UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF USING COMPUTER SIMULATION IN TEACHING CHEMICAL BONDING ON THE COGNITIVE ACHIEVEMENT OF SHS 1 CHEMISTRY STUDENTS: A CASE STUDY AT BISHOP HERMAN COLLEGE, KPANDO.

MORRISON SEFADZI KWAMI AMAFU

DECEMBER, 2015

UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF USING COMPUTER SIMULATION IN TEACHING CHEMICAL BONDING ON THE COGNITIVE ACHIEVEMENT OF SHS 1 CHEMISTRY STUDENTS: A CASE STUDY AT BISHOP HERMAN COLLEGE, KPANDO.

BY

MORRISON SEFADZI KWAMI AMAFU

(7130130003)

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

DECEMBER, 2015

DECLARATION

Candidate's Declaration

I hereby declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been presented for another degree in this university or elsewhere.

Signature……………………………………… Date……………………………….…

Morrison Sefadzi Kwami Amafu

Supervisor's Declaration

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

Signature……………………………………… Date……………………………….

Prof. K. D. Taale

ACKNOWLEDGEMENT

I wish to express my heartfelt appreciation to my supervisor, Professor K. D. Taale, a senior lecturer in the Department of Science Education, University of Education, Winneba, for his technical guidance and encouragement throughout the supervisory work on my dissertation.

I also wish to render my sincerest gratitude to Mr A. H.Y. Asare, physics tutor at Bishop Herman College, who willing opted to guide me with the data analysis. I am also grateful to all my Course mates especially Dorcas Achaampomah who always call to find out the progress of my work.

Again I extend special thanks to all other lecturers at the Science Education Department. Finally I would like to say thank you to Staff and students of Bishop Herman College, Kpando and all my siblings.

DEDICATION

Dedicated to my children; Anita Emefa Amafu, Elijah Elikem Amafu, my lovely wife, Felicia Ahoto and my mother the late madam Josephine Amakumah Afutor.

TABLE OF CONTENT

CONTENT **PAGE**

CHAPTER TWO

REVIEW OF RELATED LITERATURE

LIST OF TABLES

LIST OF FIGURE

ABSTRACT

Computer simulations are well documented in developed countries but little is known about them in developing countries like Ghana. The main objective of the study was to examine the effects of using computer simulations in teaching chemical bonding on cognitive achievement of learners and to compare the results with those of learners who were taught using the traditional method (lecture). The study employed a non-randomized control-group pre-test and post-test quasi-experimental design involving two first year science classes of Bishop Herman College, Kpando; 38 in the control group (CG) and 38 in the experimental group (EG). An Achievement Test consisting of 20 multiple-choice questions and a Structured Opinionnaire designed for participants in the experimental group were the principal data collection tools used. The test was developed to answer research questions one and two, while the Opinionnaire was to answer the research question three. The data were analysed by using SPSS 16.0 statistical program. Descriptive statistics such as mean, Standard Deviation were calculated and inferential statistics of paired t-test was used to test if significant differences exist in the understanding of chemical bonding between the experimental and control groups after the intervention. Alpha level of 0.05 was used as a criterion of either accepting or rejecting the null hypotheses. The mean test score of the experimental group (37.05) was higher than that of control group (20.47) counterparts in the post-test. The t-test analysis of the mean score on the post-test shows a significant difference between the two groups ($t(37) = -18.582$, $p = 0.000$). Therefore the null hypothesis which states "there is no statistically significant difference between the cognitive achievements of the students taught using computer simulation and those taught without the computer simulations" was rejected. This suggests that computer simulations provide feedback that minimises abstractness. The study further revealed that the participants have positive attitude towards chemical bonding and chemistry as a whole.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter covers the background of the study, statement of the problem, purpose of the study and objectives of the research. It also includes the significance of the study, research questions that guided the study, research hypotheses that were formulated and tested in the study; it further deals with the delimitations and the limitations. It finally covers the organization of the research report.

1.1 Background of the Study

The rational for teaching chemistry in Ghanaian schools are as follows; Chemistry is concerned with the study of matter and its changes. As such, it is about us and everything around us. It keeps living things alive through the numerous changes that take place in their bodies. Around us, for example, there is chemistry in food, clothing, medicine, shelter and household items like soap, plastics, books, radio and computers. These would not exist without chemistry. Chemistry enables us to understand, explain, control and prevent phenomena like bush fires, industrial pollution, corrosion of metals and depletion of ozone layer. It is therefore a subject we cannot ignore. (Teaching syllabus for chemistry, 2010).

Students respond to information differently, thus, it is often to the advantage of teachers to use many different formats and modes to teach the subject matter of a lesson. This is why teachers normally use some combination of lecture, text and hands-on laboratory activities for conveying information. With the advent of the Internet and the multiple formats that can be communicated, inclusion of technology in almost all fields of life has led to the use of computer in education in order to teach concepts, phenomena and theories. One of the promising developments in computer technology, which has an educational potential, is computer simulations that is attracting attention in educational surveys (Özdener & Sayin, 2004). Computer simulation is a program that helps to develop a simplified model of a situation in the daily life through abstracting certain features of it (Bayraktar, 2000). Simulations used in sciences are regarded as auxiliary tools effective in practical applications, gaining experience and understanding, which is a part of scientific thinking (Hsu & Thomas, 2002; Zacharia & Anderson, 2003). In addition, simulations contribute to development of students' scientific process, critical thinking and analytical skills within the process of understanding (Gaither, 2000). Use of computer simulations increases success and motivation of the students (Roach, 2003). Use of computer simulations makes contribution to development of skills and attitudes expected from the students with regard to the science and Technology lesson.

