen at the core of the curricular aims of science education, both at the secondary and university level (Erduran and Scerri, 2002). The nature of chemistry is not only related to scientific literacy and nature of science. The main goal of chemistry education is to engage students in scientific knowledge of chemistry, the nature of chemistry and how to do chemistry- that is scientific inquiry in chemistry (Hofstein, 2004).

The nature of chemical knowledge, how knowledge growth occurs and how this knowledge is structured and explained is a central part of chemistry (Erduran, 2001). The focus of technology education is moving from the skills involved in the manufacture of artefacts towards development of critical awareness of the technologically mediated world and the way technology shapes our future (Dakers, 2006). Of all the sciences, chemistry is perhaps most closely related to industry and technology (Laszlo, 2006; Sjöström 2007), and thus the nature of chemistry also contains aspects of technological literacy.

The self image of chemists has always been determined by a symbiotic relationship between the science and industry (Laszlo, 2006). Chemists use scientific thought processes in theory generation, experiment design, hypothesis testing, data interpretation and scientific discovery. In addition to technological research interests, chemistry has a laboratory core that is technological. Sjöström (2007) argues that, as chemists are not only interested in molecules' characters and behaviours, but also in generating wholly new molecules and structures or methods of production, chemistry is as closely related to technology as it is to science.

Chemistry as a scientific discipline is constantly evolving and transforming. If the goal of education is to produce scientifically and technologically literate students, there is clearly a need to take the nature of chemistry better into account when designing new chemistry syllabi. Chemistry is essentially a practical oriented subject which demands proper exhibition of science process, skills acquisition and decision making of existing phenomena in a developing country like Nigeria (Thomas and Emereole, 2002).

Studies have been carried out in an attempt to establish the causes and probably provide solutions to skills development in chemistry but not much have been achieved (Goni and Stephen, 2012). Unwaleke and Offiah (2013) reports that there is a significant relationship between students' skill possession and their achievement in chemistry. Skill is thought of as a quality of performance which does not depend solely upon a person's fundamental innate capacities but must be developed through training, practice and experience (Adeyemo, 2003).

Skill acquisition in chemistry is very essential for national growth and productivity. The products and processes of chemistry have dominated all aspects of social, cultural and economic life of the society (Okafor and Umoiyan, 2008). Without the products of chemical activities, which can be properly termed chemical skills, most of man's industrial machinery would grind to a stop and paralyse the world's economy. It is important to note that activities in chemistry are often interwoven with other science disciplines like Physics, Biology, Mathematics and

Technological activities. That was why (Njoku, 2008) states that Science and Technology Education and training are very essential for all citizens.

Seanac (2011) enumerates a number of challenges, which includes inadequate time and course content coverage and lack of qualified manpower with technical expertise in the teaching and learning of chemistry at secondary school level. This could affect students' performance in the subject at secondary school level. Onuekwusi, (2011) and Unwaleke and Offiah, (2013) reports that teaching method, poor motivation, ill-equipped laboratories, poor students' attitudes and students' laziness are major factors militating students' poor performance in chemistry in Nigerian Secondary Schools.

Akpan (2008) argues that lack of practical work by chemistry students has resulted in poor communication and observational skills and the absence of these skills leads to students' poor performance. Therefore, Nigerian chemistry teachers should be encouraged and enlightened to create awareness through instructional package to educate chemistry students on the usefulness of skills possession in real life situation.

2.3.5 Gender and Chemistry Education in Nigeria

Chemistry has been identified as a very essential subject and its importance in scientific and technological development of any nation has been widely reported (Udousoro, 2000). Despite the prime position of chemistry in Nigerian educational system, and efforts made by teachers and researchers to enhance academic achievement, students still perform inadequately in chemistry. This agrees with Kola (2012) who found that students' achievement and enrolment in theory and practical chemistry in Kwara State from 2004-2008 had been very low.

Bosede (2010) asserts that students' gender influences students' academic achievement in science subjects. Okeke (2008) gave a broad analytical concept which draws out women's role and responsibilities in relation to those of men. According to Okeke (2008), gender refers to the socially culturally constructed characteristics and roles which are ascribed to males and females in any society.

Gender is a major factor that influences career choice and subject interest of students. Okeke (2008) describes the males' attributes as bold, aggressive, and tactful while the females are fearful, nervous and submissive. Thus in schools, males are more likely to take difficult subject areas like science (chemistry) while the female take to career that will not conflict with marriage chances and responsibilities. Gender role differentiations are also encouraged in pictorial illustrations in textbooks which usually portray males as doctors, lawyers, engineers while the females are seen as nurses, cooks, mothers etc. This creates mental picture in the mind of readers of the role expectation from the society (Umoh, 2003; Babajide, 2010). Teachers also encourage gender stereotype by giving different treatment to male and female students in classrooms. They move further to give different career guidance to males and females.

Chemistry has been assigned as masculine subject and very difficult (Ekpo, 2006). Jegede (2007) found that female students show higher anxiety towards the learning of chemistry in secondary schools than male students. In another study, Okereke and Onwukwe (2011) establish that male students achieve better results than their female counterparts. This shows that the issue of gender in chemistry achievement is not yet resolved hence the need to see that both boys and girls are given equal access to education especially in science subjects.

The teaching of chemistry by means of Computer- Assisted Instruction can help both genders to process and develop information, take an active part in the learning process and develop their problem solving skills in chemistry (İşman, 2005).

2.3.6 Academic Achievement and Chemistry Teaching

Chemistry teaching can only be result-oriented when students are willing and the teachers are favourably disposed, suing the appropriate methods and resources in teaching the students. However, record of analysis of students' results in Chemistry and other science subjects such as Physics and Biology for a number of years has revealed dismal failure, with Chemistry being the poorest (WAEC Annual Report, 2010- 2014). Student's attitude towards the learning of chemistry is a factor that has long attracted the attention of researchers. Adesokan (2002) asserts that in spite of realization of the recognition given to chemistry among other science subjects, it is evident that students still show negative attitude towards the subject, thereby leading to poor performance and low enrolment.

The achievement of students in chemistry is also reported to be causally influenced by the previous experience of the students in integrated science. Students cannot learn chemistry effectively without going through some experiences in integrated science (Adeyemo, 2003). Other factors that may have causal relationships with students' academic achievement in science, particularly chemistry, include teacher attendance at chemistry workshop, laboratory adequacy, class size and school location.

Laboratory adequacy which is a school environment factor has been reported to affect the performance of students in chemistry (Adeyegbe, 2005). Afolabi (2002), argues that students tend to understand and recall what they see more than what they hear as a result of using laboratories in the teaching and learning of science.

When students learn chemistry meaningfully, their ability to reflect on their own learning and make adjustments accordingly fosters deeper learning. Deeper learning is the key strategy through which students find meaning and understanding from course material and experiences (Warburton, 2007). This in turn may result to competence of knowledge transfer to other domains and how to apply the knowledge in answering questions and resolving problems (Pellegrine and Hilton, 2012). Computer Assisted Instruction provides opportunity for students to have meaningful understanding of lesson which in turn may help the students to achieve better in chemistry.

2.4 Use of ICT in Teaching and Learning of Chemistry at Secondary School Level

The role of Information and Communication Technology in teaching and learning is rapidly becoming one of the most important issues in contemporary education policy (Thierer, 2000). Most experts in the field of education agree that, when properly used, Information and Communication Technology holds great promise to improve teaching and learning in addition to shaping workforce opportunities. The recent reoccurrence of the internet as an educational tool has given rise to the quality of education experienced at many parts of the world, with many more countries still catching up with current trends in education (Fu, 2013).

Secondary education is fundamental because it is the gateway to opportunities and benefits of economic and social development. In today's world, secondary education is being recognized as the keystone of educational systems in the 21st century (Gonczi, 2008). Quality Secondary education is indispensable in creating a bright future for individuals and nations alike. Use of computer has enhanced meaningful chemistry learning and developed learning environment (Paul, 2002).

In secondary education, Information and Communication Technology is relevant because its knowledge helps learners to search for the information and to organize their findings. (Otis, Grouzet and Pelletier, 2005). Many believe that ICT needs to be integrated into curriculum so that all schools produce computer literate, independent learners. Students often do not perform satisfactorily in basic chemistry (Morgil *et al.,* 2005).

For concepts due to the traditional teaching methods employed by the teacher Chemistry education at secondary level, more ground-breaking pedagogical methods should be applied in teaching. Particularly, for difficult and abstract concepts, student-centred approaches, especially those that employ modern Information and Communication Technologies should be used. Furthermore, ICT addresses the actual changes that must take place to apply technology in order to create some modifications in curriculum design. In particular, it provides new opportunities for chemistry teaching (Bennet, 2002). There are several literatures written in line with how useful ICT has become to science teaching and learning. Some of the literatures on the advantages of using ICT to teach are hence discussed.

2.4.1 Advantages of using ICT in Teaching

Recent developments in Information and Communications Technology (ICT) provide new opportunities to improve teaching and learning in the classroom (Abdoolatiff and Narood, 2009). According to Cigridisk and Ergul (2009), using computers in teaching has led to an improved teaching quality which in turn leads to better learner achievement. ICT creates a powerful learning environment by providing avenues for students and educators to access an abundance of information using multiple information resources (Smeets, 2005). Besides that, it encourages individual-learning, student-student interactions, teacher-student interactions. It has been reported that CAI can develop students' ability to understand and evaluate scientific processes (Cepni, Tas and Kose, 2006).

According to Wodi and Dokubo (2006) Information Communication Technology (ICT) based learning intervention can be used to enhance practical investigation or as a virtual alternative to real practical work where a simulation supports exploration of the investigation model through a computerized representation of the phenomena under study. Olele (2008) opines that interesting and well designed programmes can be motivational and students can spend more time on tasks; assessment, diagnostics and remediation can be built into programmes to help learners achieve mastery of the concepts taught.

Musker (2000) in the editorial page of Education in Science Reports carried out several studies comparing test results of year 10 student groups. He found that ICT could improve students' performance by allowing them to obtain result easily in a more visually stimulating manner. Musker also found that students appear to be more motivated towards their lessons when ICT is used effectively especially when it supports other successful methods of learning. This shows that students using an enriched ICT science curriculum improved their performance.

Skills development such as drawing graphs and ability to interpret them appear to be positively influenced by computer-based experiences (Bins, Bell and Smetana, 2010). Chang (2001) also supports the idea that Computer Assisted Learning had positive effects on students' achievements. Students who were exposed to Problem Based Computer Assisted Instruction (PBCAI) achieved significantly higher test scores than students in the Direct Interactive Teaching Method (DITM) group. Morgil *et al*., (2005) compared traditional and computer-assisted learning in teaching the concept of acids and bases. They found a significant difference in the Chemistry Achievement Test favouring the group learning chemistry using the internet (experimental group) compared with that of the control group.

Akcay, Durmaz, Tuysuz and Feyzioglu (2006), conducted a study to compare the effectiveness of computer-based learning and the conventional method with regard to students' achievement in analytical chemistry. The post-test results showed that students exposed to computer-based learning performed significantly better than students who were taught using the traditional method. Ozmen, (2008) conducted another study on the effects of computer-assisted instruction on students' conceptual understanding of chemical bonding involving grade II students. The post-test scores from the Chemical Bonding Achievement Test showed a statistically significant difference in favour of the experimental group. Research findings also indicated that students using computers were more successful in the learning of alternative concepts.

Okolocha (2010) in a research titled: e-learning: A veritable tool for preparing Business Education teachers in tertiary institutions in Anambra State, Nigeria observed that e-learning holds great potential for enhancing students' performance through students' individualized learning, independent study, and making learning more enjoyable and practical as well as encouraging students to work in a dynamic interactive learning environment. In a study by Mkpanang (2010) on the effect of Computer-Assisted-Instruction (CAI) with drill and practice it was observed that students taught with CAI performed significantly better than those taught with expository method.

However, it can be seen that integrating ICT into the curriculum, and utilizing computer to teach and learn science using a variety of computer course wares and online materials ensure that students get the best benefits from current information technology especially in understanding and developing students' motivation in learning science. Students' motivation affects meaningful chemistry learning. Motivation can be intrinsic or external (Marzano, 2001). Various factors affect students' intrinsic motivation to engage in a learning task, including their interest, needs, goals and beliefs about their own abilities and competencies as well as expectation of success, that is, student self-efficacy (Schunk and Ertmer, 2000). Students' external motivation can be affected by the responses of others, for instance (Chemistry teachers and students) and by rewards, incentives, penalties and punishment (Asunta, 2003).

Rapid advancement in Computer Technology has helped researchers to develop more innovative products to enable teaching and learning more effective in the classroom. Students' motivation for chemistry learning is incorporated in the design of a rich learning environment through Computer Assisted Inquiry (Osborne, 2003).

Although all the findings reports so far indicated a glowing picture about the use of computers in teaching, some other studies reports different findings. Arowolo (2009) reports that analysis of the results of the post-test of his study shows that even though the two groups (experimental and control group) show no statistical significant difference in their performance from the pre-test, they also show no statistical significant difference in their performance in the post-test, which means that computer assisted teaching did not help in improving students performance. Hence, the use of Computer Assisted Instruction in teaching and learning is not without problems.

Therefore, one should expect problems to be encountered in using it to teach. The challenges of using ICT to teach are hence discussed.

2.4.2 Challenges in the use of ICT in Teaching

The principal problem encountered in the use of ICT in the classroom is the failure of teachers to effectively integrate these technologies in teaching and learning processes (Demiraslan and Usluel, 2005; Usun, 2006; Gülbahar, 2008). There are historical problems in the use of ICT for teaching a wide range of topics (Tversky, 2003). Teachers with no training on using Information and Communication Technologies may not know how to use them to teach their classes. Not every teacher is capable to update his or her knowledge on ICT when teaching. That is because it is not possible for some teachers to update their knowledge on technologies that they are not capable to use. The updating of knowledge becomes nearly impossible in cases in which there is no sponsor or money to pay for training courses on ICT (Suárez, 2013).

The use of Computer Technology could cause a careless attitude among students whereby they will not take their work seriously. Moreover, ICT tools distract students' attention in the classroom and provide a tendency for the students to use short forms and informal abbreviations in their writing tasks (Yunus, Nordin, Salehi, Redzuan and Embi, 2013). Animations for example can mislead learning causing misunderstandings and misperceptions. Viewers often interpret movements of forms and figures in an animation as having causality and agency (Martin and Tversky, 2003).

Learners assume that the colours and the shapes reflect the actual reality of the represented items, when often the shapes and colours are either symbolic or an idealization of time and space relations. According to Brosnan (2001), attitude, motivation, and computer self-efficacy are factors affecting teachers' use of computers in their lessons. Teacher resistance and lack of enthusiasm to use ICT in education may also be another limitation. Furthermore, many teachers may not have the required IT skills and feel uncomfortable, nor do they have trainings needed to use the technology in their teaching hence fear ICT and its uncertainty values to their learners (John, 2005). Sometimes teachers attend courses to be trained to use ICT to teach in their schools, if the teacher does not get support from the school particularly the head teacher, it will be difficult for that teacher who has been trained to adopt and implement the new skills learnt (Scrimshaw, 2004).

On the other hand, the limitation of ICT use in education is related to student behaviour. Appropriate use of computer and the internet by students have significant positive effects on students' attitude and their achievement. Yousef and Dahmani (2008) described online gaming, use of face book, chat rooms, and other communication channels are perceived drawbacks of ICT use in education because, students easily switch to these sites at the expense of their study. Therefore, the impact of availability of ICT on students learning strongly depends on its specific uses. When ICT is not properly used, the disadvantages will overweight the advantages. Educational technology is not, and never will be transformative on its own. However, it requires the assistance of educators who integrate technology into the curriculum, align it with student learning goals, and use it for engaged learning projects.

Computer Technology though has gained prominence, have not been implemented in science teaching effectively because of various factors ranging from teacher level to school-level barriers (Becta, 2003). This section therefore reviews literature on some of the barriers to the use of ICT in teaching and learning.

2.4.3 ICT Competence

Another barrier, which is directly related to teacher confidence, is teachers' competence in integrating ICT into pedagogical practice (Becta, 2004). Computer competence is defined as being able to handle a wide range of varying computer applications for various purposes (Van-Braak, 2004). Many teachers who do not consider themselves to be well skilled in using ICT feel anxious about using it in front of a class of children who perhaps know more than they do (Guha, 2000). Guha (2000) found that teachers were worried about showing their pupils that they did not know how to use the equipment, and that it was the teachers who experienced this kind of anxiety who were less willing to make use of computers in their teaching. In addition, pupils' attitudes and expectations of their teachers' competence in ICT are likely to contribute to this teacher anxiety.

Some studies have investigated the reasons for teachers' lack of confidence with the use of ICT. For example, Beggs (2000) asserts that teachers' fear of failure caused a lack of confidence. On the other hand, Balanskat, Blamire and Kefala (2006) found that limitations in teachers' ICT knowledge makes them feel anxious about using ICT in the classroom and thus not confident to use it in their teaching.

According to Kennedy and Finn (2000), as cited in Bordbar (2010), teachers' computer competence is a major predictor of integrating ICT in teaching. In Australian research, Newhouse (2002) found that many teachers lacked the knowledge and skills to use computers and were not enthusiastic about the changes and integration of supplementary learning associated with bringing computers into their teaching practices.

Effective training is crucial if teachers are to implement ICT effectively in their teaching (Kirkwood, Van Der kuyl, Parton and Grant, 2000). If training is inadequate or inappropriate, then teachers will not be sufficiently prepared, and perhaps not sufficiently confident to make full use of technology in and out of the classroom. The lack of teacher competence, together with the associated lack of quality training for teachers, can be seen as a barrier to teachers' use of ICT. Knezek and Christensen (2002) revealed that teachers' competence with computer technology is a key factor for effective use of ICT in teaching. Peralta and Costa (2007) conducted a study on 20 teachers' competences and confidence regarding the use of ICT in classrooms. They revealed that in Italy, teachers' technical competence with Technology is a factor of improving higher confidence in the use of ICT.