Over ten (10) years now, Ghanaian SHS chemistry teachers have used the traditional instructional approach which involves lecture, demonstration, illustration and discussion in their classrooms to deliver their chemistry lessons. This approach has however, proven to be ineffective in helping SHS students to understand complex and confusing concepts in chemistry like chemical bonding.

The effect of computer simulations instructional packages as a tool for classroom instruction has been noted by a number of researchers. Sahin (2006) for instance, has observed that computer simulations are good supplementary tools for classroom instruction and in science laboratories, as they give students the opportunity to observe a real world experience and interact with it. Computer simulations are also good tools to improve students' hypothesis construction, graphic interpretation and prediction skills (Sahin, 2006). It therefore seems that the incorporation of computer simulations instructional packages in the teaching and learning processes improves the understanding of learners. A study to investigate the effect of computer simulations instructional packages in the teaching and learning of complex and confusing chemistry concepts, like chemical bond, in Ghanaian Senior High Schools (SHSs) is therefore desirable.

To address some of the factors militating against science education and to improve on the quality of science delivery, the Government of Ghana has developed a national document in line with Government vision 2020. The basic objective of 'vision 2020' among others is to seek to develop adequate Science and Technology capabilities and to provide infrastructure, which will enable industries and other sectors of the economy to provide the basic needs of society (MESS, 2004). Ghana's vision 2020 identified science and technology clearly as the bases of launching Ghana into a state of middle income earning and a competitor with other developing nations in the 21st century. The Ministry of Education, Science and Sports (MESS) was tasked to orient all levels of the educational system to the teaching and learning of science and technology (MESS, 2004). The 2006 Educational Reforms buttressed the Vision 2020 by drastically reviewing the state of science education at all the pre – university levels of the educational system. The science syllabus has been thematically organized to make science education more related, integrated and more relevant to everyday life experiences.

In Ghana, although few researchers worked on the use of computer simulations in the teaching and learning of abstract concepts in biology, very little is known to the best of my knowledge, about the effect of the incorporation of computer simulations instructional packages in the teaching and learning processes on students' performance in chemical bonding. A study to investigate the effect of the incorporation of computer simulations instructional packages in the teaching and learning processes on the performance of Ghanaian SHS students in chemical bonding is therefore beneficial.

1.2 Statement of the problem

Researchers in Chemistry and Chemistry education have documented that a major difficulty with learners studying Chemistry is that of the discipline's dependency on the use of abstract concepts and models (Chalmers, 1998). Access to computers in the general society is on the increase and schools are being equipped with computer laboratories. For this reason, learners can have simulation packages installed even on home computers to enable them practice complex abstract concepts on their own to enhance their understanding and interest in the subject. Simulation might not only motivate learners but provides accessible ways for learners to develop intuitive understanding of abstract Physical phenomena (Squire, Barnett, Grant, & Higginbotham, 2004) as cited by Kotoka (2013).

Many of the first year Senior High students in Bishop Herman College Kpando, where the researcher happens to be teaching chemistry, find it difficult to understand the concept of chemical bond. The students turn to memorize the concept without understanding them.

The researcher received complaints from students that chemistry is too abstract, such that they do not understand the concepts whenever their teachers are teaching. The declining performance of Ghanaian students in the West African Senior Secondary Certificate Examination (WASSCE) in chemistry has been a worry for many stakeholders in the educational enterprise for some years now. Citing Bishop Herman College for instance;

Passing rate of Bishop Herman College students in Chemistry

Year	No. of students	No. of student per grade	
		A_1 - B_3	D_7 - F_9
2012	151	82	33
2013	339	207	20
2014	173	50	59

Many reasons were adduced to this poor performance in chemistry. According to Samba and Eriba (2012), Agogo (2003) and Agwai (2008), it is due to the abstract nature of chemistry concepts and concepts difficulty.

1.3 Purpose of the study

The main purpose of the study was to investigate the effect of computer simulations' instructional approach to the teaching and learning of chemical bonding on the performance of first year Senior High Students (SHS 1).

1.4 Objectives

The objectives of the study were as follows:

1. To determine students' content knowledge prior to the formal teaching of chemical bonding.

2. To determine the outcome of the use of Computer Simulations (CS) on students' cognitive achievement in chemical bonding.
3. To determine the effect of using Computer Simulations' instructional package on students' attitude towards chemistry after the teaching session.

1.5 Research Questions

The following research questions guided the study.

1. To what extent are the students' content knowledge levels prior to the formal teaching of chemical bonding?

2. What are students' cognitive achievements in chemical bonding when they are taught using computer simulations?

3. What are the effects of using Computer Simulations' Instructional package on students' attitude towards chemical bonding after the teaching session?

1.6 Hypotheses

The following null hypotheses (H_o) were tested in the study:

Ho 1. There is no statistically significant difference in the content knowledge of students prior to the teaching of chemical bonding.

Ho 2. There is no statistically significant difference between the cognitive achievements of the students taught using computer simulation and those taught without the computer simulations.

1.7 Significance of the Study

The outcome of this study will go a long way to enhance the teaching and learning of chemical bonding in Senior High Schools in Ghana. It will also enable students to visualize scientific concepts “dynamically and authentically” (Jackson, Krajcik & Soloway, 2000) and stir up their interest in chemistry.

The use of computer simulations would also bring to light possible misconceptions which when addressed would enhance students’ performance in their examinations. To curriculum developers and designers, the success in the use of computer simulations in the teaching and learning of chemical bonding would give them a new perspective in recommending its use across the educational system. The use of the computer simulations would also bring to light the best and modern pedagogical practices used by science teachers all over the world.