2.4.4 Lack of Access to ICT Resources

Mumtaz (2000) points out that evidence of very good practice in the use of ICT is invariably found in those schools that also have high quality ICT resources and that lack of computers and software can seriously limit what teachers can do in the classroom with regard to the implementation of ICT. In a worldwide study of the obstacles to the integration of ICT in education, Pelgrum (2001) found that the most frequently mentioned problems when teachers were asked about obstacles to their use of ICT, was the insufficient number of computers available to them.

Guha (2000) found similar results, with many teachers surveyed indicating that the number of computers in their classrooms was insufficient, and that if teachers were to continue to implement ICT into their work, then they will require the appropriate hardware and software to familiarise themselves with first, before guiding their students accordingly.

Inappropriate software is also identified as a barrier in the research undertaken by the Centre for Guidance Studies (Bosley and Moon, 2003). Bosley and Moon, (2003) reports that inappropriate software design can disengage the pupils from the intended learning processes, and as a result can create a barrier to ICT use.

2.4.5 Teachers Resistance to Change and Negative Attitudes Found in ICT

Gomes (2005) found that science teachers' resistance to change concerning the use of new strategies is an obstacle to ICT integration in science teaching. At a wider level, Becta (2004) argues that resistance to change is an important barrier to teachers' use of new technologies in education. One key area of teachers' attitudes towards the use of technologies is their understanding of how these technologies will benefit their teaching and the students' learning (Becta, 2004). According to Empirica (2006), teachers who do not use new technology such as computers in their classroom are still of the opinion that the use of ICT has no benefits or unclear benefits.

In theory, some researchers had the opinion that teachers who had not experienced ICT throughout their learning tend to have a negative attitude towards it, as they may lack the training in that area of the curriculum. The researcher therefore, agrees with Mumtaz (2000) who asserts that there is a need for adequate and careful training so that teachers become aware of the range of uses and possible benefits of ICT.

2.4.6 Lack of Effective Training in ICT

Lack of effective training is the barrier that is frequently referred to in literatures (Beggs, 2000; Albirini, 2006; Balanskat *et al.,* 2006; Ozden, 2007). Beggs

(2000) reports that one of the top three barriers to teachers' use of ICT in teaching students is the lack of training. Recent research in Turkey found that the main problem with the implementation of new ICT in science education is the insufficient amount of in-service training programs for teachers.

Corresponding research by Gomes (2005) relating to science education concludes that lack of training in digital literacy, lack of pedagogic and didactic training on how to use ICT in the classroom are obstacles to using new technologies in classroom practice. Providing pedagogical training for teachers, rather than simply training them to use ICT tools, is an important issue (Becta, 2004).

2.4.7 Affordability of ICT Facilities

A major obstacle to the use of technology in instruction is the cost involved in purchasing the hardware, software, installing, maintenance and servicing. Arowolo (2009) argues that many education departments in African countries cannot afford such big budget on computers. In addition, learners from low-income families may not have computers at home or may have computers at home with no access to the internet. Consequently, learners in low-income communities may be disadvantaged. According to the IT learning exchange cited in Brahmbhatt (2012), in most schools ICT will be the single largest curriculum budget cost hence there will be little money left over for other significant costs.

2.4.8 Lack of Time to Use ICT Facilities

One major problem that exists for teachers in many aspects of their work is that of the lack of time allocated for them to complete given tasks, and teaching ICT is certainly an area that is affected by this (Preston and Cox, 2000). In their report, teachers pointed out that a great deal of work is required in preparing accurate ICT materials for use by children with a range of abilities, and complained of the lack of time restricting them from exploring materials for potential use with ICT.

Cuban, Kirkpatrick and Peck (2001) provided evidence to support this. In their survey of teachers at two American high schools, they found that there was not enough time for computers to be incorporated fully into daily teaching. Teachers explained that they would need hours to preview web sites, prepare multimedia materials for lessons, and to undertake training. In the same study it was found that this problem did not only apply to those teachers who made little use of ICT; similar complaints were made by teachers who were attempting to make full use of the technology in their lessons, as they had to work longer hours in order to make their ICT use successful, paying the price in exhaustion for this kind of dedication. Recent studies show that lack of time is an important factor affecting the application of new technologies in science education (Al-Alwani, 2005).

2.4.9 Gender Differences and ICT

The rate at which technology is used in teaching is greatly influenced by gender. Gender differences and the use of ICT have been reports in several studies. However, studies with reference to teachers' gender and ICT use have cited female teachers' low levels of computer use due to their inadequate technology access, skill, and interest (Volman and van Eck, 2001). Research studies reveal that male teachers used more ICT in their teaching and learning processes than their female counterparts (Kay, 2006). Similarly, Markauskaite (2006), investigated gender differences in self reports ICT experience and ICT literacy among first year graduate trainee teachers. The study reveals significant differences between males and females in technical ICT capabilities and situational sustainability. Males' scores were higher.

The EC report (European Commission, 2002), notes that gender is a factor which determines the use of ICT by teachers, stating that 77% of male teachers use a computer off-line, compared with 66% of female teachers, and points out that the gap is wider when looking at the use of the internet; 56% of male teachers compared with 38% of females.

2.5 Obstacles to the use of ICT to Teach in Nigerian Secondary Schools

There are several impediments to the successful integration of ICT in Nigerian secondary schools. Some of which include;

2.5.1 Inadequate ICT Manpower in Schools

One of the problem facing Nigerian Secondary Schools and its ICT programme is workforce training (Goshit, 2006). Teaching as a profession in Nigeria is considered to be for the less privileged ones, therefore with this deplorable condition, teachers are not motivated to go the extra mile in assisting their students to acquire computer education (Oduroye, 2007). However, in schools where these personnel exist, they lack skills in designing and delivering courses/lectures in electronic formats.

2.5.2 High Cost of ICT Facilities

Cost is one of the factors that influence provision and use of ICT services in Nigerian Secondary Schools (Adomi, 2006). The cost of computer is too high for many to afford. Monthly internet rates are exorbitant and the charges for satellite television are unaffordable for most people in Nigeria (Brakel and Chisouga, 2003). This has made it difficult for Nigerian Secondary Schools to acquire and install ICT facilities for the use of teachers and students.

2.5.3 Poor Perception of ICT among Teachers and Administrators

There is widespread ignorance and misconceptions about ICT amongst Nigerians (Ighoroje and Ajayi, 2009). One of the major inhibitors to Nigeria fully embracing ICT is the average Nigerian's general lack of exposure to them. For most Nigerians, Information technology is still something unfamiliar and mysterious. Rather than being as a tool for personal and national development, Information Technology is seen as a hurdle (NITDA, 2003).

2.5.4 Poor Internet Facilities and Frequent Electricity Interruption

Research report by Adomi (2006), confirms that ICT development and application are not well established in Nigerian Secondary Schools due to poor information infrastructure. It has been reports by Southwood (2004) that more than 40 percent of African Populace including Nigeria are in areas not covered by telecom services hence schools located in such areas will experience ICT connectivity problems.

Electricity failure has been a persistent problem militating against the use of ICT in Nigerian secondary schools (Adomi, Okiy and Ruteyan, 2003). This makes the few schools with ICT facilities unable to use them.

2.6 Computer Assisted Instruction in Chemistry Teaching

Learning and Understanding of Chemistry is challenging due to the complex and abstract nature of chemical concepts (Solsona, Izquierdo and De Jong, 2003). Helping students comprehend scientific ideas and chemical phenomena is the purpose of every chemistry instructor. One way of teaching for understanding is to engage students with information processing and problem solving activities that focus on real-world experience, and daily life chemistry (Dori and Hameiri, 2003).

Another way is to utilize visualization tools for enhancing conceptual understanding among students (Barak and Dori, 2005). Information processing, problem solving and utilizing visualization can be done by integrating ICT (information and communication technologies) into chemistry curriculum. Another study shows that ICT-enhanced learning has a positive effect on students' chemistry achievement, provided the students were actively engaged in the learning environments (Dori, Barak and Adir, 2003).

Despite the fact that ICT has been integrated in many chemistry courses and has shown positive educational benefits, changing conventional method of teaching is yet a challenging process. For successful integration of new teaching methodologies and ICT, instructors need to have high proficiency in pedagogical as well as scientific knowledge. They also need to be open to new ideas, adopt changes and be flexible. However, most science faculty have little, if any, professional training in teaching

(NRC, 2003) and curriculum changes are not easily adopted nor accepted (Davis, 2003). For successful integration of ICT in teaching chemistry, a number of factors need to be considered such as good infrastructure and adequate support, introduction of learning and communication platforms, ICT becoming part of school subjects, a clear vision and policy on what schools need to accomplish when it supports its teaching and learning using ICT.

2.7 Background to Chemical Bonding

Chemical Bonding is one of the most important topics in undergraduate chemistry and the topic involves the use of a diversity of models varying from simple analogical models to complicated abstract models possessing of significant mathematical complexity (Coll and Taylor, 2002; Coll and Treagust, 2003). It is also a topic that students commonly find challenging and develop a wide range of alternative conceptions.

The concepts of electron, ionization energy, electronegativity, bonding, geometry, molecular structure, and stability are central to chemistry, from reactivity in organic chemistry to spectroscopy in analytical chemistry (Nicoll, 2001). It is important for students to grasp these concepts in understanding why and how chemical bonds occur.

One of the goals of chemistry-teaching is to develop more effective and scientifically related strategies to teach secondary school students the key concept of chemical bonding. According to Teichert and Stacy (2002), this attempt is motivated by many studies conducted worldwide that revealed that the traditional approach of teaching bonding is problematic. More specifically, during the last two decades, researchers have found that students lack a deep conceptual understanding of the key concepts regarding the bonding concept and fail to integrate their mental models into a coherent conceptual framework (Taber, 2001).

Bonding is a central concept in chemistry teaching, and therefore a thorough understanding of it is essential for understanding almost every other topic in chemistry such as carbon compounds, acids and bases, chemical energy, and thermodynamics (Hurst, 2002). According to literature, bonding is considered by teachers, students, and chemists to be a very complicated concept (Robinson, 2003; Taber, 2001). The concepts associated with chemical bonding and structure, such as covalent bonds, molecules, ionic bonds and hydrogen bonds are abstract and in order to understand these concepts, students must be familiar with the physical concepts that are associated with the bonding concept such as orbital, electronegativity and bond polarity. Chemical compounds are combinations of atoms held together by chemical bonds. These chemical bonds are of two basic types: ionic and covalent. Ionic bonds result when one or more electrons from one atom or group of atoms are transferred to another atom. Positive and negative ions are formed. In covalent compounds the electrons are shared by the bonded atoms. The physical property of a substance such as melting point, solubility, and conductivity tells a lot about the type of bond in a compound.

2.7.1 Atoms and Elements

Atoms are the smallest particles of matter, while a substance composed of atoms with identical atomic number is called an element (Kelder, 2008). Symbols are used to represent element by chemist. For example, the symbol of helium is (He) and that of nitrogen is (N) (Kelder, 2009).

2.7.2 Molecules and Compounds

A molecule is the smallest subdivision of a compound that still retains the properties of that compound, while a compound is a substance formed when two or more elements are chemically combined together. Water, salt, and sugar are examples of compounds. When elements combine, the atoms lose their individual properties and have different properties from the elements they are composed of (Kelder, 2009).

2.7.3 Chemical Bond

A chemical bond is a strong attraction between two or more atoms. Bonds hold atoms in molecules and crystals together. There are many types of chemical bonds, but all involve electrons which are either shared or transferred between the bonded atoms.

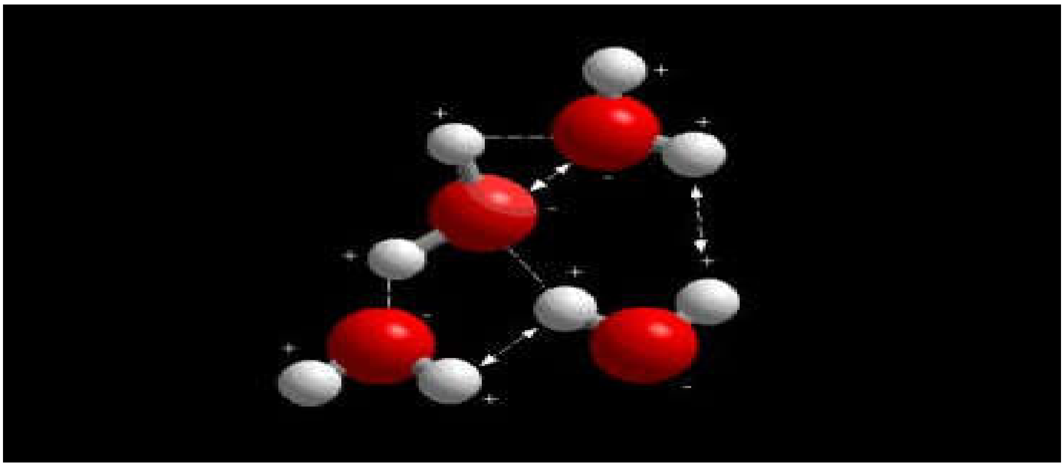


Figure 2.2 Structure of a Chemical Bond

2.7.4 Covalent and Ionic Bonding

Typically, covalent and ionic bonds are presented dichotomously, as ‘electron sharing’ or ‘electron transferring’ bonds, respectively. However, in hetero-atomic systems, bonding is better described in terms of a continuum of a covalent-ionic dimension or 'scale' (Levy *et al.,* 2004; Sproul, 2005; Taber and Coll, 2002). Furthermore, bonds between two identical atoms are purely covalent, but purely ionic bonds actually do not exist at all. The dichotomous presentation impedes the understanding of the more subtle 'scale'.

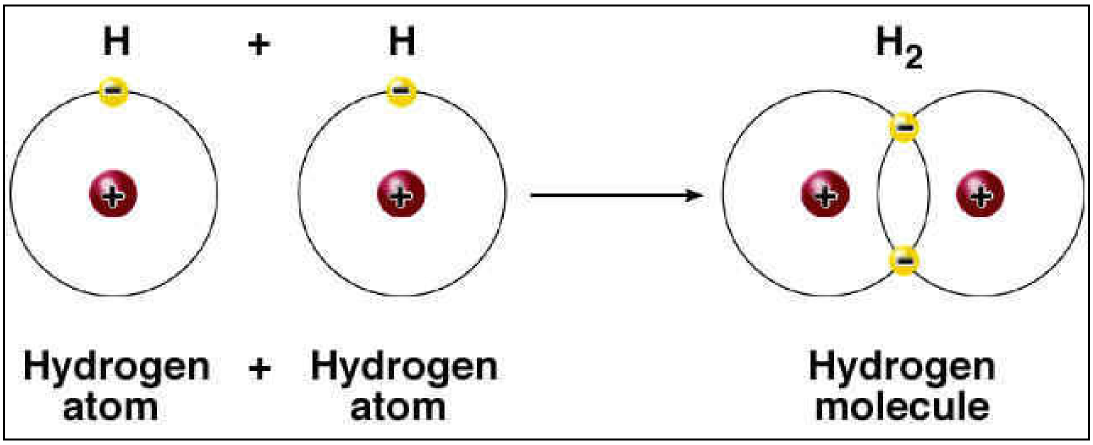


Figure 2.3 Formation of a Covalent Bond

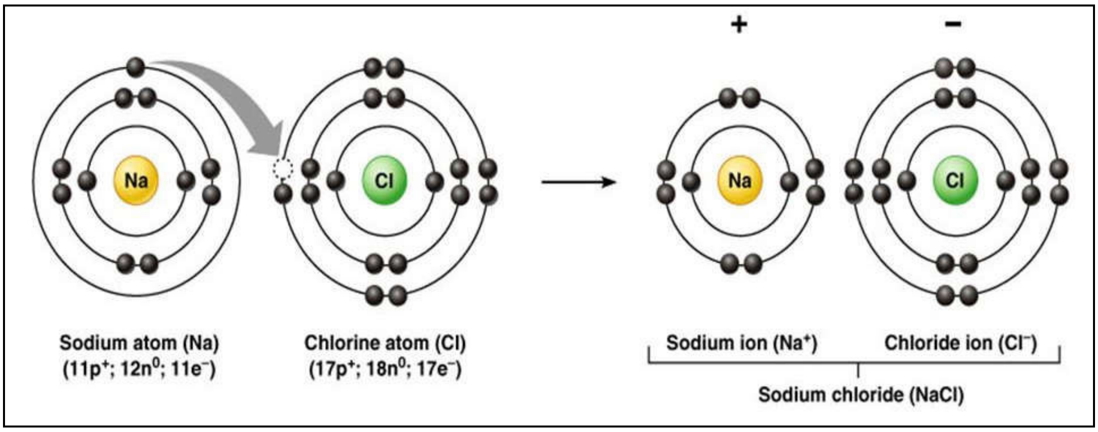


Figure 2.4 Formation of an Ionic Bond

2.7.5 Electronegativity and Bond Polarity

Electronegativity describes the tendency of an atom to gain an electron. Within the traditional approach, bond polarity is essentially viewed as an additional characteristic of covalent bonds (Hurst, 2002; Taber and Coll, 2002). The important concept of electronegativity is only introduced in the context of covalent bonding and not as an integral part of bond polarity concepts (Weinhold and Landis, 2005). Electronegativity differences between atoms are then used as an indication of whether compounds should be classified as ionic or covalent. However, electronegativity differences are not the ultimate measure for predicting bond type (Sproul, 2005). Indeed, cases of bonds between atoms with large electronegativity differences that nevertheless possess a significant covalent nature are known experimentally. Electronegativity value indicates the attraction of an atom for shared electrons. It increases from left to right going across the period on the periodic table. It is high for non-metals with fluorine as the highest and low for metals.

2.7.6 Hydrogen and Van der Waals Forces

In most textbooks, covalent and ionic bonds are described as 'real' chemical bonds, whereas hydrogen and van der Waals bonds are often presented as 'just forces' (Taber and Coll, 2002). While the relative strengths of different types of bonds are, of course, very important, even 'weak' bonds do indeed bond together different chemical units and sub-units and can have profound chemical consequences (Taber and Coll, 2002; Levy *et al.,* 2004), e.g., hydrogen bonding in biochemistry (for example in the double helix structure of DNA).

2.8 Review of Empirical Studies

Akcay, Durmaz, Tuysuz and Feyzioglu (2006) conducted a study to compare the effects of computer based learning and traditional methods on students 'attitudes towards Analytical Chemistry. 142 students from Faculty of Dokuz Eylul University

Turkey participated in the study. The participants were divided into three groups randomly, Experimental group 1, Experimental group 2 and Control group. Likert scale items to measure computer attitudes and analytical attitudes were developed as a pre-test and post-test. Each learning method was used for one group for teaching acid-base titration. The first method was computer-based learning process, applied to experimental group 1, the second process was prepared on MS Excel applied to experimental group 2 and the third was traditional method of teaching applied to control group.

Although significant and positive changes were found on students' attitudes towards analytical chemistry in the first two methods, the result show no significant differences in control group students 'attitudes towards analytical chemistry in traditional teaching method. However, the results of analytical chemistry presented students who were taught by the first two methods were more successful than the students who were taught using traditional method of teaching. Hence computer based education is found to be more effective than traditional method on students' attitudes towards analytical chemistry.

Similarly, a study was conducted in South-Africa by Kotoka (2013) on the effects of computer simulation in the teaching of Atomic Combinations to grade II Physical Science Students. The sample of the learners who took part in the study was a total of 105 grade II Physical Science learners. One of the two classes of the two different High Schools that were chosen at random to be an experimental group was made up of 52 learners and the other, the control group was made up of 53 learners. The study made use of a Non-Randomized Quasi-Experimental pre-test and post-test control group designs where learners in existing grade II Physical Science classes were used. An Achievement Test consisting of 30 multiple-choice questions and a

Structured Questionnaire designed for teacher and learner participants were the principal data collection tools used. The questionnaire tested how much learners and teachers were familiar with the use of computers and if there were any hindrances to computer usage. The intervention took two and a half weeks for each of the schools involved in the study. Analyses of scores of the two groups in post-test were compared using Statistical Package for the Social Sciences (SPSS) independent t-test version 16.0. The findings revealed no significant difference between students exposed to simulation method and those exposed to traditional method of teaching.

Adesina (2011) examined the effect of multimedia instruction on senior secondary school students' cognitive achievement in physics. The sample comprised of 198 (106 boys and 92 girls) students from four senior secondary schools in Isokan and Ayedeade local Government Areas, Osun State, Nigeria. Two instruments such as Multimedia Instruction Software (MIS) and Physics Achievement Test (PAT) were used. There were three experimental groups and a control group. Three courseware versions namely, animation + on-screen text, animation + narration, animation + on – screen text + narration were developed to examine the interface effects. A traditional lecture method group served as control. Four intact classes were used for this study. The physics teacher in each school served as an assistant. The study deployed the use of quasi-experimental. Results showed that, on the average, students in the animation + on-screen text + narration group took best quality notes and this seemed to have influenced their superior cognitive achievement in physics. Generally, students under multimedia instruction performed better than their colleagues in the lecture group.

In another study conducted by Udo and Etiubon (2011) in Uyo, Nigeria on relative effectiveness of computer-based science simulations on students' achievement in chemistry at secondary school level when compared with guided-discovery and traditional method of teaching. A sample of 89 SSII chemistry students drawn from three intact classes in three co-educational public secondary schools in Uyo local government area of Akwa-Ibom State. The instrument used in collecting data was a researcher-developed 25-item 4-option multiple choice test - the Chemistry Achievement Test (CAT) - designed to measure students' achievement in the area of chemical combination. The test had a reliability index of 0.72 determined using test-retest approach. The study used non-randomized pre-test- post-test control group design. Criterion sampling technique and analysis of covariance (ANCOVA) were deployed. The findings showed that students taught using computer-based science simulation performed significantly better than students taught using traditional method but had comparable performance with students taught using guided discovery approach.

The observed facilitative effect of computer-based simulations on students' achievement in chemistry supports Okolocha (2010) assertion that e-learning holds great potential for enhancing students' performance. Hence it is recommended that chemistry teachers should adopt Computer-Assisted Instruction technique in teaching chemistry concepts in view of its high facilitative effect on students' performance. It is also recommended that similar study should be conducted in other parts of the country to allow for meaningful generalization.

2.9 Implication of Literature Reviewed

Udo and Etiubon (2011) conducted a study in Uyo, Nigeria on relative effectiveness of computer- based science simulations on students' achievement in chemistry at secondary school level when compared with guided-discovery and traditional method of teaching. The findings shows that students taught using computer-based science simulation performed significantly better than students taught using traditional method but had comparable performance with students taught using guided discovery approach.

Adesina (2011) examined the effect of multimedia instruction compared with traditional method of teaching on senior secondary school students' achievement in physics and found that students taught using multimedia instruction performed better than their colleagues taught using traditional method of teaching. Ozmen and Kolomuc (2004) investigated the effect of the Computer-Assisted Instruction on tenth grade students' achievement in solution concept. They found that the experimental group that took Computer-Assisted Instruction had a better understanding than the control group that was given traditional instruction.

Similar studies confirmed that the performance of students exposed to CAI packages were enhanced in other subjects like Mathematics (Udousoro, 2000) and Chemistry (Okoro and Etukodo, 2001).

Kotoka (2013) conducted a study in South Africa on the effects of computer simulation in the teaching of Atomic Combinations to grade II Physical Science Students. The findings revealed no significant difference between students exposed to simulation method and those exposed to traditional method of teaching.

Onasanya, Daramola and Asuquo (2006) investigated the effect of Computer Assisted Instructional Package on students' performance in Introductory Technology in Ilorin, Nigeria. The result of the t-test analysis showed that there was no significant difference in the performance of students of Introductory Technology who were exposed to individualized CAI package and those taught using traditional method of instruction. This result is contrary to results of similar studies in other subjects.

Research study by Udo and Etiubon (2011) in Uyo, Nigeria used non-randomized students pre-test post-test group design with a sample of 89 SSII students drawn from three intact classes in co-educational schools. Adesina (2011) used a sample of 198 students from four senior secondary schools in Osun State, Nigeria. The study used three experimental group and one control group. Kotoka (2013) in South-Africa made use of non-randomized quasi-experimental pre-test and post-test control group design with a sample of 105 grade II physical science students involving one experimental and one control group.

However, literatures reviewed addressed the impact of Computer Assisted Instruction on students' academic achievements in various subjects in totality without focus on gender difference in academic achievement. Also not many researchers have looked into the effect of Computer Assisted Instruction on academic achievement in teaching and learning of chemical bonding especially in Kano State, Nigeria hence the gap this study intends to fill. The study sought to use two experimental and two control groups using a sample of 210 students from four science secondary schools in Kano State.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter highlights the methodology of the entire study. The Research design, Population and sample size of the study, Sampling Technique, Data Collection Instrument, Validity and Reliability of the instrument, Data Collection Procedure as well as method of Data analysis.

3.2 Research Design

A Quasi- experimental pre-test and post-test design was adopted where the pre-test and post-test involved both experimental and control groups (Kerlinger, 1973).

EG ⟶ O_1 ⟶ X_1 ⟶ O_2

CG ⟶ O_1 ⟶ X_0 ⟶ O_2

Figure 3.1 Systematic Representation of the Research Design

EG – Experiment Group	X_1 – Computer Assisted Instruction
CG – Control Group	X_0 – Traditional Method of Teaching
O_1 – PreTest	O_2 – PostTest

3.3 Population and Sample Size of the Study

3.3.1 Population of the Study

The target population of the study consist of 7,785 students as of 2015. There are three boarding schools of boys only; two are day schools of boys only while the remaining two schools are only girls' boarding schools. All the seven schools are single sex schools. Table 3.1 indicates the names of science schools, their Local Government Areas, as well as number of students enrolled into SSII in the year 2015.

Table 3.1 Population of Science Secondary Schools in Kano State

S/No	Names of Schools	Rural/Urban	Number of SSII Students
1	Dawakin Kudu Science College	Rural	400
2	Dawakin Tofa Science College	Rural	417
3	Maitama Sule Science College	Urban	383
4	Day Science College, Kano	Urban	384
5	Governor's College	Urban	448
6	First Ladies College	Urban	438
7	Girls Science College, Garko	Rural	485

Source: Science and Technical Schools Board, Kano State (2015).

3.3.2 Sample and Sampling Procedure

The sample selected for this study consists of two hundred and ten (210) senior secondary year two (SSII) chemistry students drawn from four (4) out of seven (7) Government owned science secondary schools in Kano State, comprising of 110 males and 100 females.

The four (4) science secondary schools were randomly selected to represent the population of the study of which two schools served as the control group while the remaining two schools served as the experimental group. The reason for choosing two experimental and two control group is that science secondary schools in Kano State are not Co-educational, hence the need so as to be able to answer research question (3).

Table 3.2 Sample size of the study

Names of Schools	Rural/Urban	Number of SSII Students
First lady's college	Urban	41
Girls Science College, Garko	Rural	59
Dawakin Tofa Science College	Rural	56
Day Science College	Urban	54
Total		**210**

3.3.3 Sampling Technique

Stratified Random Sampling Technique was used to select the sample. Stratified sampling is a way to guarantee desired representation of relevant subgroups within the population like gender. This technique involves dividing a population into several sub-populations that are individually more homogeneous than the total population (the different sub-populations are called 'strata') then random samples can be selected from each stratum or group (Kothari, 2004).

From the four schools that were randomly selected, each intact class was chosen using simple balloting so as not to disrupt the organizational setting of the school system. The four (4) sampled schools were merged into two (2) groups i.e. experimental group (E) and control group (C). In other to confirm the achievement level of the subject in the population, a pre-test was administered on the population of the study of which the result showed equivalence in achievement between the groups. The four (4) schools selected comprised of two (2) male schools and two (2) female schools.

3.4 Instrument for Data Collection

The instrument that was used for this study is a Standardized Chemical Bonding Achievement Test (CBAT) which contained thirty items of multiple-choice questions type with four options A, B, C and D. The test covered the learning areas under the topic Chemical Bonding (Atoms, Molecules and Compounds, Bond types, Molecular formulae, hydrogen bonding, bond polarity and electronegativity). The test items were adopted from W.A.E.C past examination questions.

3.5 Validity of the Instrument

The instrument was made to undergo content and face validation by an expert in Test and Measurement, a Ph.D. and a Snr. Lecturer of chemistry with above 10 years of experience. These personalities were asked to critically review the test items and assess correctness in terms of clarity, content coverage, and appropriateness. This is to ensure that the instrument is well structured and well organized based on the content of the learning area under the topic Chemical Bonding.

3.6 Pilot Test

The researcher conducted a pilot study to establish its reliability. Maitama Sule Science College, Gaya was used for the trial testing. The aim of the pilot study was to determine the characteristics of the test items which included their facility and discrimination indices and the reliability coefficient.

3.6.1 Reliability of the Instrument

Split half method was used to establish the internal consistency. Split – half reliability, also known as parallel forms of internal consistency reliability, measures equivalence or correlates two equivalent forms of scale. Olaofe (2010) simply explains that the split-half method is a process involving the administration of a test to a group and scores obtained in one half of the test are correlated with those in the second half. Spearman Rank Order Correlation Coefficient was used to calculate the reliability whereby the reliability coefficient was found to be 0.93 (Appendix Seven). According to Gay (2009) a lenient cut off of 0.60 in exploratory research is common, 0.80 or higher is adequate reliability and 0.90 or higher is good reliability. Therefore the reliability coefficient obtained for the instrument was 0.93 and therefore the instrument is reliable and valid for this study.

3.6.2 Facility Indices

Facility index refers to the item difficulty level because if items are too easy or too difficult, then the item is no use in educational testing of attainment of students. The facility index (F_1) of a test according to wood (1990) in Jiya (2011) is the percentage of the students that got an item right.

It was determined by using the formula.

$$F_1 = \frac{R}{T} \times \frac{100}{1}$$

Where R = number of correct responses

T = Total number of study

Furst (1958) in Atadoga (2001) recommended values within the range of 30 % to 70% for good test item values in assessing achievement. The facility index obtained for the study fell between 30-70%.

3.6.3 Discrimination Indices

Discrimination index refers to power or ability of a test item to distinguish between good student and a weak student. A good test item or test instrument should be able to clearly discriminate or differentiate between good and weak students.

The discrimination index/indices is the discriminating power of each of the test items or is the ability to sort or separate between high and low ranking students in the whole test. The calculation was done using scores of the top twenty seven percent (27%) and bottom twenty-seven percent (27%) of the total respondents. This was calculated using the formula given by (Furst (1958) in Atadoga 2001).

$$D_1 = \frac{R_u - R_i}{{}^1/_2 N}$$

Where D = discrimination index
Ru = Number among upper 27% of respondents.
Ri = Number among lower 27% of respondents.
N = total number of respondents.
Discrimination index ranging from 0.30 to 0.49 are described as moderately positive, those above 0.59 to 0.70 are highly positive or has high positive value (Furst, 1958). The discrimination index obtained for this study falls between 0.30 and 0.70.

3.7 Data Collection Procedure

A Pre-test was administered to both Experimental and Control group to determine the equivalence of the groups. The test was marked and recorded by the researcher. The topic (Chemical Bonding) was taught by the researcher. For the control group, normal classroom Teacher-Centred method was used to teach the bonding concept. While for the experimental group; Computer- Assisted Instruction was used to teach the same areas of Chemical Bonding by the researcher consisting of power point presentation with texts and still pictures, videos and explanation.

After the delivery of the lessons to the two groups, the various questions in the pre-test were rearranged and re administered to the students as the post-test to eliminate the effect of familiarity with the items in the instruments. This was to ensure that the level of difficulty for the pre-test and the post-test is maintained, and the tests being the same for the two groups. The introductory meetings with the students, administering of the pre-tests, the presentations of the lesson and administering of the post-tests lasted for eight weeks for the two groups involved in the study as indicated in appendix two and three.

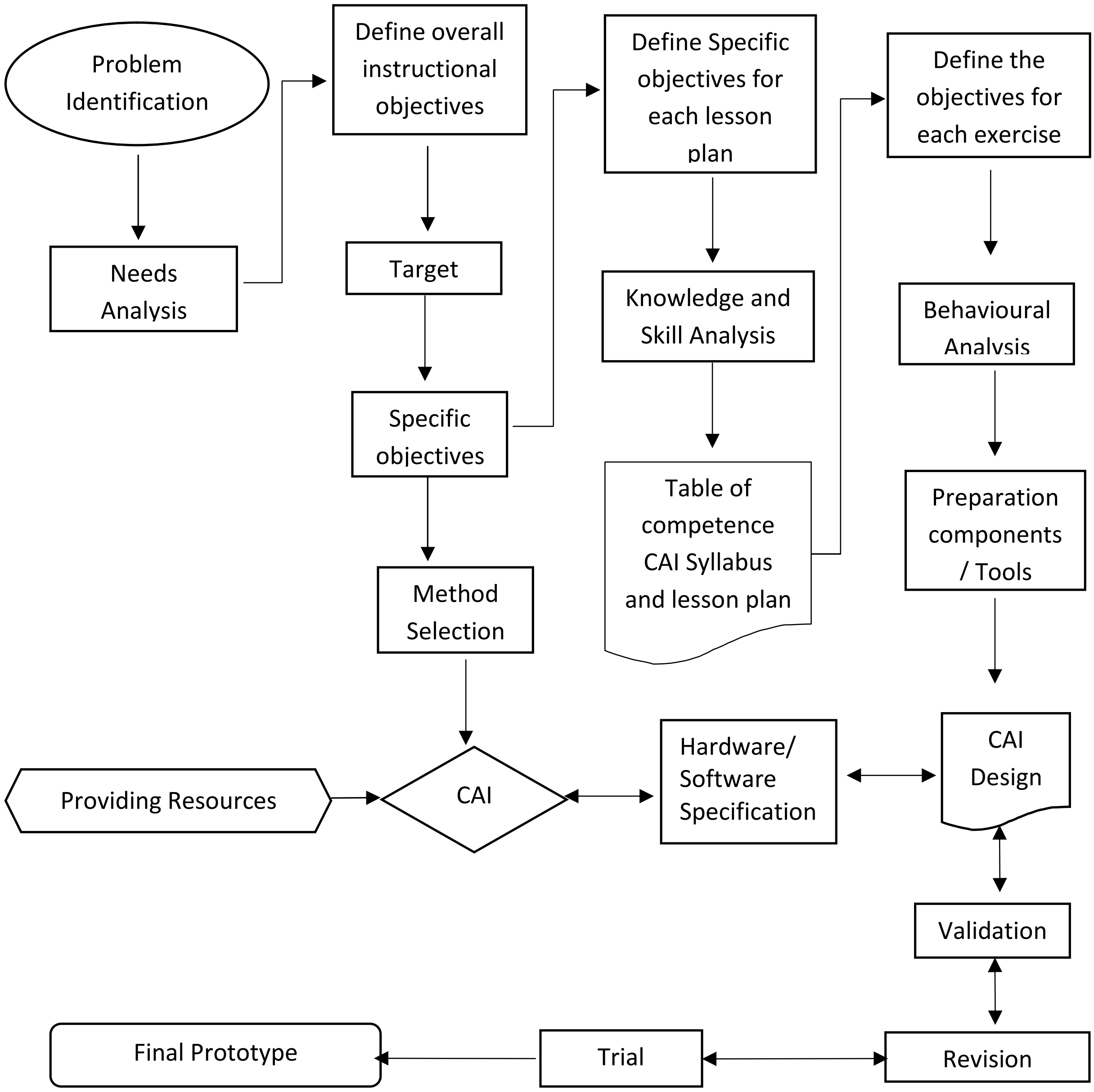


Figure 3.2 Flow Chart for Computer-Assisted Instruction
Adapted from Romiszowski (1986)

3.8 Data Analysis Procedure

Data analysis was carried out using statistical package for social sciences (SPSS) version 20.0. Research question 1 was analyzed using the mean score and standard deviation of the achievement test of the two groups. Research question 2 was analysed using mean score and standard deviation of the achievement test of urban and rural school students. Research question 3 was also analyzed using mean score and standard deviation of the achievement test of the male and female students. For null hypothesis 1, 2 and 3, t-test was used to determine the significant difference.