Furthermore, this study would serve as a reference document for the Ministry of Education (MoE), Ghana Education Service (GES), Curriculum Research and Development Division (CRDD) and other stakeholders associated with science education to make instructional changes in science education and empower them to push for the incorporation of appropriate computer simulation instructional packages in the teaching and learning of chemistry in Ghana. The MoE and GES would also have the empirical evidence to back any increased budgetary allocation that would be ear-marked for the procurement of the appropriate ICT facilities and software programmes to improve science (particularly chemistry) education in Ghanaian schools.

The research would also improve the state of resources available for science teaching and learning in senior high schools since the modules would be made available to any school that may be interested in them. Finally, it would serve as a base for other researchers who would wish to conduct research studies into the effects of the incorporation of computer simulation instructional packages on the teaching and learning of Chemistry.

1.8 Delimitations

Due to time constrain and scarcity of resources, this study was confined to Bishop Herman College in the Kpando Municipality in the Volta Region. It was also restricted to the use of computer simulations in the teaching of chemical bonding to the first year science students only, since chemical bonding is part of the first year chemistry syllabus and the students already have had some knowledge on bonding from Junior High School (JHS).

1.9 Limitations

According to Best and Kahn (1989), limitations are conditions beyond the control of the researcher that will place restrictions on the validity of the study. The results of the study were influenced by certain occurrences such as the respondents' preference to the use of computer simulations in teaching and learning. The outcome was also influenced by materials and time availability and learner's interest in chemical bonding and science as a whole.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Overview

The main purpose of this study is to enhance student's cognitive achievement on the concept of chemical bonding by using computer simulations. This chapter therefore reviewed literature related to the problem. The review focused on theoretical and empirical research done in the field of computer simulations in science education. The topical issues to be reviewed in the literature include the theoretical and conceptual frameworks of the study, which discusses among others the theories of Jean Piaget and Lev Vygotsky upon which the study shall be hinged.

The concept of computer simulations and the influence of the use of computer simulations in teaching science (especially chemistry), factors that may hinder the use of computer simulation instructional packages in teaching chemistry, factors that affect students' interest in chemistry, as well as the content of chemical bonding shall be reviewed in the literature.

2.1 Attitude of students towards teaching and learning of chemistry in SHS:

The role of chemistry in the development of the scientific base of a country cannot be overemphasized and Ghana is not an exception. Yet with the increasing importance of chemistry to the unfolding world, the performance of Ghanaian students in the subject at the Senior High School remains a dismal failure. However it is disappointing to note that the students' performance in chemistry at internal and external examinations has remained considerably poor despite the relative importance of chemistry (Saage, 2009). Several factors have been advanced that affect students' poor performance. Korau (2006) reported that such include the student factor, teacher factor, societal factor, the governmental infrastructural problem, language problem, examination body related variables, curriculum related variables, test related variables, textbook related variables and home related variables. Saage (2009) identified specific variables such as poor primary school background in science, lack of incentives for tests, lack of interest on the part of students, students not interested in hard work, incompetent teachers in the primary school science, large classes and fear of the subject psychologically. Korau (2006) observed that the schools' populations count in thousands today against the hundreds of the previous years. Students today are overcrowded in classrooms which make it impossible to talk of an ideal class size for effective teaching of chemistry. No effective teaching can take place under a chaotic situation where a teacher cannot handle the large number of students effectively.

Quantity and quality cannot work together and these can affect the students' learning of chemistry leading to their performance.

Johnstone (1993) asserted that students have difficulty in the acquisition of abstract scientific concept especially chemistry. Chemistry is one of the major aspects of science which students dislike. Research conducted in science education by Anamuah-Mensah and Apafo (1989) found that the conceptualization of the chemistry aspect of science is indeed difficult for learners of science. This assertion is true because many students have dislike for science mainly because of Chemistry.

The chemistry syllabus and content are other factors that contributed towards students' negative attitude towards chemistry. Students dislike science because of the amount of information they have to learn as well as the amount of time spent for writing in science classes (Ward, Roden, Hewlett & Foreman, 2005) as cited by Yunus and Ali (2013). According to Jegede (2007) and Edomwonyi-Otu and Avaa (2011), a lot of students said that chemistry syllabus is too broad for them to learn in a short time. Peers and other students can also influence the students' attitude in learning chemistry. Other students' opinions on chemistry can affect students' attitude in learning chemistry (Berg, Bergendahl, Lundberg & Tibell, 2003). If a majority of the students in a school have a poor attitude and opinions in chemistry, other students are likely to have the same reaction towards the subject.

Hence, the results of present studies showed that most of the students have a positive attitude towards learning chemistry when their teachers allow them to conduct chemistry experiments in the laboratory. Conversely, students do not show a positive attitude when they are asked to listen to what the teacher is teaching in front of them.

Yunus and Ali (2013) write:

> *"The most influential factor that contributed to students' positive attitude towards learning chemistry is when the teachers are an expert in the subject. It has been observed that students like it when their teachers share their knowledge and expertise about the lesson being taught. It is easier for students to ask for ideas, opinions and questions on the subject because they can get the answer back immediately. This can enhance the students' understanding in chemistry".*

2.2 Theoretical Framework of the Study:

The theoretical framework that underpinned the study was hinged on Jean Piaget's theory of cognitive development and Lev Vygotsky's social constructivism theory. To Piaget (1954), the cognitive development of children toward formal thought could be facilitated through three cognitive processes: assimilation, accommodation and reorganization or equilibration. According to Piaget (1954), when children assimilate, they perceive new objects and events according to their existing schemata, mental models or cognitive structures. The mental models of children, formed by their prior knowledge and experience, therefore, control how they incorporate new experiences and new information into their minds. This may occur when the new experiences of children are aligned with their existing schemata (mental models or internal representations of the world) or as a result of their failure to change a faulty understanding (Piaget, 1954). Sometimes, when children's experiences contradict their existing knowledge, internal representations, or schemata, they may change their perceptions of the experiences to fit their internal representations.