The t-test measures the differences between two means of two samples and converts it into standard measure of deviation. Hence, it is used to ascertain how great the difference between the means in order to judge its significance (Oke, Olusunde and Jekayinfa, 2005). The reason for choosing a t-test is because only the mean scores from the post-test for the two groups, control and experimental were compared to see if there is any statistical significant difference at a selected probability level of 0.05 between the two groups. The mean scores of the post-tests of the two groups were compared individually to ascertain their knowledge gains after the intervention.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 Introduction

In this chapter, details of the results and their analysis for actual study are presented. This chapter is divided into data presentation, data analysis and discussions. The results of the substantive analysis are presented according to the research questions and hypothesis to which they pertain.

4.2 Data Presentation

The main purpose of this study is to examine the effect of Computer-Assisted Instruction on students' academic achievement in Chemical Bonding in some selected science secondary schools in Kano State. In this section, the results of the analysis of the data collected are presented according to the three (3) research questions and the two (2) null hypotheses stipulated for the study.

A well-structured research instrument based on standardized Chemical Bonding Achievement Test (CBAT) containing thirty items of multiple-choice questions type with four options A, B, C and D was adopted from W.A.E.C past examination questions and was validated. Pre-test and post-test were administered to both Experimental and Control group to determine the equivalence of the groups, where the control group were taught using normal classroom Teacher-Centred Method, while the experimental group were taught using Computer-Assisted Instruction on same areas of Chemical Bonding by the researcher.

During the pre-test, the two groups (Experimental and Control Group) scored low marks but their results showed similarities in performance in chemical bonding.

4.3 Data Analysis

The data analysis was carried out using SPSS statistical package version 20.0 for calculating mean, standard deviation, paired sample test and independent sample test to determine the level of significance in difference between the Academic Achievement of Chemistry Students in the experimental and control groups. The researcher further used the mean scores of the tests within each group in order to be able to compare Academic Achievement of male and female chemistry students exposed to Computer Assisted Instruction. The results from the post-test scores for the two experimental and two control groups were analysed using statistical tools as already indicated in section 3.8.

Research Question 1

What is the difference between the Academic Achievement of Chemistry Students exposed to Computer Assisted Instruction and those exposed to traditional method of teaching?

Table 4.1: Mean Difference in Academic Achievement of Chemistry Students

Groups	N	Mean	Std. Deviation
Experimental	97	34.80	5.29
Control	113	33.79	5.24
Total	**210**	**34.25**	**5.27**

Research question 1 was analysed using mean score of the achievement test as indicated in this section which involves post-test scores of experimental and control groups to analyse the difference between performances of students exposed to Computer Assisted Instruction and those exposed to Traditional method of teaching. From Table 4.1, it was observed that the experimental group achieved higher mean score of 34.80 compared to the control group with a mean score of 33.79. This shows a slight difference in achievement between the experimental group exposed to CAI and the control group exposed to traditional method of teaching.

Hypothesis 1

$H0_1$; There is no significant difference between the Academic Achievement of Chemistry Students exposed to Computer Assisted Instruction and those exposed to Traditional method of teaching in Science Secondary Schools in Kano State.

Table 4.2: Result of Difference between Experimental and Control Groups

Group	N	Mean	SD	Df	P-Value	Remarks
Experimental	97	34.80	5.29	208	0.17	Not Significant
Control	113	33.79	5.24			

From Table 4.2, Experimental and Control groups were compared, where experimental group achieved slightly higher with a mean mark of 34.80 compared to the control group with a mean mark of 33.79. The calculated t-value is 1.38 and the P-Value is 0.17 obtained at 95% confidence level with the degree of freedom Df =208.

Since P value (0.17) is greater than alpha value (0.05), the null hypothesis is accepted indicating that there is no significant difference between the academic achievement of chemistry students exposed to Computer Assisted Instruction and those exposed to traditional method of teaching. This implies that the impact of Computer Assisted Instruction is not significant on the academic achievement of chemistry students when compared with traditional method of teaching.

Research Question 2

Is there any difference in academic achievement between urban and rural school chemistry students exposed to Computer Assisted Instruction?

Table 4.3: Mean Difference in Academic Achievement Chemistry of Urban and Rural School Students

Location	N	Mean	Std. Deviation	Std. Error Mean
Urban	41	35.22	5.73	0.89
Rural	56	34.48	4.96	0.67

Research question 2 was analysed using mean score of the achievement test of urban and rural school students exposed to CAI as indicated in this section which involves analysing differences in post-test scores based on location for the Experimental groups (students exposed to Computer Assisted Instruction). From table 4.3, it was observed that urban school student achieved higher mean score of 35.22 when compared to their rural counterparts with a mean score of 34.48. This shows a difference in achievement between urban and rural school students.

Hypothesis 2

$H0_2$; There is no significant difference between the academic achievement of urban and rural school chemistry students exposed to Computer -Assisted Instruction in science secondary schools in Kano State.

Table 4.4: Result of Location Difference in Academic Achievement of Chemistry Students Exposed to CAI

Gender	N	Mean	SD	Df	P-Value	Remarks
Urban	41	35.22	5.73	95	0.50	Not Significant
Rural	56	34.48	4.96			

From Table 4.4, the urban and rural difference in academic achievement from experimental groups was compared. The mean score for urban 35.22 is higher than those of rural with a mean score of 34.48. The calculated t-value is 0.67 and the P-Value is 0.50 obtained at 95% confidence level with the degree of freedom Df = 95.

Since P value (0.50) from Table 4.4 is greater than alpha value (0.05), the null hypothesis is accepted indicating that there is no significant difference between the academic achievement of urban and rural school chemistry students exposed to Computer -Assisted Instruction. This implies that the difference in Academic Achievement between urban and rural school chemistry students when exposed to Computer Assisted Instruction is not significant suggesting that Computer- Assisted Instruction is not locational biased.

Research Question 3

Is there any difference in Academic Achievement between male and female Chemistry Students exposed to Computer Assisted Instruction?

Table 4.5: Mean Difference in Academic Achievement Chemistry of Male and Female Students

Gender	N	Mean	Std. Deviation	Std. Error Mean
Boys	56	34.48	4.96	0.67
Girls	41	35.22	5.73	0.89

Research question 3 was analysed using mean score of the achievement test of male and female students exposed to CAI as indicated in this section which involves analysing differences in post-test scores based on gender for the Experimental groups (students exposed to Computer Assisted Instruction). From Table 4.5, it was observed that female student achieved higher mean score of 35.22 when compared to their male counterparts with a mean score of 34.48. This shows a difference in achievement between male and female students.

Hypothesis 3

$H0_2$; There is no significant difference between the Academic Achievement of male and female chemistry students exposed to Computer Assisted Instruction in Science Secondary Schools in Kano State.

Table 4.6: Result of Gender Difference in Academic Achievement of Chemistry Students Exposed to CAI

Gender	N	Mean	SD	Df	P-Value	Remarks
Boys	56	34.48	4.96	95	0.50	Not Significant
Girls	41	35.22	5.73			

From Table 4.6, gender differences from experimental groups were compared. The mean score for girls 35.22 is higher than those of boys with a mean score of 34.48. The calculated t-value is 0.67 and the P-Value is 0.50 obtained at 95% confidence level with the degree of freedom Df = 95.

Since P value (0.50) from Table 4.6 is greater than alpha value (0.05), the null hypothesis is accepted indicating that there is no significant difference between the academic achievement of male and female chemistry students exposed to Computer-Assisted Instruction. This implies that the difference in Academic Achievement between male and female Chemistry Students when exposed to Computer Assisted Instruction is not significant suggesting that Computer- Assisted Instruction is not gender biased.

4.4 Summary of the Findings

1. Research question two on the difference between the Academic Achievement of Chemistry Students exposed to Computer Assisted Instruction and those exposed to traditional method of teaching, was achieved using hypothesis one which states that there is no significant difference between the Academic Achievement of Chemistry Students exposed to Computer Assisted Instruction and those exposed to Traditional method of teaching at Science Secondary

Schools in Kano State. Experimental and control groups compared showed that the difference in scores for students exposed to CAI and those exposed to traditional method are not statistically significant. Nevertheless, the experimental group achieved slightly higher mean score compared to the control group.

2. Research question two on difference in academic achievement between urban and rural school chemistry students exposed to Computer Assisted Instruction was achieved using hypothesis two which states that there is no significant difference between the academic achievement of urban and rural school chemistry students exposed to Computer -Assisted Instruction in science secondary schools in Kano State. The location difference in academic achievement of chemistry students exposed to CAI showed that the differences in scores for urban and rural school students exposed to CAI are not statistically significant. However, the mean score for urban school students is slightly higher than that of rural.

3. Research question three on difference in Academic Achievement between male and female Chemistry Students exposed to Computer Assisted Instruction was achieved using hypothesis three which states that there is no significant difference between the Academic Achievement of male and female chemistry students exposed to Computer Assisted Instruction in Science Secondary Schools in Kano State. The Gender difference in academic achievement of chemistry students exposed to CAI showed that the differences in scores for male and female students exposed to CAI are not statistically

significant. However, the mean score for girls is slightly higher than that of boys.

4.5 Discussion of the Results

The findings showed that students in the experimental group performed better with slightly higher mean scores as a result of Computer Assisted Instruction than the control group taught using traditional method of teaching, implying that CAI had slight effect on academic achievement of chemistry students in science secondary schools in Kano State. This is in agreement with the study of Olusi, (2008) on the effect of computer aided instruction and traditional method of instruction on junior secondary school students achievement in mathematics in Edo state Nigeria. The findings of the study revealed a higher mean score for the computer-assisted group, suggesting the effectiveness of CAI strategy over the traditional method of teaching for secondary school students in Nigeria. Also, the finding of this study is in conformity with the result of Tan and Seng (2000). They found out that Computer Assisted Instruction had an effect on students' achievement in chemistry, where tenth grade students in Singapore were treated with Computer Assisted Instruction and the students in this group performed better than those taught using traditional method.

The trend of slightly high mean score by the introduction of CAI could be as a result of self - evaluation and remedial activities provided by (CAI) which helped students to master the chemistry concepts without much difficulty than the traditional method of teaching. It could also be as a result of excitement over the new approach and the elimination of teacher bias/strained relationship of teacher and student. Furthermore, the pictorial representations and videos provided by the computer which were absent in the traditional method of teaching can be a factor that contributed to the slightly high performance.

The slightly lower mean score of students in the control group in academic achievement of chemistry students is an indication that the method adopted in teaching chemistry by science teachers is not quite effective in promoting meaningful learning of chemistry. The higher mean scores in favour of the experimental groups suggest a slight effectiveness of Computer Assisted Instruction strategy over the traditional method of teaching.

The findings from this study also revealed that the differences in mean scores are not statistically significant between the Academic Achievement of Chemistry Students exposed to Computer Assisted Instruction and those exposed to Traditional method of teaching in Science Secondary Schools in Kano State. The above result is in agreement with the studies of Bayraktar (2008) on effects of computer simulation programs on University students' achievement in physics and Etukudo (2002) on effects of computer assisted instruction on Gender and performance of Junior secondary school students in mathematics, concluded no statistically significant difference between the students exposed to CAI and those exposed to traditional method. Also the result agrees with the study of Spradlin (2009) on effectiveness of Computer-Assisted Instruction in developmental mathematics, where the study found no significant difference in the mathematical performance of Intermediate Algebra students as measured by the final exam score, although the mean score of the computer-assisted group was slightly higher.

Contrary to these findings, the result is in contrast to the previous findings of Lou, Wen and Tseng (2007), who investigated the effect of computer assisted instruction in chemistry learning achievement of students, where their findings revealed that there is a statistically significant difference between students in the experimental group who were treated with computer assisted instruction and those in the control group. Also, the findings of Safo, Ezenwa, and Wushishi (2013) on the effects of computer assisted instructional package on junior secondary school students' achievement and retention in geometry in Minna, Niger State, revealed a statistically significant difference between experimental group and the control group contrary to the current study. The study also contradicts the earlier findings of Phillips and Moss (1993) on computer assisted instruction biology packages be used to replace teacher and the findings of Jegede, Okebukola and Ajewole (1992) on students' attitude to the use of computer for learning and achievement in biological concept. Similarly, the findings disagreed with the studies of Ajelabi (1998) on the relative effectiveness of computer assisted and text- assisted programme instruction on students learning outcomes in social studies, Egunjobi, (2002) on efficacy of two computer assisted instructional modes on learners' practical geography achievement at the secondary school level in Ibadan metropolis, Udousoro, (2000) on relative effectiveness of computer and text-assisted programme instruction on students' learning outcomes in mathematics, and Okoro, and Etukudo, (2001) on CAI versus Extrinsic Motivation based traditional method, these studies conducted confirmed a significant difference between the students exposed to CAI and those exposed to conventional classroom instruction.

The urban and rural difference in academic achievement of chemistry students exposed to Computer Assisted Instruction showed that the difference in scores for urban and rural school students exposed to CAI are not statistically significant. However, the mean score for urban school students is slightly higher than the mean scores for rural school students, this could be as a result of the fully equipped computer laboratory present in the urban school. This result is in conformity with the study of Hussain and Ali (2012) who concluded that the location (Rural and Urban) differences showed no significant differences in performance of students exposed to Computer Assisted Instruction.

Analysis of gender differences in academic achievement of chemistry students exposed to Computer Assisted Instruction showed that the difference in scores for male and female students exposed to CAI are not statistically significant. However, the mean score for girls is slightly higher than the mean scores for boys, this suggest that the effectiveness in female schools is as a result of the fully equipped computer laboratory present in Experimental Group. This is similar to the findings of Ukwuru (2007) who reported no significant difference in the performance of boys and girls in chemisty and many other subjects. The finding is in conformity with those of Ash (2005), Basturk (2005) and Dantala (2006) who found no significant difference between male and female students taught physics and history using CAI package. It is also in agreement with the results of Gambari (2004), Adesoji and Babatunde (2005), and Fagbemi *et al*., (2011) who found that there is no significant difference between male and female students' performance in chemistry, biology, physics and social studies using computer-based instructional packages. Also this is similar to the study of Anyamene, Nwokolo, Anyachebelu and Anemelu (2012) on the effect of computer-assisted packages on the performance of senior secondary students in mathematics in Awka, Anambra State, where their result indicated no significant difference in the post-test performance scores of male and female students taught using CAI. Also, in a similar study by Yusuf and Afolabi (2010) on the effects of Computer Assisted Instruction on secondary school students' performance in biology in Oyo State revealed no significant difference in the performance of male and female students exposed to CAI. This shows that Computer –Assisted Instruction is not gender sensitive. Similarly, it is in conformity with the studies of Bello (1996) on comparative effective of two forms of concepts mapping instructional strategies on senior secondary school students' achievement in Biology, and Achuonye (2011) on using computer in science class: the interactive effect of gender. Both studies concluded that gender has no influence on performance of male and female pupils exposed to CAI. The finding on gender also agrees with the conclusion of Mudasiru and Adedeji (2010) on effect of Computer Assisted Instruction (CAI) on secondary school students' performance in Biology, and Hussaini and Mohammed (2004) on effect of computer-based teaching method on Senior Secondary Students' performance in mathematics. In these studies, there was no significant difference in the performance of male and female students when exposed to Computer Assisted Instruction.

The result of this study is not in conformity with the study of Achor and Ukwuru (2014) on facilitative effect of Computer Assisted Instruction (CAI) in raising retentive ability of senior secondary school students in chemical reaction and equilibrium, which rrevealed that the mean retention score of male and female students taught chemical reaction and equilibrium using (CAI) differ significantly. Also the result is not in agreement with the findings of Hassan (2012) on effects of Computer Assisted Instruction in Nupe language on Pupils' achievement in mathematics in Bida Local Government Area of Niger State and the study of Salahudeen (2012) on effects of Computer Assisted Instructional Package on learning of longitude and latitude among secondary school students in Minna Metropolis. They reported significant difference between the performances of male and female students in favour of females.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter describes the summary of the study, conclusion derived from the findings as well as recommendations.

5.2 Summary

The aim of this study is to examine the effect of Computer Assisted Instruction on students' academic achievement in Chemical Bonding in science secondary schools in Kano State. The study comprises of only SSII students who have the basic knowledge of chemistry from SSI and are not engaged with examination preparation in SS III.

The research investigated the difference between the performances of chemistry students exposed to Computer Assisted Instruction and those exposed to traditional method of teaching. The study also examines the location difference and gender difference in academic achievement of chemistry students exposed to Computer Assisted Instruction in science secondary schools in Kano State.

Stratified random sampling technique was used to select four (4) single-sex science secondary schools comprising of (2 male schools and 2 female schools). The sample selected for this study consists of two hundred and ten (210) senior secondary year two (SSII) chemistry students drawn from four (4) out of seven (7) Government owned science secondary schools in Kano State, comprising of 110 males and 100 females.

The instrument that was used for this study is a Standardized Chemical Bonding Achievement Test (CBAT) which contained thirty items of multiple-choice questions type with four options A, B, C and D. The test covered the learning areas under the topic Chemical Bonding (Atoms, Molecules and Compounds, Bond types, Molecular formulae, hydrogen bonding, bond polarity and electronegativity). The test items were adopted from W.A.E.C past examination questions.

From the findings; Experimental groups showed higher mean scores than control groups with lower mean scores indicating a slight effect of CAI on academic achievement of chemistry students in science secondary schools in Kano State. It also showed that the difference in scores for students exposed to CAI and those exposed to traditional method are not statistically significant, which implies that CAI has no significant impact on the academic achievement of chemistry students. Nevertheless, the experimental group achieved slightly higher mean score compared to the control group.

The location difference in academic achievement of chemistry students exposed to CAI, showed that the differences in scores for urban and rural school chemistry students exposed to CAI are not statistically significant suggesting that Computer Assisted Instruction is not location biased.

Gender difference in academic achievement of chemistry students exposed to CAI, showed that the differences in scores for male and female students exposed to CAI are not statistically significant suggesting that Computer Assisted Instruction is not gender biased.

In summary, the current study found no statistically significant difference in the academic achievement of chemistry students, their location and also gender as measured by their scores in CAI and traditional methods of teaching, although the mean score of the Computer-Assisted group was found to be slightly higher than traditional methods of teaching.

5.3 Conclusions

This study has examined the effect of Computer Assisted Instruction in Chemical Bonding in government science secondary schools in Kano State. It was established that the differences in academic achievement of chemistry students in teaching and learning of chemical bonding using Computer- Assisted Instruction and traditional method of teaching conducted between Experimental and Control groups showed that the difference in both methods are not statistically significant. Also the location and gender difference in academic achievement of chemistry students exposed to Computer Assisted Instruction between the two Experimental groups revealed no statistically significant differences. However, there exist slight differences in mean scores with higher mean scores for Computer-Assisted Instruction and lower for traditional method of teaching which implies that CAI is location and gender friendly. The result of this study is also an indication that students of all ability groups can perform significantly better and enhanced academic performance in classrooms where CAI teaching strategies are used comprehensively.

5.4 Contribution to Knowledge

This research work has contributed to knowledge in the following ways:

1. That Computer Assisted Instruction is slightly more effective than using traditional teaching methods in the teaching of chemical bonding in government science secondary schools in Kano State

2. That Computer Assisted Instruction and flow chart adapted and used in this study contributes to knowledge when applied as a guide in the design of CAI.

3. That the experimental test and lesson plan used can be replicated in other field of study such as Mathematics, Physics and Biology.

4. That Computer Assisted Instruction is not location and gender bias in the teaching of chemical bonding in government science secondary schools in Kano State.

5.5 Recommendations

Based on the research questions and findings of this study, the following recommendations are made;

1. Necessary attention should be accorded to computer literacy in secondary schools and relevant computer assisted instructional packages should be developed for use within the school systems. In addition, schools should be equipped with necessary ICT facilities to leverage the potentials of ICT and Computer Assisted Instruction in chemistry.
2. Students should be encouraged to develop social interaction in the use of computers for increased interest and CAI teaching strategies should be used comprehensively in conjunction with traditional method of teaching.
3. More computers should be procured for the male schools and rural schools so as to match the performance of the female schools and urban schools which are fully equipped with computers. Both male and female chemistry students should be more exposed to Computer Assisted Instruction to attain excellent scores.

5.6 Suggestions for Further Studies

The following recommendations for further investigation were based on the findings of this study;

1. To further validate the findings of this research, the study should be replicated with larger samples and in other developmental courses other than chemistry. Additional research should be conducted comparing the success rates (percent of A, B, C course grades) in secondary level chemistry courses and other developmental subjects receiving traditional instruction supplemented with Computer Assisted Instruction, and online instruction.

2. Studies are recommended to investigate any possible learning style or other differences in boys and girls that may influence performance. It is possible females have acquired habits that lead to success in school. An examination of attendance, class participation, and visits to a tutoring centre for male and female developmental chemistry students is suggested. A case study would provide an in depth investigation of the behaviour of students in a developmental chemistry course which may reveal any differences in male and female behaviours associated with success or failure.

REFERENCES

Abdullah, S. and Shariff, A. (2008). The Effects of Inquiry- Based Computer Simulations with Cooperative Learning on Scientific Thinking Conceptual Understanding of Gas Laws. *Eurasia Journal of Mathematics, Science and Technology Education,* 4(4), 387-398.

Abdoolatiff, S. and Narood, F.B. (2009). Investigating the Effectiveness of Computer Simulations in the Teaching of Atomic Structure and Bonding in Chemistry Education in the ICT Age. Springer Netherlands, 85-100.

Achor, E.E and Ukwuru, J.O. (2014) facilitative effect of Computer Assisted Instruction (CAI) in raising retentive ability of senior secondary school students in chemical reaction and equilibrium. *Benue State University Journal of Education (BSUJE)*, 1(13), 1-7

Achuonye, K.A., (2011). Using Computer in Science Class: The Interactive Effect of Gender. *Journal of Africa studies and Development*. 3(7), 131- 134

Adedayo, J. O. (2011). Improving STEM Education in Nigeria: The Challenges of Science Educators. *52nd STAN Proceedings. Reforms in STEM Education* (In Okechukwu, S. A. (Ed.). Heinnemann Educational Books Publishers, Ibadan: Nigeria.

Adesoji, F.A. and Babatunde, A.G. (2005). Expressive teaching behaviour: Bridging the gender gulf in secondary school chemistry achievement. *International Journal of African and African American Studies*, 4(1), 54-61.

Adegoke, B.A. (2010). Integrating Animations, Narrations and Textual Materials for Improving Students' Learning Outcomes in Senior Secondary School Physics. *Electronic Journal of Research in Educational Psychology.*

Adesokan, C.O (2002). Students Attitude and Gender as Determinants of Performance in JSS Integrated Science. *Unpublished B.Ed Project* Chemistry of Nigeria.

Adeyegbe, S.O. (2005). In Search of Indices for Measuring the Standard of Education: Aneed for a shift in Paradigm. *A special seminar by West African Examinations.*

Adeyemo, S.A. (2003). Studies of the Effects of Aptitude, Instructional Leadership Styles and Learning Environment on Students' Achievement in Physics, *Doctoral Thesis*, University of Lagos; Nigeria.

Adomi, E.E. (2006). Mobile Phone Usage Patterns of Library and Information Science Students at Delta State University, Abraka, Nigeria. *Electronic Journal of Academic and Special Librarianship* 7 (1).

Adomi, E.E., Okiy, R.B. and Ruteyan, J.O. (2003). A Survey of Cybercafés in Delta State, Nigeria. *The Electronic Library* 21 (5):487—95.

Afolabi, F. (2002). School Factors and Learner Variables as Correlates of Senior Secondary Physics Achievement in Ibadan. *Unpublished Ph.D Thesis*. University of Ibadan, Ibadan.

Ajelabi, A (1998): The relative effectiveness of computer assisted and text- assisted programme instruction on students learning outcomes in social studies. Unpublished PhD thesis of the University of Ibadan, Ibadan, Nigeria

Akçay, H., Durmaz, A., Tüysüz, C. & Feyzioglu B. (2006). Effects of computer based learning on students' attitudes and achievements towards analytical chemistry. *Turkish Online Journal of Educational Technology*, 5(1), Article 6

.

Akpan J.P, Andre T. (2000). Using a Computer Simulation Before Dissection to help Students Learn Anatomy. *J Comp MathSci Teach,* 19(3): 297-313.

Akpan, B.B. (2008). *Nigerian the future of science education.* Science Teachers Association of Nigeria (STAN). Ibadan, Nigeria: Oluseyi Press limited

Akpan, B.B. (2012). Science Education in Nigeria. From the Beginning to the Future. Ivowi U.M.O. (Ed.). Lagos: Foremost Educational Services Limited.

Al-Alwani, A. (2005). Barriers to Integrating Information Technology in Saudi Arabia Science Education. *Doctoral dissertation,* the University of Kansas, Kansas.

Albirini, A. (2006). Teachers' Attitude towards Information and Communications Technologies: The Case of Syrian EFL Teachers. *Computers Education*, 47,373-398.

Anyamene, A., Nwokolo, C., Anyachebelu, F. and Anemelu V.C (2012). Effect of Computer-Assisted Packages on the Performance of Senior Secondary Students in Mathematics in Awka, Anambra State, Nigeria. *American International Journal of Contemporary Research*. 2(7); 61-65.

Arowolo, K.M. (2009). The Impact of Information and Communications Technology (ICT) in the Teaching and Learning of Kinematics in Grade 11 Physical Science. *Unpublished masters dissertation,* University of the Witwatersrand, Johannesburg, South Africa.

Ash, J.E. (2005). The effectiveness of computer-assisted instruction on middle school mathematics achievement. Retrieved on 30th March, 2016, from http://www. research Enstae.edu/dissertation/AA 13187984.

Asunta, T. (2003). Knowledge of Environmental Issues – Where Pupils Acquire Information and how it affects their Attitudes, Opinions and Laboratory Behaviours. *Research Report no.22 1.* University of Jyvaskyla: Jyvaskyla Studies in education.

Atadoga, M.M., (2001).A Study of the Strategies Used by Senior Secondary School Students to Solve Problems in Physics and their Effects on Academic Achievement. Unpublished PhD. Dissertation, Ahmadu Bello University Zaria.

Atkins, P.W and Beran, J.A. (1992). An Elementary Introduction to Chemical Bonding. General Chemistry, 2nd ed

Babajide, V.F.T. (2010). Generative and Predictive Observe- Explain Instructional Strategies as Determinant of Senior Secondary School Students' Achievement and Practical Skills in Physics. *Unpublished Ph.D. Thesis*, University of Nigeria, Nsukka.

Balanskat, A., Blamire, R., and Kefala, S. (2006*). A Review of Studies of ICT Impact on Schools in Europe, European Schoolnet.*

Barak, M., and Dori, Y. J. (2005). Enhancing Undergraduate Students' Chemistry Understanding through Project-Based Learning in an IT Environment. *Science Education, 89*(1), 117-139.

Basturk, R. (2005). The effectiveness of Computer-Assisted Instruction in teaching introductory statistics. *Educational Technology and Society*, 8 (2) 170-128.

Bayraktar, C. (2008). Effects of computer simulation programs on University students' achievement in physics. *Turkish online journal of Distance Education*, 9(5), 53-62.

Beggs, T.A. (2000). Influences and Barriers to the Adoption of Instructional Technology. *Paper Presented at the Proceedings of the Mid-South Instructional Technology Conference*. Murfreesboro, TN.

Bello, G., (1996). Comparative Effective of Two Forms of Concepts Mapping Instructional ` Strategies on Senior Secondary School Students Achievement in Biology. University of Ilorin, Nigeria

Bennett, F. (2002). The Future of Computer 28. The Delphi Technology in K-12 Education. Phi Delta Method: Techniques and Applications. *kappan Magazine*. Available at from Massachusetts: Addison-Wesley http://www.cris.com/~faben1/phidel~1.s.html

Bordbar, F. (2010). English Teachers' Attitudes towards Computer-Assisted Language Learning. *International Journal of Language Studies*, vol. 4, no. 3, pp. 27-54.

Bosede, A.F. (2010). Influence of Sex and Location on Relationship between Students' Academic Performances. *The social science*, 5(4) 340-345.

Bosley, C., Moon, S. (2003). Review of Existing Literature on the Use of Information and Communication Technology within an Educational Context. Derby: Centre for Guidance Studies, University of Derby.

Brahmbhatt, T. (2012). The Realm of ICT in Teacher Education. *Quest International Multidisciplinary Research Journal.* I(2), ISSN : 2278 – 4497. www.mahidachintan.com

Brakel, P.A., and Chisouga, J. (2003). Impact of ICT Based Distance Learning: The African Story. *The Electronic Library* 21 (5), 476-486.

Becta, (2003). What the research says about barriers to the use of ICT in Teaching. *Report of the BECTA ICT Research network.*

Becta, (2004). A Review of the Research Literature on Barriers to the Uptake of ICT by Teachers. British Educational Communications and Technology Agency. Version 1, June 2004 http://www.becta.org.uk page.

Brosnan, T. (2001). Teaching using ICT. University of London: Institute of Education.

Cepni, S., Tas. E and Kose, S. (2006). The Effects of Computer Assisted Materials on Students' Cognitive Levels, Misconceptions and Attitude towards Science. *Computers and Education,* 46, 192-205.

Chang, (2001). Does Computer Assisted-Instruction + Problem Solving = Improved Science outcome? A Pioneer Study. *Journal of Educational Research*, 95 (3), 143-150.

Christie, A. (2005). Constructivism and its Implication for Educators http://alicechristie.com/edtech/learning/constructivism/index.htm.

Cigrik, E. and Ergül, R. (2009). The Investigation of the Effect of Simulation Based Teaching on the Student Achievement and Attitude in Electrostatic Induction. *Procedia Social and Behavioral Sciences* 1, 2470–2474.

Coll, R.K., and Taylor, N. (2002). Mental Models in Chemistry: Senior Chemistry Students' Mental Models of Chemical Bonding. Chemistry Education: Research and Practice in Europe, 3(2), 175–184.

Coll, R.K., and Treagust, D.F. (2003). Investigation of Secondary School, Undergraduate, and Graduate Learners' Mental Models of Ionic Bonding. *Journal of Research in Science Teaching,* 40(5), 464–486.

Cuban, L., Kirkpatrick, H., Peck, C. (2001). High Access and Low Use of Technologies in High School Classrooms: Explaining an Apparent Paradox. *American Educational Research Journal,* 38 (4), pp. 813 – 834.

Dakers, J. R. (2006). Towards a Philosophy for Technology Education. In J.R. Dakers (Ed.), *Defining Technological Literacy: Towards an Epistemological Framework*, pp. 145–158. New York, NY: Palgrave Macmillan.

Dalgarno, B. (2001). Interpretations of constructivism and consequences for computer assisted learning. *British Journal of Educational Technology*, 32(2), 183-194.

Dantala, N.M. (2006). Effect of Computer-Assisted Instruction (CAI) package for individualized learning of history in the senior secondary school in Niger State, Nigeria. An unpublished M. Tech. Thesis, Science Education Department, Federal University of Technology, Minna

Davis, K.S. (2003). Change is Hard: What Science Teachers are Telling us about Reform and Teacher Learning on Innovative Practices *Science Education?*, 87, 3–30.

Demiraslan, Y. and Usluel, Y. (2005). ICT Integration in Turkish Schools: Using Activity Theory to Study Issues and Contradictions. *Australasian Journal of Educational Technology,* 24(4), 458-474. http://www.ascilite.org.au/ajet/ajet24/demiraslan.html

Dori, Y.J. and Barak, M. (2000). Computerized Molecular Modelling: Enhancing Meaningful Chemistry Learning. In B. Fishman and S. O'Connor-Divelbiss (Eds*.), Proceedings of the Fourth International Conference of the Learning Sciences*, pp: 185-192, Mahwah, NJ:Erlbaum.3.

Dori, Y.J., Barak, M., and Adir, N. (2003). A Web-based Chemistry Course as a Means to Foster Freshmen Learning*. Journal of Chemical Education*, 80(9), 1084–1092.

Dori, Y.J., and Hameiri, M. (2003). Multidimensional Analysis System for Quantitative Chemistry Problems-Symbol, Macro, Micro and Process Aspects. *Journal of Research in Science Teaching,* 40(4), 278–302.

Egunjobi, A. O. (2002). The efficacy of two computer assisted instructional modes on learners' practical geography achievement at the secondary school level in Ibadan metropolis, Nigeria. Paper delivered at NAEMT conference, 20 -23 Nov. 2002.

Ekpo, (2006). Tips on Teaching Difficult Concepts in Senior Secondary School Chemistry. *Review of Education,* Institute of Education, University of Nigeria, Nsukka.

Emmanuel, B. (2013). The Place of Nigeria Certificate in Education Chemistry Teachers in UBE Basic Science Programme. *54th Science Teachers Association of Nigeria Annual Conference Proceedings*, 177-181.

Empirica, (2006). Benchmarking Access and Use of ICT in European Schools 2006: Final Report from Head Teacher and Classroom Teacher Surveys in 27 European Countries. Germany: European Commission.

Engel, T. and Reid, P. (2006). *Physical Chemistry*. San Francisco: Pearson Education Inc.

Engestrom È.M.Y. (2005). Expansive Learning at Work: Towards an Activity Theoretical Reconceptualization. *Journal of Education and Work,* 14(1),133-156.

Erduran, S. (2001). Philosophy of Chemistry: An Emerging Field with Implications for Chemistry Education. *Science and Education*. 10, 581-593.

Erduran, S., and Scerri, E. (2002). The Nature of Chemical Knowledge and Chemical Education. In J.K. Gilbert, and J. Van Driel (Eds.), *Chemical Education: Towards Research –Based Practice* (pp.7-28).

Etukudo, U.E.(2002).The effects of computer assisted instruction on Gender and performance of Junior secondary school students in mathematics. Abacus: *The Journals of Mathematical Association of Nigeria.* 27(1), 1-8

European Commission. (2002). *Commission Staff Working Paper*: eEurope 2002 Commission of the European Communities. Benchmarking: European Youth into the Digital Age SEC(2003)72 Brussels:

Ezeliora, B. (2002). Improving Chemistry Teaching and learning using Computer. 41st Annual Conference Proceeding of Science Teachers Association of Nigeria (STAN), 186 -187:

Fagbemi, P. O., Gambari, A. I., Oyedum, N. A., and Gbodi, E. B. (2011). Effects of computer-assisted instructional package on social studies achievement among senior primary school pupils in Niger State, Nigeria. *Journal of Science, Technology, Mathematics and Education*, 7(2), 204 -214.

Falvo, D. A. (2008). Animations and Simulations for Teaching and Learning Molecular Chemistry. *International Journal of Technology in Teaching and Learning,*4 (1),68-77.

Froyd, J. and Simpson, N. (2010). Student-Centered Learning Addressing Faculty Questions about Student-centered Learning. Texas AandM University.

Fu, J. S. (2013). ICT in Education: A Critical Literature Review and Its Implications. *International Journal of Education and Development using Information and Communication Technology,* 9 (1).

Furst, E.J., (1958). Constructing Evaluation Instruments. New York: Longman, Green Co.

Gambari, A. I. (2004). Effects of computer-assisted instruction package on the performance of senior secondary students in physics in Minna (Unpublished master's thesis). Federal University of Technology, Minna, Nigeria.