Accommodation however, results as children reframe or modify their existing schemata or mental representations of the external world to fit their new experiences for learning to occur (Piaget, 1954). Hence, as children exercise existing mental structures in particular environmental situations, accommodation-motivating disequilibrium results and the children construct new mental structures to resolve the disequilibrium (Piaget, 1954). The state of disequilibrium and contradiction arising between the existing schemata and the more sophisticated mode of thought adopted by the new experience therefore, has to be resolved via equilibrium process.

Equilibration maintains the balance between always taking in new knowledge, and always assimilating knowledge with previously gained knowledge. Knowledge is therefore, not a mirror of the world but is created or 'constructed' from the individual's continuous revision and reorganisation of cognitive structures in conjunction with experience (Piaget, 1954). Thus in the view of Piaget, students are actively involved in the construction of their own knowledge. It is therefore, argued that knowledge is constructed through action and that children must continually reconstruct their own understanding of phenomena through active reflection on objects and events till they eventually achieve an adult's perspective. Piaget (1952) hence posited that the process of intellectual and cognitive development is similar to a biological act, which is adaptation to environmental demands.

The work of Vygotsky (1978) provided the foundation for the application of sociocultural learning theory. This important theorist underscored the dynamic interdependence between the social and individual processes in learning. Vygotsky's work emphasized three major themes. First, he contended that cognitive development, including higher-order learning, is rooted in social interactions and mediated by abstract symbols, which he referred to as tools. Second, Vygotsky asserted that these tools are not created in isolation but rather are products of the sociocultural evolution of an actively involved individual. Third, Vygotsky viewed learning as a developmental or genetic process. This general genetic law of cultural development emphasized the importance of concentrating on the process by which higher functioning is established,

With such a strong link between sociocultural interaction and cognitive development, "the more knowledgeable other" place a key role in this feature (McLeod, 2007). The more knowledgeable other can be parents, adults, teachers, coaches, experts, professionals, other children, friends and even the technologies that we have today such as computers and computer simulations, cell phones and other gadgets or simply anyone who has a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. The requirement for the "more knowledgeable other" is linked to what Vygotsky defined intelligence as "the capacity to learn from instruction" (James, 2010), he believed that children's thinking is affected by their knowledge of the social community which is learnt from either technical or psychological cultural tools.

The use of tools in education influences students' learning and their learning process (Vygotsky, (1978)). In *Tool-mediated Learning* (Figure 1), the *learner* interacts with a *learning objective* (e.g., knowledge of conservation of energy), mediated by some tool (e.g., a computer simulation). While the learning objective is often content knowledge, it could also be scientific reasoning, enjoyment, community participation, or a combination of these (or other) goals.

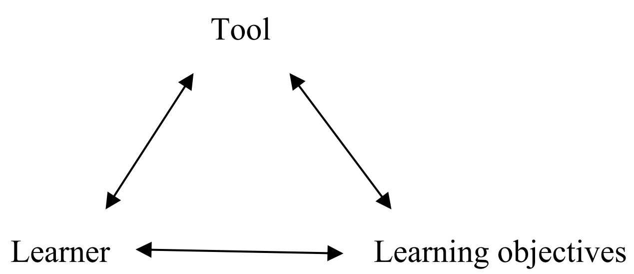


Fig. 1 Schematic diagram of tool-mediated learning

The design of the tool impacts how learners interact with the content, participate in learning activities and construct knowledge. As highlighted by Vygotsky (1978), the tools used in teaching and learning mediate how students engage with, perceive, and achieve the learning objectives (Figure 1). Simulations that employ well-designed implicit scaffolding provide a significant opportunity to mediate students' interaction with science learning objectives in new and powerful ways.

2.3 Concept of computer simulations

Simulation is the imitation of the operation of a real-world process or system over time. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviours or functions of the selected physical or abstract system or process.

Computer simulation therefore is a programme or simulation, run on a single computer, or a network of computers, to reproduce behaviour of a system.

2.3.1 Designing Computer Simulations:

The language in which a computer simulation is written and how many particles are simulated are only two of the many parameters to be chosen when designing and implementing a computer simulation. The overall process of determining the principles and characteristics that guide the design of a visualization tool is a difficult task, and it has been the focus of numerous research works (e.g. Chandler, 2004; Mayer, 2003; Rieber, Tzeng & Tribble, 2004; Wu & Shah, 2004).

In most of these, the high cognitive demands of learning from dynamic visualizations are pointed out, and the importance of basing the design of dynamic visualizations on existing theories of learning has become a central issue.

There are many learning theories of distinct natures; however, when addressing learning through multimedia and visualization tools. The Dual Coding Theory (Clark & Paivio, 1991) occupies a primary role. It is an empiric theory based on a major assumption called The Dual Channel Assumption. According to this assumption humans possess separate information processing systems for visual and verbal representations. This assumption has been supported also by cognitive science researches about the nature of human learning (e.g. Kozhevnikov, Hegarty & Mayer, 2002; Mayer, 2003). The Dual Channel

Theory defines two different kinds of links between the visual and verbal systems: **referential connections**, which join verbal and visual codes allowing operations such as imaging words and naming pictures; and **associative connections**, which join representations within verbal and nonverbal systems. Furthermore, it predicts that more and effective learning should result when information is encoded both visually and verbally, and connections are made between the visual and verbal codes (referential processing).