Gay, L. R. (2009*). Educational Research:* Competences for Analysis and Applications (9th ed). Macmillan Publishing Coy. P.26.

Glenn, J. (2000). Before it's too Late: *A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century*. Washington, DC: U.S. DoEd.

Gomes, C. (2005). Integration of ICT in Science Teaching: A Study Performed in Azores, Portugal. Recent Research Developments in Learning Technology.

Gonczi, A. (2008). Corporate Australia and the 'Education Revolution'. The University of Sydney. Retrieved January 5, 2013 from www.australianreview.net/digest/2008/09/gonczi.html

Goni, A. D. and Stephen, S. H. (2012). Analysis of University Students' Knowledge and Exposure to Analytical Chemistry: *International Journal of Emerging Sciences* 2 (3), 416-432.

Goshit, T. (2006). Nigeria's Need for ICT: SP. 259 Technology and Policy in Africa.

Guha, S. (2000). Are we all Technically Prepared? Teachers' Perspectives on the Causes of Comfort orDdiscomfort in using Computers at Elementary Grade Teaching. *Paper Presented at the Annual Meeting of the National Association for the Education of Young Children Atlanta, GA,* November 8-11, 2000.

Gulbahar, Y. (2008). ICT Usage in Higher Education: A Case Study on Pre-Service Teachers and Instructors. *The Turkish Online Journal of Educational Technology*, 7(1),32-37.

Hassan, U., (2012). Effects of Computer Assisted Instruction in Nupe Language on Pupils' Achievement in Mathematics in Bida Local Government Area of Niger State, Nigeria.Unpublished M.Tech thesis, FUT, Minna.

Hodson, D. (2003). Time for Action: Science Education for an Alternative Future. *International Journal of Science Education, 25,* 645–670.

Hofstein, A. (2004). The Laboratory in Chemistry Education: Thirty Years of Experience with Developments, Implementation and Research. *Chemistry Education and Practice*. 3, 247-264.

Hurst, O. (2002). How we Teach Molecular Structure to Freshmen. *Journal of Chemical Education,* 79(6), 763 – 764.

Hussain, L. and Ali, U. (2012). Role of CAI on the Interest and Retention of Students at Secondary School Level. *Academic Research International*. 3(2): 366-344

Hussaini, A and Mohammed, A.R. (2004). The effect of computer-based teaching method on Senior Secondary Students' performance in mathematics. In G.A. Ashituble andI.AKolo (Eds), Education for sustainable development in Nigeria. Book of Readings 1, 400-408. Minna: Peak Press Limited.

Ighoroje, A.D., and Ajayi, O.B. (2009). Female Awareness Level of Information Technology in Nigeria. Available: http://archive.wigsat.org/gasat/papers1/6.txt

İşman, A. (2005). *Instructional technology and material development.* Ankara: Pegem A Publishing.

Jan A.O., Ruth O., Catherine, B and Juan, E. (2012). Investigating the Effectiveness of Computer Simulations for Chemistry Learning, *Journal of Research in Science Teaching vol. 49, no. 3, pp. 394–419.*

Jegede, O., Okebukola, P.A. and Ajewole, G. (1992). Students' attitude to the use of computer for learning and achievement in biological concept. *Journal of Science Teachers Association of Nigeria,* 27 (2), 61 – 65

Jegede, S.A. (2007). Students' Anxiety Towards the Learning of Chemistry in some Nigerian Secondary Schools. *Educational Research and Review* 2 (7) 193-197.

Jegede, S.A. (2010). Nigerian Students Perception of Technical Words in Senior Secondary School Chemistry Curriculum. *Pakistan Journal of Social Sciences* 7(2), 109-111.

Jenks, M.S. and Springer, J.M., (2002). A View of the research on the efficacy of CAI?Electronic *Journal for the Integration of Technology in Education*.1(2). 43 - 58.

Jimoyiannis, A., and Komis, V. (2001). Computer Simulations in Physics Teaching and Learning: A case study on Students' Understanding of Trajectory Motion. *Computers and Education,* 36, 183–204.

John, C. and Morrison, A, (1993). Electronic Structure of Atoms and Molecules, in George L. Trigg (ed.), Encyclopedia of Applied Physics, 1(6): 45–98.

John, P. (2005). The Sacred and the Profane: Subject Sub-Culture, Pedagogical Practice and Teachers' Perceptions of the classroom uses of ICT. *Educational Review*, 57 (4), 471-490.

Kay, R. (2006). Addressing Gender Differences in Computer Ability, Attitudes and Use: The Laptop Effect. *Journal of Educational Computing Research,* vol. 34, no. 2, pp. 187-211.

Kelder, K.H. (2008). *NCS Study and Master Physical Sciences, Learner book 10*. (2nd edition), Cape Town: Cambridge University Press. Pages 123-124.

Kelder, K.H. (2009). *NCS Study and Master Physical Sciences, Learner book 11*. (2nd edition), Cape Town: Cambridge University Press. Pages 177-194.

Kerlinger, F.N. (1973). Foundation of Behavioural Research, London Holt Rinehart and Wiston.

Kennedy, D. and Finn, S. (2000). The Use of ICT Pedagogy Summary. Datalogging in Teaching Physics and Chemistry in 31. Helmer, O., 1983. Looking forward: A Guide to Futures Second-Level Schools in Ireland, Available at Research. Beverly Hills, CA:Sage Publications. http://schplar.google.com.

Kiboss, J. K., Ndiragu, M., and Wekesa, E.W. (2004). Effectiveness of a Computer-Mediated Simulations Program in School Biology on Pupils' Learning Outcomes in Cell Theory. *Journal of Science Education and Technology*,13(2), 207-213.

Kirkwood, M., Van Der Kuyl, T., Parton, N., Grant, R. (2000). The New Opportunities Fund (NOF) ICT Training for Teachers Programme: Designing a Powerful Online Learning Environment. *Paper Presented at the European Conference on Educational Research*. Edinburgh, 20-23 September.

Knezek, G. and Christensen, R. (2006). Pathway for Preparing Tomorrow's Teacher to Infuse Technology. Computers in the Schools, vol. 23, no. 3/4, pp. 1-21.

Kola, (2012). Gender Differences in Motivation to Learn Chemistry in Nigerian Secondary Schools. *STM Education series.*

Kolawole, E.B. (2007). Effects of competitive and cooperative learning strategies on academic performance of Nigerian students in mathematics. *Educational Research Review,* 3(1), 33-37.

Kothari, C.R. (2004). Research Methodology, Methods and Techniques *(Second Revised edition).* New Age International Publishers.

Kotoka, L. (2013). Effects of Computer Simulations on the Teaching of Atomic Combinations to Grade 11 Physical Science Learners. *Proceedings of the ISTE International Conference on Mathematics, Science and Technology Education*, South Africa, pp. 522-531.

Landu, I.T. (2003). Information Communication Technology (ICT): Science Teachers' Awareness. In M.A.G. Akale (Ed*.). Proceedings of 44th Annual Conference of Science Teachers Association of Nigeria (STAN*), PP.41-44. Ibadan: Heinemann Educational Books (Nigeria) Plc.

Laszlo, P. (2006), On the Self-Image of Chemists, 1950–2000. HYLE*: International Journal for Philosophy of Chemistry,* 12, 99–130.

Leahy, W. and Sweller, J. (2004) Cognitive Load and the Imagination Effect. *Applied Cognitive Psychology* 18:7, 857-73.

Levy, N.T., Hufstan, A., and Bar-Dov, Z. (2004). Can Final Examination Amplify Students' Misconceptions in Chemistry? Chemistry Education: Research and Practice in Europe, 5(3), 301-325.

Lou, S., Wen, H. and Tseng, K. (2007). A study Of Integrating Concept Mapping into Computers Assisted Instruction in Chemistry Learning Achievement and learning Attitude at a comprehensive High Schools: *Chinese Journal of Science Education*. 15 (2).69-194.

Markauskaite, L. (2006). Gender Issues in Pre Service Teachers' Training: ICT Literacy and online Learning. *Australasian Journal of Educational Technology*, vol. 22, no. 1, pp. 1-20.

Martin, B., and Tversky, B. (2003). Segmenting Ambiguous Events. *Proceedings of the Cognitive Science Society Meetings,* Boston.

Marzano, R. J. (2001). Designing a New Taxonomy of Educational Objectives. Thousand oaks', CA: Corwin Press.

Mayer, R. E. and Moreno, R. (2003). Nine Ways to Reduce Cognitive Load in Multimedia Learning. *Educational Psychologist.* 38, 43 – 52.

Memije-Cruz, L. (2010). Importance and Uses of Chemistry. Manila, NCR, Philippines. Retrieved January 5, 2013 from liwaymemijecruz.blogspot.com/2010/.../importance-of-chemistry.ht...

Mkpanang, J. T. (2010). Effects of Computer-Assisted Instruction (CAI) with Drill and Practice on Academic Achievement of Students in Physics. *Nigerian Journal of Science and Science Education*, 8 (2), 72-86.

Morgil, I., Yavuz, S., Oskay, O., and Arda, S. (2005). Traditional and Computer-Assisted Learning in Teaching Acids and Bases. *Chemistry Education Research and Practice*, 6 (1), 52.

Mudasiru, O. T and Adedeji, O.A. (2010). Effect of Computer Assisted Instruction (CAI) on Secondary School Student Performance in Biology. TOJET: *The Turkish Online Journal of Educational Technology*, 9 (I), 62-69.

Muir-Herzig, R. G. (2004). Technology and its Impact in the Classroom. *Computers and Education,* 42, 111–131.

Mumtaz, S. (2000). Factors Affecting Teachers' Use of Information and Communications Technology: A Review of the Literature. *Journal of Information Technology for Teacher Education,* 9 (3), pp.319-341.

Musker, R. (2000). Why ICT Makes a Difference. *Education in Science*, 4, 186.

Mwanza, D. And Engestrom, Y. (2003). Managing Content in e-Learning Environment. *British Journal of Education Technology,*36 (3),453-463.

National Research Council (NRC). (2003). Evaluating and Improving Undergraduate Teaching in Science, Mathematics, Engineering, and Technology. Washington, DC: National Academy Press.

Newhouse, C.P. (2002). The Impact of ICT on Learning and Teaching*: A Literature Review for the Western Australian Department of Education.* p. 52.

Nicoll, G. (2001). A Report of Undergraduates' Bonding Misconceptions. *International Journal of Science Education,* 23(7), 707–730.

NITDA, (2003). Use IT: National Information Technology Development Agency, Abuja, Nigeria. Available http;//www.nitda.gov.ng/use it.htm.

Njoku, Z. C. (2004). Fostering the Application of Science Educational Research Findings in Nigeria Classrooms: Strategies and Needs for Teachers Professional Development. In M. A. G. Akale (Ed.). *Proceedings of 45th Annual Conference of Science Teachers Association of Nigeria (STAN*), pp.217-222. Ibadan: HEB Plc

Njoku, Z.C. (2007). Comparison of Students Achievement in the Three Categories of Questions in SSCE Practical Chemistry Examination. *Journal of Science Teachers Association of Nigeria.* 42 (1 and 2), 67-72.

Njoku, Z.C. (2008). Strategies for Effective Science Teaching to Special Needs Learners. *Proceedings of the 49th Annual Conference of Science Teachers Association of Nigeria.* 290, Ibadan .HEBN Publishers.

Oduroye, A.P. (2007). Challenges of Learning and Teaching with Computers. Available: http://www.itnetwork.org.uk/56.htm

Ogunsola, M.F. (2002). Use of Computer Simulators in Science Practical. In M.A.G. Akale (Ed.). *Proceedings of 43rd Annual Conference of Science Teachers Association of Nigeria (STAN*) Ibadan: HEB Plc, pp.537-538.

Okafor, N. and Umoiyan, I.E. (2008). Evaluating the Learning Strategies of NCE Year one non- major Chemistry Students. Proceedings of the 49th Annual Conference of Science Teachers Association of Nigeria, 116-121. Ibadan. HEBN Publishers.

Oke, C.S. Olusunde, G.R. and Jekayinfa A.A. (2005). Research Methodology and Statistics in Education: Theory and Practice. Ibadan: Emola-Jay Communication Inc.

Okeke, E.A.C. (2008). Clarification and Analysis of Gender Concepts Focus on Research, Reproductive Health Education and Gender Sensitive Classrooms*, STAN- Gender and STM Education series* No.2 5-8.

Okereke, C. and Onwukwe, E.O. (2011). Influence of Gender, School Location and the Use of Play Simulation on School Achievement in Chemistry.

Okolocha, C.C. (2010). E-learning: A Veritable Tool for Preparing Business Education Teachers in Tertiary Institutions in Anambra State. Nigeria. *African Research Review*, 4 (4), 260-276.

Okoro, C.A. and Etukudo, U.E (2001). CAI versus Extrinsic Motivation based traditional method: It's Effect on Female Genders' Performance in Chemistry. A paper presented at 42nd STAN Conference in Ilorin.

Olaofe, I.A. (2010). *Research writing for Academic Growth*. Zaria: Ahmadu Bello University Press ltd.

Olele, C.N. (2008). Emerging Issues for Computers in Schools: A Bridge for Digital Divide Phenomenon in Nigeria. In N. Udofia (Ed.). *Proceedings of 49th Annual Conference of Science Teachers Association of Nigeria (STAN*) Ibadan: HEBN Publishers Plc, pp.195-199.

Oloyede, O.I. (2008). Problems of Teaching and Learning Science in Primary and Junior Secondary Schools, *Workshop Paper Presented at SUBEB Teachers Training Workshop.*

Oloyede, O.I. (2010). Enhanced Mastery Learning Strategy on the Achievement and Self Concept in Senior Secondary School Chemistry. *Humanity and Social Sciences Journal* 5(1), 19-24.

Olusi, E.I. (2008). Using computer to solve mathematics by junior secondary school students in Edo State Nigeria. *College Student Journal*, 42(3), 748-755.

Onasanya, S.A. Daramola, F.O. and Asuquo, E.N. (2006): Effect of Computer Assisted Instructional Package On Secondary School Students' Performance In Introductory Technology In Ilorin, Nigeria. *The Nigeria Journal of Educational Media and Technology. Vol. 12 No. 1.*

Onuekwusi, C.N. (2011): Test Development Competence of Chemistry Teachers in Owerri Educational Zone of Imo State. *Unizik Journal of STM Education*. Department of Science Education, Nnamdi Azikwe University Awka. Iferic Publisher Limited Oba Anambra State Nigeria.

Osborne, J. (2003). Attitudes towards Science: A Review of the Literature and its Implication. *International Journal of Science Education,* 25, 1049-1079.

Otis, N., Grouzet, F.M.E., and Pelletier, L. G. (2005). Latent Motivational Change in an Academic Setting: A 3-year longitudinal study. *Journal of Educational Psychology*, 97 (2), 170-183.

Orisebiyi, O.O. (2007). Effects of instructional Video Tape Package on senior secondary school student's performance in Biology in Fidit, Oyo state Unpublished M-Tech thesis F.U.T, Minna

Ozden, M. (2007). Problems with Science and Technology Education in Turkey. *Eurasia Journal of Mathematics, Science and Technology Education, 3(2),* 157-161.

Ozmen, H. (2008). The Influence of Computer-Assisted Instruction on Students' Conceptual Understanding of Chemical Bonding and Attitude toward Chemistry: A case for Turkey. *Computers and Education* 51, 423–438.

Ozmen, H. and Kolomuc A. (2004). Effect of computer-based teaching on students' achievement in solution chemistry. *Kastamonu Education Journal,* 12(1), 57–68.

Papanastasiou, E.C., Zembylas, M., and Vrasidas, C. (2003). Can computer use hurt science achievement?: The USA results from PISA. Journal of Science Education and Technology, 12(3), 325–332.

Paul, C. (2002). Literature Review: The Impact of ICT on Learning and Teaching, Available at http://www.det.wa.edu.au/pdf

Paul, S.Y. and Babaworo, S. (2006). Information and communication technologies (ICTs) in teacher education: The way forward. Proceeding of 19th Annual National conference of Nigerian Association of Teacher of Technology (NAIT).

Pellegrine, J.W. and Hilton, M.L. (2012). Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st century. *National Research Council,* HowlettFoundation

Pelgrum, W. J. (2001). Obstacles to the Integration of ICT in Education: Results from a worldwide educational assessment. Computers and Education, 37 pp.163-178.

Peralta, H., Costa, F. A. (2007). Teachers' Competence and Confidence Regarding the use of ICT. *Educational Sciences Journal*, vol. 3, pp. 75-84.

Phillips, T. and Moss, G.D. (1993). Can computer assisted instruction biology packages be used to replace teacher? *Journal of Biological Education*, 27 (3), 213 – 215.

Preston, C. and Cox, K. (2000). Teachers as Innovators: An Evaluation of the Motivation of Teachers to use Information and Communication Technology. MirandaNet,

Raviola, A. (2001). Assessing students' conceptual understanding of solubility equilibrium. Journal of Chemical Education, 78(5), 629–631.

Robinson, W. (2003).Chemistry Problem-Solving: Symbol,Macro, Micro, and Process Aspects. *Journal of Chemical Education*, 80, 978 – 982.

Romiszowski, A.J. (1986). Developing auto-instructional materials: from programmed texts to CAL and interactive video. London: Kogan Page.

Safo, A.D., Ezenwa, V.I., and Wushishi, D.I. (2013). Effects of Computer Assisted Instructional Package on Junior Secondary School Students Achievement and Retention In Geometry in Minna Niger State, Nigeria. *International Journal of Humanities and Social Science Invention*. 2(5);2319 – 7714.

Sanger, M.J., Phelphs, A.J., Fienhold, J., (2000). Using a Computer Animation to Improve Student's Conceptual Understanding Of A Can-Crushing Demonstration. *Journal of Chemical Education*, 77(11); 1517-1520.

Salahudeen, Y. (2012). Effects of Computer Assisted Instructinal Package on Learning of Longitude and Latitude among Secondary School Students in Minna Metropolis.Minna *Journal of Educational Studies (MIJES).*5(1), 131 – 138

Schunk, D.H. and Ertmer, P. A. (2000). Self- Regulation and Academic Learning: Self-efficacy Enhancing Interventions. *Handbook of self regulation*, pp.631-650. San Diego: Academic.

Scrimshaw, P. (2004). Enabling Teachers to Make Successful Use of ICT. Becta. www.becta.org.uk/page_documents/research/enablers.pdf

Seanac, (2011). Harmonization of Analytical Chemistry Curricula. *A Working Document Report* Prepared by SEANAC Committee Held at Angust.

Sjöström, J. (2007). The Discourse of Chemistry (and Beyond). *HYLE: International Journal for Philosophy of Chemistry, 13,* 83–97.

Smeets, E. (2005). Does ICT Contribute to Powerful Learning Environments in Primary Education?. *Computer Education*, 44(3),343-355.

Solsona, N., Izquierdo, M., and De Jong, O. (2003). Exploring the Development of Students_ Conceptual Profiles of Chemical Change. *International Journal of Science Education*, 25(1), 3–12.

Southwood, R. (2004). African Telecom Indicators; What do they use and why? Available http://www.balanceingactAfrica.com/news/back/balancingact147.html

Spasser, M.A. (2002). Realist Activity Theory for digital library evaluation: Conceptual framework and case study. Computer Supported Cooperative work,11 (1/2),81-110.

Spradlin, K.D. (2009). The Effectiveness of Computer-Assisted Instruction in Developmental Mathematics. A Dissertation Presented to The Faculty of the School of Education Liberty University In Partial Fulfilment of the Requirements for the Degree Doctor of Education.

Sproul, G.J. (2005). Electronegativity and Bond Type: *Journal of Chemical Education*, 78,387-390.

Stieff, M., and Wilensky, U. (2003). Connected Chemistry-Incorporating Interactive Simulations into the Chemistry Classroom. *Journal of Science Education and Technology,* 12(3), 285–302.

Suárez, M.B. (2013). ICT in the EFL Teaching in the Public Schools of the Department of Boyacá: An Overview to the World. *Enletawa Journal*, (4 Jan).

Taber, K.S. (2001). The Mismatch between Assumed Prior Knowledge and the Learners' Conceptions: A typology of learning impediments. Educational Studies, 27(2), 159 – 171.

Taber, K.S., and Coll, R.K. (2002). Chemical Bonding. In J. K. Gibert, O. de Jong, R. Justi, D. F. Treagust, and J. H. Van Driel (Eds.), Chemical Education: Research-based Practice (pp. 213-234). Dordrecht: Kluwer Academic Publishers. BV.

Tan, A and Seng, C.Y. (2000). The effects of incorporating concept mapping into Computer Assisted Instruction. Baywood Publishing Company Inc.

Tasker R., (2004). Using Multimedia to Visualize the Molecular World: Educational Theory into Practice. In *A Chemist's Guide to Effective Teaching*, Pienta N., Greenbowe T. and Cooper M., eds., Chapter 16, (pp. 256-272), Prentice Hall.

Tasker, R., Dalton, R., Sleet, R., Bucat, B., Chia, W., and Corrigan, D. (2002). Description of VisChem: Visualising Chemical Structures and Reactions at the Molecular Level to Develop a Deep Understanding of Chemistry Concepts. Retrieved January 20, 2007, from Learning Designs Web site: http://www.learningdesigns.uow.edu.au/exemplars/info/LD9/index.html

Teichert, M. and Stacy, A. (2002). Promoting Understanding of Chemical Bonding and Spontaneity through Student Explanation and Integration of Ideas*, Journal of Research in Science Teaching,* 39(6), 464 – 496.

Thierer, A. (2000). Divided over the Digital Divide, Washington, DC: Heritage Foundation.

Thomas, P.Y. and Emereole, H.U. (2002). Effect of Computer-Based Instruction on Performance in Physics. *African Journal of Research in Mathematics, Science and Technology Education,* 6, 97-112.

Tversky, B. (2001). Spatial Schemas in Depictions. In M. Gattis (ED.), Spatial Schemas and Abstract Thought. Pp. 79-111. Cambridge: MIT Press.

Tyson, L., and Treagust, D.F. (1999). The complexity of teaching and learning chemical equilibrium. *Journal of Chemical Education*, 76, 554–558.

Udo, M.E. and Etiubon, R.U. (2011). Effects of Guided-discovery, Student-centred Demonstration and the Expository Instructional Strategies on Students' Performances in Chemistry. *African Research Review*, 4 (4), 389-398

Udousoro, V.J. (2000). The relative effectiveness of computer and text-assisted programme instruction on students' learning outcomes in mathematics. Unpublished Ph.D. Thesis of the University of Ibadan.

Udousoro, V.J. (2000). Gender Difference in Computing Participation. The Case of University of Uyo. *International Journal of Educational Development (IJED),* 2 (1) 190-199.

Umaru, J. (2003). Introduction to Computer Studies Book 2. Ilorin: Nathedex Publishers, (Chapter 7).

Umoh, C.G. (2003). A Theoretical Analysis of the Effects of Gender and Family Education on Human Resource Development*. Journal of Curriculum Organization of Nigeria*, 10(1) 1-4.

Unwaleke, C.C. and Offiah, F.C. (2013): The Relationship between Senior Secondary School Students Analytical Skill their Achievement in Chemistry in Anambra State. *International Journal of Engineering Science Invention*, 2, (7), 44-57.

Usun, S. (2006). Applications and Problems of Computer Assisted Education in Turkey. *The Turkish Online Journal of Educational Technology,* 5 (4), 11-16.

vanBraak, J. (2001). Factors Influencing the Use of Computer Mediated Communication by Teachers in Secondary Schools. *Computers and Education*, 36 (1), 41-57.

Venkataiah, N. (2004). Educational Technology. The Associated Publishers.

Volman, M. and van Eck, E. (2001). Gender Equity and Information Technology in Education: The Second Decade. *Review of Educational Research*, vol. 71, no. 4, pp. 613-634.

Voska, K.W., and Heikkinen, H. W. (2000). Identification and Analysis of Student Conceptions used to solve Chemical Equilibrium Problems. *Journal of Research in Science Teaching,* 37, 160–176.

Vygotsky, L.S. (1978). Mind in Society*: The Development of the Higher Psychological Processes*. Cambridge, MA: The Harvard University Press.

Warburton, K. (2003). Deep Learning and Education for Sustainability. *International Journal of Sustainability in Higher education.* 4 (10), 44-56.

Weinhold, F. and Landis, C.R. (2005). Valency and Bonding: A Natural Bond Orbital, Donor Acceptor Perspective; Cambridge University Press, Cambridge.

Weiss, R.E., Knowlton, D.S. and Morrison, G.R. (2000). Principles for Using Animation in Computer-Based Instruction: Theoretical Heuristics for Effective Design. Computers in Human Behaviour, 18,465-477.

WAEC (2012). Chief examiner's report. Lagos: Research and Statistics Unit, WAEC. 78-98.

West African Examination Council (WAEC) *Annual Report*, (2010- 2014).

West African Examination Council (WAEC) (2006). West African Examination Council Chief Examiner‟s Report.

West African Examination Council (WAEC) (2007). West African Examination Council Chief Examiner‟s Report.

West African Examination Council (WAEC) (2008). West African Examination Council Chief Examiner‟s Rseport.

Wiegand, P. (2003). School Students' Understanding of Chloropleth Maps: Evidence from Collaborative Mapmaking using GIS*, Journal of Geography*, 6, 234-242

Wieman, C. (2007). Why not try a Scientific Approach to Science Education? Change, 9–15.

Williams, M., Linn, M.C., Ammon, P., and Gearhart, M. (2004). Learning to Teach Inquiry Science in a Technology-Based Environment: A Case Study. *Journal of Science Education and Technology,* 13(2), 189-206.

Wodi, S.W., and Dokubo, A. (2006). The Relevance of ICT in Science and Technology. *Journal of Curriculum Organization of Nigeria*, 13 (1), 200-206.

Yousef, A.B. and Dahmani, M. (2008).The Economics of E- Learning: The Impact of ICT on Students' Performance in Higher Education: Direct Effects, Indirect Effects and Organizational Change (http://rusc.uoc.edu, downloaded March 4, 2011).

Yunus, M.M., Nordin, N., Salehi, H., Redzuan, N.R., and Embi, M.A. (2013). A Review of Advantages and Disadvantages of using ICT Tools in Teaching ESL Reading and Writing. *Australian Journal of Basic and Applied Sciences*, *7*(4).

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

Zacharia, Z. (2003). Beliefs, Attitudes, and Intentions of Science Teachers Regarding the Educational Use of Computer Simulations and Inquiry-Based Experiments in Physics. *Journal of Research in Science Teaching*, 40(8), 792–823.

Zayum, S.D. (2008). Performance Enhancement Skills for Teachers of Junior Secondary Schools, *Paper Presented at Bauchi State SUBEB workshop*.

APPENDICES

APPENDIX ONE: AN INTRODUCTORY LETTER FROM KSSTSB

SCIENCE AND TECHNICAL SCHOOLS BOARD,
KANO STATE

REF: STB/ADMIN/90/VOL.II/ DATE: 25/08/2015

All Principals,
Science College,
Kano State.

RE: STUDENTS' RESEARCH ENQUIRIES

I am directed to write and introduce to you **BINTA IBRAHIM KHALIFA** from the Department of Science and Technology, Bayero University, Kano who is currently writing her research work titled "Examining the effectiveness of computer – Based learning on students' Achievement in Teaching and learning of Chemical Bond in Science secondary schools of Kano State.

Kindly consider and comply, please.

Best regards

NASIRU SHEHU MUSA
(DDPRS (RO)
FOR: EXECUTIVE SECRETARY

APPENDIX TWO: LESSON PLAN FOR CONTROLLED GROUP

LESSON ONE

DATE.......................

SUBJECT: CHEMISTRY CLASS: SSII

TOPIC: CHEMICAL BONDING LEARNING UNIT: PERIODIC TABLE

REFERENCES: SENIOR SECONDARY SCHOOL CHEMISTRY TEXTBOOK BY OSEI YAW ABABIO

INSTRUCTIONAL AIDS: CHART, CHALK AND CHALKBOARD, TEXTBOOK

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students should be able to

i. List the first 20 elements of the periodic table.
ii. Draw the electronic configuration of atoms such as Oxygen, Nitrogen etc.
iii. Define elements, compounds and molecules

PREVIOUS KNOWLEDGE: The students were taught chemical symbols of elements with their valances

INTRODUCTION: The lesson is to be introduced by reviewing the previous lesson.

PRESENTATION: The lesson is to be presented in the following steps:

STEP 1

The teacher presents the lesson by defining the periodic table and further explains the classification of elements and how they are arranged in different groups on the periodic table, those that fall under metals and non-metals, as well as transition metals

STEP 2

The teacher further explains the concepts of valence electrons, and valance using atomic structure e.g., Na loses its valence electron to become Na^+

STEP 3

The teacher writes notes on the blackboard for the students to copy in their various note books.

EVALUATION: The teacher evaluates the lesson by asking the student questions related to the learning unit to test their understanding.

CONCLUSION: The teacher concludes the lesson by giving the students room to ask questions and introduces the next lesson.

LESSON TWO

DATE ....

SUBJECT: CHEMISTRY CLASS: SSII

TOPIC: CHEMICAL BONDING LEARNING UNIT: CHEMICAL BONDING

REFERENCES: SENIOR SECONDARY SCHOOL CHEMISTRY TEXTBOOK BY OSEI YAW ABABIO

INSTRUCTIONAL AIDS: CHART, CHALK AND CHALKBOARD, TEXTBOOK

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students should be able to:

i. Define Chemical Bonding
ii. List the types of bonds and how they are formed
iii. List the unique characteristics of bond types

PREVIOUS KNOWLEDGE: The students were taught the periodic table, elements and how they are arranged on the periodic table.

INTRODUCTION: The teacher introduces the lesson with leading questions such as what do you understand by chemical bonding? Name the types of bond you are familiar with.

PRESENTATION: The teacher presents the lesson in the following steps:

STEP1

The teacher defines chemical bonding and lists its types such as ionic, covalent and metallic bonding.

STEP 2

The teacher explains to the students how these bonds are formed by drawing some examples on the board for them to see. e.g.

Ionic Bonding

$$\underset{2,8,1}{Na} + \underset{2,8,7}{Cl} \longrightarrow \underset{2,8}{Na^+} \quad \underset{2,8,8}{Cl^-}$$

Covalent Bonding

Cl + Cl ⟶ Cl —— Cl
2,8,7 2,8,7 2,8,8 2,8,8

STEP 3

The teacher further states the characteristics of each type of bond.

EVALUATION: The teacher evaluates the lesson by asking the students questions to test their knowledge gain and gives them few exercises to solve.

CONCLUSION: The teacher concludes the lesson by giving the students notes to copy.

LESSON THREE

DATE ....

SUBJECT: CHEMISTRY CLASS: SSII

TOPIC: CHEMICAL BONDING

LEARNING UNIT: ELECTRONEGATIVITY, HYDROGEN BONDING AND VAN DER WAALS FORCES.

REFERENCES: SENIOR SECONDARY SCHOOL CHEMISTRY TEXTBOOK BY OSEI YAW ABABIO AND ESSENTIALS OF CHEMISTRY.

INSTRUCTIONAL AIDS: CHART, CHALK AND CHALKBOARD, TEXTBOOK.

BEHAVIOURAL OBJECTIVES: At the end of the lesson, students should be able to:

i. Define the concept of electronegativity.
ii. Explain Hydrogen Bonding.
iii. Explain the concept of Van der Waals forces.

PREVIOUS KNOWLEDGE: The students were taught chemical bonding, its types and unique characteristics.

INTRODUCTION: The teacher introduces the lesson by reviewing the previous lesson.

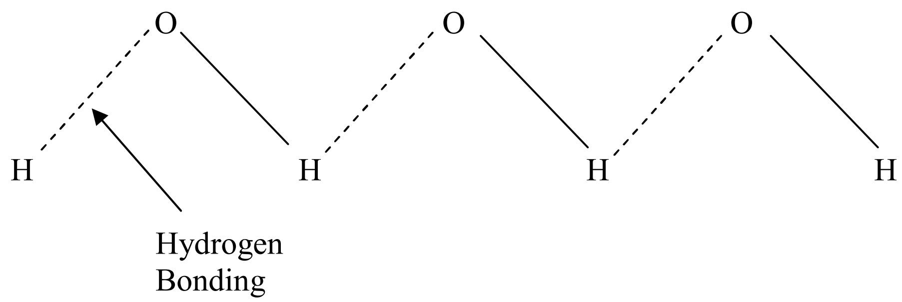
PRESENTATION: The lesson is to be presented in the following steps.

STEP 1

The teacher defines electronegativity and shows some examples of elements with their electronegativity values to the students using the chart of the periodic table.

STEP 2

The teacher explains hydrogen bonding and lists some examples of molecules containing hydrogen bond.



STEP 3

The teacher further explains the concept of van der Waal's forces.

EVALUATION: The teacher evaluates the lesson by giving the students room to ask questions and answers them accordingly.

CONCLUSION: The teacher concludes the lesson by writing notes on the board for the students to copy.

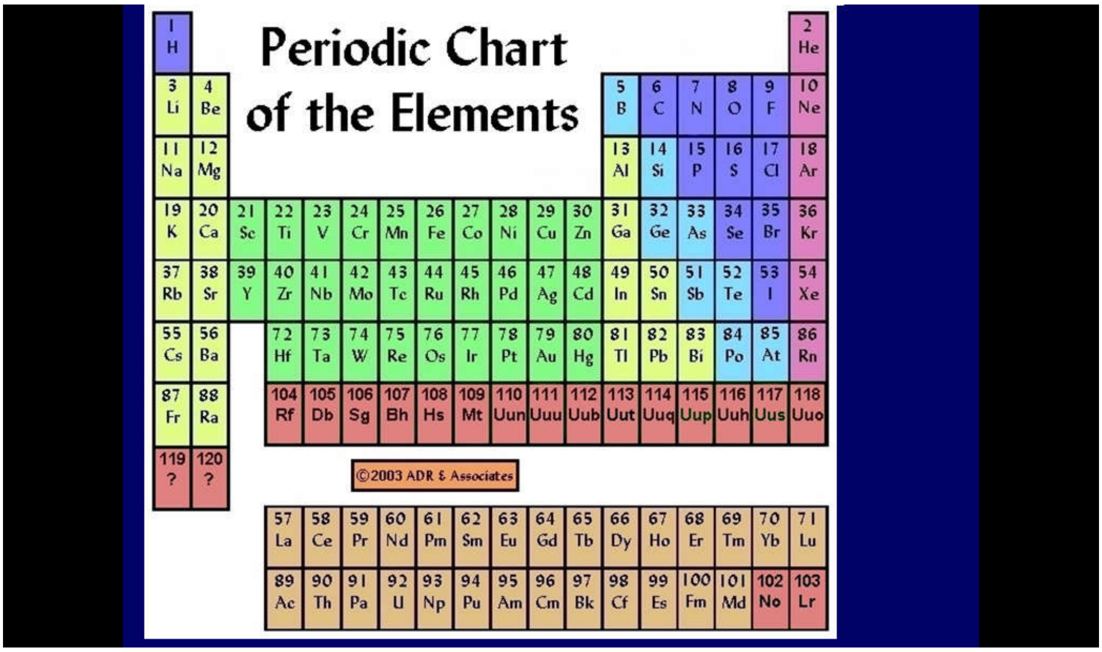
LESSON FOUR

During the final lesson, the researcher reviewed the whole content of the topic (chemical bonding). The lesson proceeded with more examples on bond formation. Few learners were invited to the chalkboard to show the bonding processes of some other compounds after which the researcher administered the test instrument to the students.