This prediction was reinforced by several further studies, which emphasize the crucial role of relating verbal and visual information (e.g. Clement, 2005; Mayer, 2003; Wu & Shah, 2004). Following these studies Rieber, Tzeng and Tribble (2004) investigated the role, timing and structure of explanations during an interactive computer-based simulation. They looked for "the right mix" between verbal and visual information to maximize referential processing and learning. Their results show that explanations should be on one hand brief enough so that they do not interrupt the interactive nature of the simulation, and on the other hand wide enough to provide sufficient guidance and opportunity for reflection. For example, students were found to learn more deeply when words are presented personally, in a conversational manner, rather than in a formal style (Mayer, 2003). In addition, the learning activities are designed according to the Predict-Observe-Explain (POE) model purposed by White and Gunstone (1992).

Students are first asked to **predict** what will happen in the simulation if some existing parameter or condition will be changed, and explain the reasons for such prediction. They then **observe** what happen in the simulation as a consequence of the change, and finally **explain** what they saw, whether or not it was in accordance with what they predicted, and

why they think it happened. This approach was shown to significantly improve the effectiveness of computer simulations (Zacharia, 2003).

2.3.2 Effects of computer simulations in science education:

Computer simulations have been given different meanings by different authors; however, in a broad sense, simulations are imitations of systems (Chung & Newman, 2000). Computer simulations are therefore computer-generated versions of real world objects. Computer simulations 'provide near-authentic environment, context and situation for task-based learning' (Chen, Nurkhamid, Wang, Yang, Lu, & Chang, 2013: 172).

Computer simulations have become a popular method of instruction in the last 15 years (Quellmalz, Timms, Silberglitt & Buckley, 2012; Donnelly, Reilly & McGarr, 2012) and this is because of commercially available software that is based on scientific and technological models which replicate actual situations.

In addition, Rutten, Joolingen & Van der Veen, (2012) who reviewed 51 articles from 2001 to 2010 show that traditional classroom can be improved by using computer simulations. These simulations enable learners to view events, processes and activities that otherwise may not have been available to them. Using computer simulations has been reported to increase learners' gains up to a maximum effect (Rutten et al., 2012; Donnelly et al., 2012) and other gains were reported by Howe, Devine and Tavares, (2013) where children worked in pairs rather than working individually.

Although at first, computer simulations were mainly used in applied fields such as aviation and medical imaging, these technologies have now edged their way into science

classrooms (Strangman & Hall, 2000; Kaheru, Mpeta & Krick, 2011; Quellmalz et al., 2012).

For example, demonstrating how chemical molecules and processes take place can be observed on a computer screen in many different forms, ranging from 3-dimensional geometric shapes to highly interactive, computerized laboratory experiments (Strangman & Hall, 2003).

Globally, many learners experience difficulties in understanding chemistry concepts because of the manner in which they are taught and as a result many learners form misconceptions in this regard (Özmen, 2009). In order to minimize these misconceptions, computer simulations are employed in science education (Akpan & Andre, 2000; Michael, 2001; Huppert, Lomask & Lazarowitz, 2002; Özmen, 2009). Studies from developed countries have mainly addressed three areas: conceptual change, skills development and content. Little is known about the effectiveness of computer simulations in developing countries. Available research indicates that computer simulations may bridge the gap between the concrete and the abstract world (Mintz, 1993). Gokhale (1996) believes that these virtual experiences could provide the learner with an opportunity to learn by doing. Furthermore, Gokhale supports the findings of Menn (1993) who stated that learners retained 90% of what they had learned using computer simulations. The concretization of objects, atoms, molecules and bacteria, for example, makes learning meaningful and appealing to real life situations.

Learning is an active process (Brown & Cocking, 2000; Mayer, 2009); students build knowledge from multiple resources (Hammer, Elby, Sherr, & Redish, 2005); and tools,

such as computer simulations, play a critical role mediating learning and knowing (di Sessa A. A., 2001; Vygotsky, 1978).

Many researchers and educational practitioners believe that Virtual reality (VR) technology has provided new insights to support education. Duffy and Jonassen (1992) claimed that today's educational technology practices should indeed be couched in the constructivist paradigm. This plays out in terms of developing systems that are situated in the real world as much as possible and are as experiential as possible. Sung and Ou (2002) reported that VR's capability to facilitate constructivist-learning activities is one of its key advantages. Therefore, as an experiential learning tool, virtual reality is an enactive knowledge-creation environment. Interactive learning environment by using animations and simulations for abstract topic, where students become active in their learning, provide opportunities for students to construct and understand difficult concepts more easily (Demirci, 2003). In this content, appropriate simulations and applications based on simulations generally increase learning speed by allowing students to express their real reactions easily (Karamustafaoglu, Aydin & Ozmen, 2005). Better designed simulations provide students opportunities to express their cognitive style and to choose from the computer screen. Such opportunities allow students to develop their own hypothesis about the topic and develop their own problem solving methods (Windschitl & Andre, 1998). According to Isman, Baytekin, Balkan, Horzum and Kiyici (2002), complex information given to students is simplified by technology and provides them opportunities to learning by doing.

Therefore, uses of simulation programs overcome some of the problems faced in traditional laboratory applications and make positive contributions in reaching the objectives of an educational system.

Winberg and Berg, (2007) developed a computer-simulated pre-lab, which aimed to prepare students cognitively to real lab activity about acid-base titration. As a result of their study, they concluded that the experimental group of students showed a positive attitude towards learning. According to Mintz (1993), one of the most promising computer applications in science instruction is the use of simulations for teaching concepts, which cannot be taught by conventional laboratory experimentation. But can a simulation be as effective as a conventional laboratory or replace it? For more than two decades, several studies have been done to see whether the computer simulation experiments or traditional laboratory experiments are effective on the students' achievement about science subjects. The answer would be that it depends on the concept or the situation.

For example, Kerr, Rynearson, and Kerr (2004) compared achievement among students instructed using hands-on Chemistry labs versus those instructed using virtual Chemistry labs (eLabs). They found out that there were no significant differences in achievement gain scores for the traditional versus the online students. They commented on that the findings obtained from their study demonstrated that students who completed the traditional, hands-on labs performed as well as students who completed the virtual labs. On the other hand, some other studies reported that computer simulation experiments are more effective (Douglas 1990; Lewis 1993; Greenbowe 1994; Russell et al. 1997, Svec & Anderson, 1995; Redish, Jeffery & Steinberg, 1997).

2.3.3 Barriers to the use of computer simulations in schools

The barriers to the use of computer simulations in schools especially science classes may be viewed from the following angles; some of the schools are not connected to the national grid therefore source of power to run the computers is a problem. In some cases, the power is readily available but the computers are not there in the schools. The teachers too are not innovative enough to get some of the free instructional simulations that are available on the internet these days, since they or the school cannot afford the commercial ones. This is due to the fact that some teachers are not ICT inclined. Moizer, Lean, Towler and Abbey (2009) summarize the barriers as follows:

2.3.3.1 Resource as a barrier

Resources used in support of teaching with simulations and games are both tangible and intangible in nature. *Tangible* resources would include finance, physical and technological infrastructure, materials and academic support services. A shortage of such resources may be regarded as a barrier to teaching and learning with simulations. More substantive resource barriers might be expected where computer-based simulation games are employed because of software costs and the requirement for technical support.

Intangible resources such as personal creativity and time for developing simulations and game to suit the lesson to be taught especially in cases where the commercially produced ones are not available or are expensive.

2.3.3.2 Risk as a barrier

Risk, in the context of teaching with simulations and games, relates to the unintended negative outcomes that might arise from employing such techniques. For example, lack of control over how students are engaged in the exercise, since some commercially produced simulations have music and some other videos to keep students attention in the lesson but this may rather take their attention away. Another example may be technical problem where the computer may not produce correct information during the process as a result of technology failure. Interest of students can also be seen as form of risk when teaching with simulations and games. According to Kumar and Lightner (2007: 57), some students learning with simulations and game may associate the learning process with 'childish' activities and therefore may not attach any seriousness to such lessons.

2.4 Background to chemical Bond formation

As the study of Chemistry begins, one of the exercises which give a lot of fascination and challenge to the young chemists is the writing of chemical symbols, formulae and equations; for instance, H for hydrogen atom, O for an oxygen atom and H_2O for a molecule of water. Chemical symbols, formulae and equations are very essential to the chemist. They represent information which would have needed many words. This saves time and provides easy communication of chemical knowledge. Chemical formulae are not created in the same haphazard manner that many names are chosen and given to humans. They are obtained from experiments. The tested common facts about the experiments are written down as chemical laws. Therefore, chemical formulae are based on chemical laws. A chemical formula is an expression of the results of experimental

work to find the amounts of elements which combine to form a compound and shows the ratio of the number of atoms of each element present in a unit of the compound. The study of the different amounts of elements that combine to form compounds and the different amounts of substances which react to form new substances is called stoichiometry (Ameyibor & Wiredu, 1999).

2.4.1 Bond type: 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. A covalent bond is a very strong attraction between two or more atoms that are sharing their electrons. In structural formulas, covalent bonds are represented by a line drawn between the symbols of the bonded atoms. Covalent compound is a compound made of molecules and not ions. The atoms in the compound are bound together by shared electrons which are also called a molecular compound (De Vos, Gebretnsae, Grayson, Harris, Roodt & Schreuder, 2012).

An Ionic bond is an attraction between ions of opposite charge. Potassium bromide consists of potassium ions (K^+) ionically bonded to bromide ions (Br^-). Unlike covalent bonds, ionic bond formation involves transfer of electrons, and ionic bonding is not directional. Ionic compound is a compound made of distinguishable cations and anions, held together by electrostatic forces.

Example of ionic bonding:

$$Na \qquad Na^{+} + e^{-}$$

$$Cl + e^{-} \qquad Cl^{-}$$

$$Na^{+} + Cl^{-} \qquad Na^{+}Cl^{-}$$

2.4.2 Molecular Formulae and IUPAC Naming

Molecular formula is a notation that indicates the type and number of atoms in a molecule. The molecular formula of glucose is $C_6H_{12}O_6$, which indicates that a molecule of glucose contains 6 atoms of carbon, 12 atoms of hydrogen, and 6 atoms of oxygen. International Union of Pure and Applied Chemistry (IUPAC) is an organization which sets international standards for chemical nomenclature, atomic weights, and the names of newly discovered elements. Common names of substances usually give no information about their chemical composition. Hence to describe the atomic makeup of compounds, chemists use systematic methods for naming compounds and for writing chemical formulas (De Vos, et al., 2012).

2.4.3 Chemical bonding in general

Chemical bonding in general is defined in several ways, for instance as: ‘forces that hold atoms together in stable geometrical configuration’ (Lagowski, 1997a); ‘forces that hold atoms of elements together in a compound’ (Silberberg, 2003); ‘strong attractive force that holds together atoms in molecules and crystalline salts’ (Parker, 1997); ‘an attractive force between atoms strong enough to permit the combined aggregate to function as a unit' (Lewis & Hawley 2007). These forces between particles (e.g. atoms) arise from electrostatic attractions between opposite charges and are labelled chemical bonding (Silberberg, 2003). The reasons for bonding to occur in general terms, are that bonding lower the potential energy between positive and negative particles, where the particles could be oppositely charges ions or atomic nuclei and the electrons between them (Silberberg, 2003).