APPENDIX THREE: LESSON PLAN FOR EXPERIMENTAL GROUP

LESSON ONE

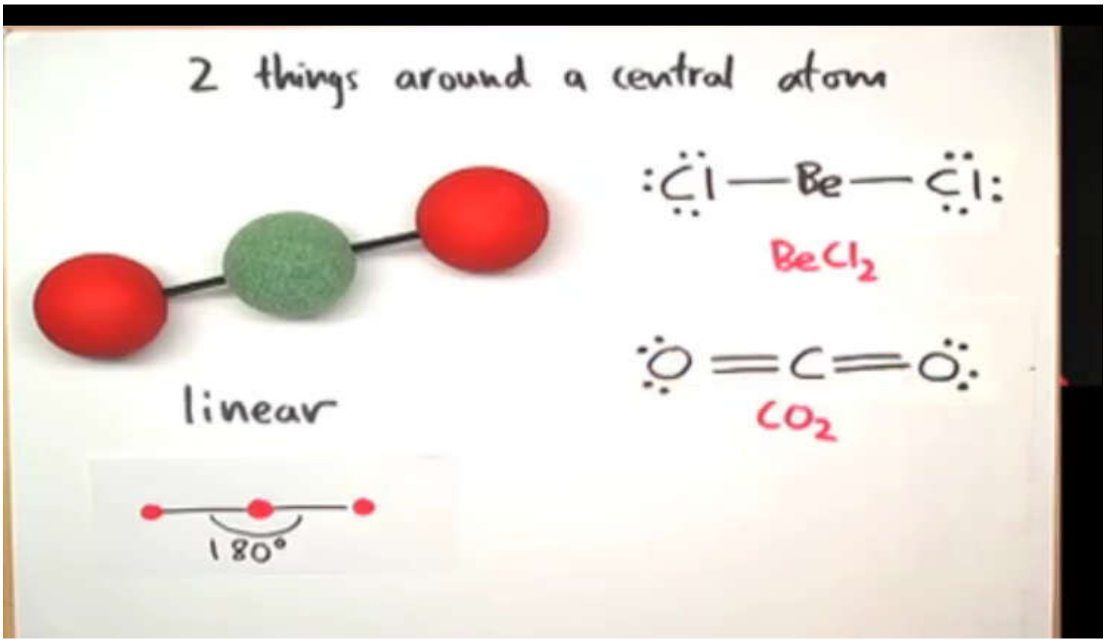
As in the case of the control group, the periodic table was revised by means of introduction. Colours have been used to classify the elements into Alkali metals, Alkaline earth metals, transition metals to name just but a few. The animation of the periodic table has the groups, temperature, and properties tabs. It also gives the timeline that is when the elements were discovered, it shows the properties of the elements like the density, mass number, atomic radius and so on. Hence the different ‘groups’ of elements on the periodic table and their properties were dealt with thoroughly. The students listened, participated and made notes where necessary in their books for future reference.



Screenshot of the Modern Periodic Table

LESSON TWO

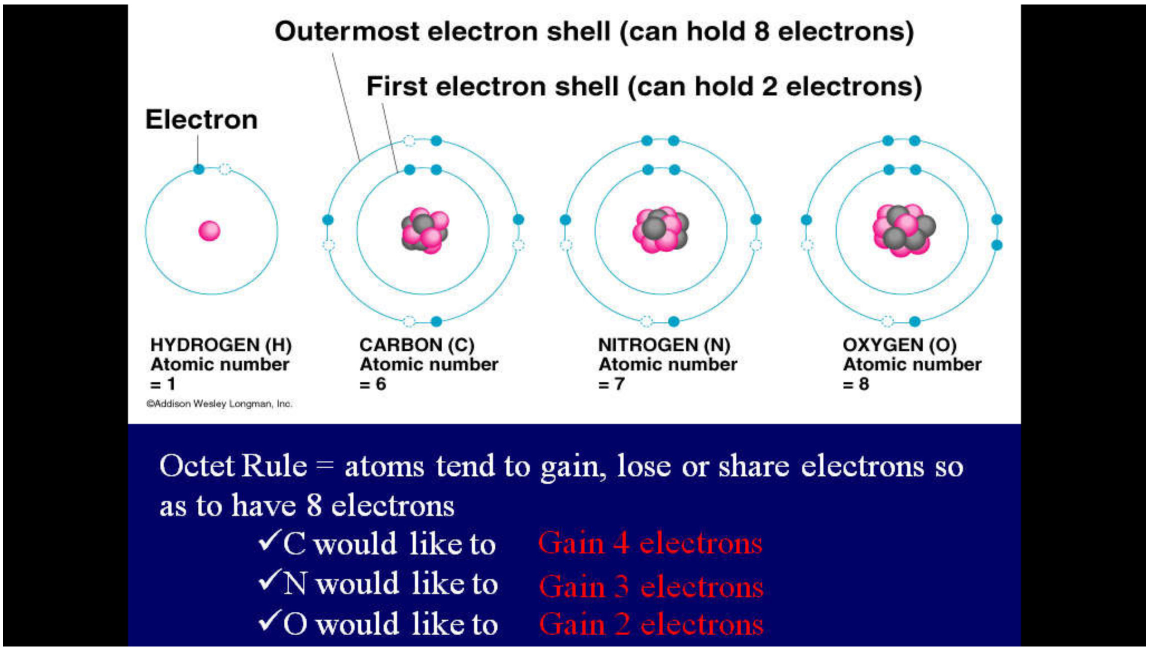
The researcher further interprets the first twenty elements, stating the number of electrons on each orbital of the atoms and how they should be arranged, among other things using power point presentation. The students watched and listened attentively to the researcher as the lesson proceeded. Using the video, the researcher was able to focus on the atomic structures or substances such as metals and non-metals. Students were able to view all shells of the elements during the lesson and asked questions, for example, how many electrons must be on the first and second shell? The researcher gave further clarifications on the questions.



Screenshot of shapes of molecules

LESSON THREE

The researcher discussed valence electrons, valency and electronegativity using power point presentation. For each element among the first twenty elements, its electronic configuration was displayed making it possible to know the number of the valence electron. The researcher then showed the students, bond types, namely Covalent and Ionic bonds. Students were asked to enumerate properties of Covalent and Ionic bonds and how these bonds are formed, of which the students attempted.

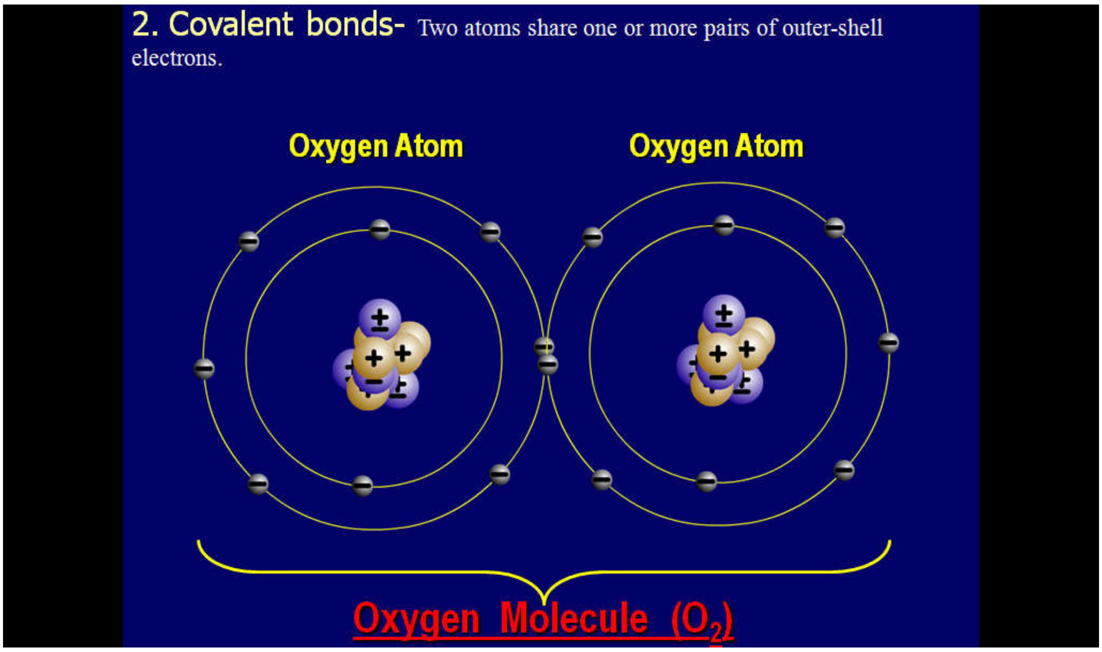


Screenshot of Valence Electrons in shells of Atoms

LESSON FOUR

The researcher then explained chemical bonding to the students and used videos to show how these bonds are formed. Different Covalent bonds were formed between non-metallic elements, for example carbon and oxygen to form carbon dioxide, carbon and hydrogen to form methane and so on. The video on covalent bond gives the formula and names of the compounds formed. The researcher also used power point presentation to treat metallic and Ionic bonding.

The students also watched attentively the power point presentation on hydrogen and van der waals forces. The researcher further explains how these intermolecular forces of attraction are formed. The students listened and made notes from the explanation.



Screenshot of Covalent Bonding

APPENDIX FOUR: TEST QUESTIONS

CHEMICAL BONDING ACHIEVEMENT TEST
TOTAL MARKS: 60

Name: …………………………………………………………………

Date: …………………………………………………………………….

Duration: 40-45 minutes
Each question carries 2 marks
Instruction: circle the letter that best completes the statements or answers the question:

1. The bonds in crystalline ammonium chloride are:-

a. covalent and dative b. ionic and covalent c. ionic, covalent and dative
d. ionic, covalent and hydrogen bond.

2. Which of the following bond types is responsible for the high boiling point of water?

a. metallic bond b. covalent bond c. ionic bond d. hydrogen bond

3. The compound formed by the combination of two elements with a large electronegativity difference is likely to be

a. polar covalent b. giant molecular c. covalent d. ionic

4. At ordinary temperature H_2O is a liquid while H_2S is a gas. This is because H_2O has a

a. weak intermolecular force holding its molecules together b. strong hydrogen bonds holding its molecules together c. induced dipole induced dipole forces between its molecules d. ionic forces between its molecules.

5. Which of the following elements is diatomic?

a. Sodium b. Oxygen c. Iron d. Neon

6. The types of chemical bond that exist between potassium and oxygen in potassium oxide is

a. ionic b. metallic c. covalent d. dative

7. In the lewis structure, what do the dots represents?

a. protons b. neutrons c. valence electrons d. shell

8. When element $_{20}A$ combines with element $_{8}Y$,

a. a covalent compound, AY is formed b. an ionic compound, AY is formed c. An ionic compound A_2Y is formed d. an ionic compound AY_2 is formed

9. The shape of a molecule of water is ……

a. bent b. octahedral c. pyramidal d. tetrahedral

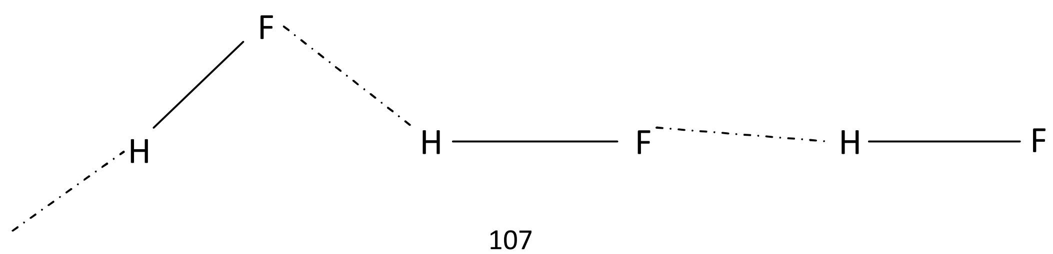
10. The compound formed between $_{14}X$ and $_{16}Y$ is …………………………

a. XY b. XY_2 c. X_2Y d. X_4Y_6

11. Which of the following molecule has a linear shape?

a. CH b. CO_2 c. H_2S d. NH_3

12. Which type of bond is represented by the dotted lines in the following structure?



a. covalent bond b. dative bond c. electrovalent bond d. hydrogen bond

13. Which of the following molecules has a triple bond in its structure?
a. CH_4 b. NH_3 c. N_2 d. O_2

14. Which of the following species does not contain a co-ordinate bond?
a. Al_2Cl_6 b. CCl c. H_3O^+ d. NH_4^+

15. What type of chemical bonding is involved in the formation of NH_4^+ from a molecule of ammonia and a proton?
a. covalent bonding b. co-ordinate covalent bonding c. electrovalent bonding d. hydrogen bonding

16. What is responsible for metallic bonding?
a. Attraction between delocalized electrons and fixed positive lattice point (cations)
b. Attraction between positive and negative ions
c. Sharing of electrons between the metal atoms
d. Transfer of electrons from one atom to another

17. What type of bond will be formed between elements P and Q if their electronegativity values are 0.8 and 4.0?
a. covalent bond b. co-ordinate bond c. ionic bond d. metallic bond

18. Which of the following can be used to predict the type of bonding in HCL
a. pH value b. electronegativity difference c. heat of neutralization
d. heat of solution

19. The type of bonding between calcium and oxygen in calcium oxide is ………………
a. metallic b. covalent c. ionic d. coordinate covalent

20. In metallic solid, the force of attraction is between the mobile valence electrons and the ….a. atoms b. neutrons c. negative ions d. positively charged nuclei

21. In bonded atoms, increase in electronegativity difference
a. increases polarity b. decreases polarity c. has no effect on polarity
d. oxidation number

22. The atomic number of chlorine is 17. What is the number of electrons in a chloride ion?
a. 16 b. 17 c. 18 d. 19

23. A hydrogen atom which has lost an electron contains
a. one proton only b. one neutron only c. one proton and one neutron d. one proton, one electron and one neutron

24. The atom of an element X has two electrons in its outermost shell. What is the formular of the compound formed when X combines with Aluminium ($_{13}Al$)?
a. AlX_2 b. Al_2X c. Al_2X_2 d. Al_2X_3

25. Elements which belong to the same group in the periodic table are characterized by……
a. difference in +1 in the oxidation numbers of successive numbers
b. presence of same number of outermost electrons in the respective atoms
c. difference of 14 atomic mass units between successive members
d. presence of the same number of electron shells in the respective atoms

26. Which of the following compounds is covalent?
a. $CaCl_2$ b. MgO c. NaH d. CH_4

27. Which of the following has the greatest electronegativity?
a. H b. Cl c. O d. F

28. Which of the following properties of covalent compounds is not correct?
a. are non-electrolytes b. are mostly gaseous and volatile liquids c. have low melting points d. oxidation number

29.The force of attraction between covalent molecules is ………………..
a. dative bonding b. hydrogen bonding c. ionic force d. Van der Waals force

30.Which of the following compounds has hydrogen bonds between its molecules?
a. HF b. HBr c. HCI d. HI

APPENDIX FIVE: MARKING SCHEME FOR THE CHEMISTRY ACHIEVEMENT TEST

1	**B**
2	**D**
3	**D**
4	**B**
5	**B**
6	**A**
7	**C**
8	**C**
9	**A**
10	**B**
11	**B**
12	**D**
13	**C**
14	**B**
15	**B**
16	**A**
17	**C**
18	**B**
19	**A**
20	**D**
21	**A**
22	**C**
23	**A**
24	**D**
25	**B**
26	**D**
27	**D**
28	**D**
29	**B**
30	**A**

APPENDIX SIX; TABLE OF SPECIFICATION

S/No	Content	Knowledge	Comprehension	Application	Total
1	Atom and Elements	2	1	1	4 13%
2	Molecules and Compounds	1	2	1	4 13%
3	Bond Types	3	4	2	9 30%
4	Electronegativity	2	2	1	5 17%
5	Bond Polarity	1	1	1	3 10%
6	Hydrogen Bonding	2	1		3 10%
7	Van der Waals	1	1		2 7%
	Total	12 40%	12 40%	6 20%	30 100%

APPENDIX SEVEN: SPSS RESULTS FOR RELIABILITY COEFFICIENT

Correlations

			pretest	posttest
Spearman's	pretest	Correlation Coefficient	1.000	-.021
		Sig. (2-tailed)	.	.930
		N	20	20
	posttest	Correlation Coefficient	-.021	1.000
		Sig. (2-tailed)	.930	.
		N	20	20

APPENDIX EIGHT: SPSS RESULTS FOR EXPERIMENTAL AND CONTROL GROUPS

Group Statistics

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Posttest	Experimental	97	34.8000	5.28668	.54240
	Control	113	33.7913	5.24069	.48870

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Posttest	Equal variances assumed	.152	.697	1.383	208	.168	1.00870	.72947	-.42942	2.44681
	Equal variances not assumed			1.382	192.9794	.169	1.00870	.73008	-.43096	2.44835

APPENDIX NINE: SPSS RESULTS FOR URBAN AND RURAL DIFFERENCES IN POST-TEST FOR EXPERIMENTAL GROUPS

Group Statistics

	Location	N	Mean	Std. Deviation	Std. Error Mean
	Urban	41	35.2195	5.72500	.89409
	Rural	56	34.4815	4.95923	.67487

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post-test	Equal variances assumed	.573	.451	0.672	95	.503	0.73803	1.09831	1.44300	-2.91906
	Equal variances not assumed			0.659	84.850	.512	0.73803	1.12020	1.49160	-2.96766

APPENDIX TEN: SPSS RESULTS FOR GENDER DIFFERENCES IN POST-TEST FOR EXPERIMENTAL GROUPS

Group Statistics

	Sex	N	Mean	Std. Deviation	Std. Error Mean
Post-test	Boys	56	34.4815	4.95923	.67487
	Girls	41	35.2195	5.72500	.89409

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post-test	Equal variances assumed	.573	.451	0.672	95	.503	0.73803	1.09831	1.44300	-2.91906
	Equal variances not assumed			0.659	84.850	.512	0.73803	1.12020	1.49160	-2.96766