Forces between molecules, *inter-molecular forces*, are in some education research literature (e.g. Taber & Coll, 2002) included as chemical bonding, but in some university literature they are not included (e.g. Atkins, 1994; Lagowski, 1997b; Lewis & Hawley, 2007; Parker, 1997; Silberberg, 2003). For instance, the inter-molecular forces are called *non-bonding forces* (Silberberg, 2003). According to Silberberg (2003), the forces breaking in chemical reaction are chemical bonding, bonding forces or intra-molecular forces, influence the chemical properties of the substance, and intermolecular forces influence the physical properties of the substance. According to Atkins (1994), intermolecular forces are the forces responsible for holding molecules together, and affect the structure of solids and properties of liquids and real gases.

2.4.4 Ionic bonding

In the university chemistry literature, the transfer of electrons from a metal to a non-metal is central when ionic bonding is explained (Silberberg, 2003; Parker, 1997; Chang, 2005). Silberberg describe this transfer as a central idea and a solid is formed when the resulting ions attract each other strongly. Parker describes ionic bonding as a type of bonding in which one or more electrons are transferred, and Atkins (1994) defines ionic bonding to be formed when one or more electrons are transferred from one atom to another. Chang defines ionic bonding as the electrostatic force that holds ions together in ionic compound, but use reactions in terms of transfer of electron to introduce ionic bonding. In contrast, this transfer is not central according to Lagowski (1997b) when ionic bonding is defined. Ionic bonding is defined as the result of electrostatic attraction between oppositely charged atoms or groups of atoms (Lagowski, 1997). Lagowski (1997) later on says that the charged particles in ionic compounds are ions. Lewis and Hawley (2007) defines ionic bonding as the result of electrostatic attraction between oppositely charged ions at one place, but refers to the transfer of electrons at another place. Atkins describes ionic bonding as one of the principal types of bond, in addition to covalent bonding, where the particles are hold together by Coulombic attraction between ions of opposite charge, and ionic bonding could be seen as 'a limiting case of a covalent bond between dissimilar atoms'.

The main-group element that forms mono-atomic ions are described to often attain filled outer levels, two or eight electrons, when forming mono-atomic ions, as the nearest noble gas (Silberberg, 2003). Ion formation requires energy, but a large amount of energy is released when the gaseous ions form a solid, called the lattice energy, also described as the enthalpy change when the gaseous ions form a solid (Silberberg, 2003). The lattice energy is also described as the energy required to overcome the attractive forces in an ionic compound (Lagowski, 1997b). The lattice energy depends on ionic size and charge, and can be calculated from the Born-Haber cycle

(Silberberg, 2003; Chang, 2005; Lagowski, 1997).

The importance of the lattice energy is pointed out by Chang (2005) and Lagowski (1997) when saying that the lattice energy determines the stability of the ionic compound, and by Silberberg: 'ionic solids exist only because the lattice energy drives the energetically unfavourable electron transfer'. Further, Lagowski points out that the stability is not determined by the electron configuration obtained when ions are formed.

The oppositely charged ions are held rigidly in position throughout the ionic lattice by strong electrostatic attractions (Silberberg, 2003; Lagowski, 1997b). This ionic lattice explains the properties of ionic solids: hard, rigid, brittle, and conduct electricity when melted or dissolved in water but not in the solid state (Silberberg, 2003; Lagowski, 1997).

2.4.5 Covalent bonding

The covalent bonding model not based on quantum mechanics is described in terms of sharing of electron pairs by two atoms, explained by the American chemist Lewis, G.N. in 1916, before quantum mechanics were established fully (Atkins, 1994). According to Lagowski (1997b), this model is simple but 'extremely reliable'. Covalent bonding was explained by Lewis as the sharing of electron pairs between two atomic centres, the electrons placed between them, with electrostatic force between the negative shared electrons and the positive nuclei (Lagowsk, 1997). Chang (2005) describes that 'each electron in a shared pair is attracted to the nuclei of both atoms' and this attraction is responsible for covalent bonds. The molecule became stable if the atoms in the molecule then had a complete octet of electrons, and the shared electron pair is described as 'the glue that bonds the atoms together by electrostatic interaction' (Lagowski, 1997). According to Silberberg (2003), covalent bonds occur when a shared pair of valence

electrons attracts the nuclei of two atoms and hold them together, filling each atom's outer shell. This attraction draws the atoms closer, and repulsion between the atoms' nuclei and electrons also occur. The covalent bond results from the balance between these attractions and repulsion, where the system has its minimum energy (Silberberg, 2003). Covalent bonding is also defined as a bond in which two electrons are shared by two atoms (Atkins, 1994; Chang, 2005) or by two atomic nuclei or a pair of atoms (Lewis & Hawley, 2007), or as a bond where 'each atom of a bound pair contributes one electron to form a pair of electron' (Parker, 1997).

2.4.5 Polar covalent bonding

Polar covalent bonding is described in terms of covalent bonding with unequally sharing of electrons. This unequally sharing of electrons between the atoms emerges when atoms with different electro negativities form a bond (Silberberg, 2003; Lagowski, 1997c) resulting in partially negative and positive poles of the bond (Silberberg, 2003), or that the electron density is shifted toward the more electronegative atom (Lagowski, 1997). The unequal sharing is also described to occur when the electron pair is held more closely by one of the atoms (Parker, 1997). Further reasons for the unequal sharing is that the electrons spend more time in the nearby region of one atom than the other, seen as a partial electron transfer or shift in electron density where the property electro negativity can be used to distinguish between non polar covalent bond and polar covalent bond (Chang, 2005).

Lewis and Hawley (2007) does not use the term polar covalent bonds, instead covalent bonds are said to range from evenly shared electrons, non-polar, to 'very unevenly

shared', extremely polar. According to Atkins (1994), a covalent bond is non-polar when the electron sharing is equal and polar when it is unequal. Valence-shell electron-pair repulsion (VSEPR) theory, are used to construct the molecular shape from Lewis structure. 'Each group of valence electrons around a central atom is located as far away as possible from the others in order to minimize repulsion' (Silberberg, 2003). A group is defined as any number of electrons that occupy a region around an atom, e.g. single, double or triple bound, or a lone pair. The three-dimensional arrangement of nuclei joined by the electron groups gives rise to the molecular shape.

A molecule with polar covalent bonds between the atoms and where the shape of the molecule leads to the molecule having a net imbalance of charge is called a polar molecule (Silberberg, 2003). According to Lagowski (1997c), polar covalent bonds impart to a molecule local densities of somewhat positive and negative charges of the molecule that 'contribute to the overall polarity or the dipole moment of the molecule' (p.1222). According to Chang (2005), a polar molecule is a molecule that has dipole moments, while Atkins (1994) define polar molecule as a molecule with permanent electric dipole moment.

2.4.6 Metallic bonding

Metallic bonding is explained in terms of the electron-sea model (Silberberg, 2003; Parker, 1997). In this model, the metallic lattice is described to consist of the atomic cores, seen as cations, surrounded by the metal atoms' delocalized valence electrons that form an 'electron sea'(Silberberg 2003), or immersed in a sea of delocalized electrons (Chang, 2005).

The electrons attract the metal cations together (Chang; Silberberg). There also exists models for metallic bonds in terms of electron-sea but without the term delocalized electrons and lack of the bond due to the attraction between cores and electrons. The metallic bond is then seen as the result of the sea of electrons free to move throughout the metallic lattice (Parker, 1997). Some literature do not use the term electron-sea, but similar to Silberberg, the metallic bonds are seen as the attraction between the atomic nuclei and the 'outer shell electrons' which are shared 'in a delocalized manner' (Lewis & Hawley, 2007).

2.4.7 Models of chemical bonding

Taber and Coll (2002) claimed that due to the way chemical bonding is taught, students over-generalise the limited teaching model 'the octet rule', and develop a common alternative conceptual framework, labeled the octet framework. This framework then influences the students' thoughts about bonding. Factors in the way chemical bonding is taught that can be seen as sources of developing the octet frame work are: use of the octet rule and focus on electronic configurations, a focus on separate atoms, lack of reason for why bonding occurs, anthropomorphic descriptions of chemical processes, and not pointing out that chemical bond is due to electrostatic forces (Taber & Coll, 2002). The authors argued that if there is a lack of discussion of why chemical reactions occur, it leads to an 'explanatory vacuum' and if the octet rule and focus on electronic configuration are used to present chemical bonding, the octet rule will be a feasible alternative explanation for why bonding occur. The fecundity of the octet rule depends on the students' conception that everything derives from and comprises of atoms. Therefore,

a focus on separate atoms regarding chemical reactions can be seen as a source for students to develop the octet frame work (Taber & Coll, 2002). Anthropomorphic descriptions of chemical processes might be the source for students to think that atoms have needs or wishes, a contribution to the development of the octet framework. Further, if anthropomorphic explanations are used habitually, they could shift from standing-in into taking the place of the explanation. Hence, students may not see a reason to develop more sophisticated explanations

(Taber & Coll, 2002; Taber & Watts, 1996). The octet framework can lead to the overall idea that students expect atoms wanting to have 'octets' or a 'full outer shell', and this is the reason for chemical processes to occur (Taber & Coll, 2002). The students then maintain an incorrect and inappropriate reason for why bonding occurs. For chemical bonding in general, research reports that it is common for students to use the right concept but wrong explanation and students are not able to provide a correct explanation for bonding phenomena and why bonding occurs (Nicoll, 2001). The source of this might be the absence of discussing the reason for why bonding occurs (Taber & Coll, 2002).

Additional sources of students' learning difficulties are proposed in the literature. For instance, if ionic bond is presented in terms of electron transfer, together with not presenting chemical bonding due to electrostatic forces, it could lead to the conception that ionic bonding is identified with electron transfer instead of electrostatic forces. Further, that ionic compound contains molecules and ionic bonds only exist between ions which had transferred electrons (Taber & Coll, 2002). The teaching model of covalent bonding as pairs of electrons shared by two atoms is the most common model used to explain covalent bonding. If covalent bonds are presented in terms of: electron sharing,

the octet rule, anthropomorphic descriptions and are not presented as due to electrostatic forces, it might give the students the alternative conception that the shared electron pair in itself *is* the bond and the electron pair hold the atoms together because they then receive a noble gas shell (Taber & Coll, 2002). Students commonly have difficulties to proceed further from the idea of the shared electron pair, which does not provide for progression (Taber, 2001; Taber & Watts, 2000). Presenting ionic and covalent bonding in terms of electron transfer and electron sharing in addition to the octet framework, possibly results in students discounting from bonding anything which does not fit the description of 'electron sharing' or 'electron transfer' (Taber & Coll, 2002). Regarding the concept of polar covalent bonding, Harrison and Treagust (1996) indicated that the bond polarity, shape of molecules and polarity of molecules are unclear to the students. The reason for this, according to Taber and Coll (2002) could be confusion over the understanding of electro negativity and presenting ionic and covalent bond as a dichotomy. The authors also suggested the latter as the reason for the fact that students tend to see bond polarity as a characteristic of the covalent bond instead of something in between ionic and covalent bonds. There are several research findings concerning the students' difficulties in appreciating lattice structure, which does not consist of molecules, for instance, ionic compounds, giant covalent lattice and metals. One source of this could be if these bonded non-molecular materials are presented as involving discrete molecules. And regarding metallic lattice, if the students are very influenced by the term 'sea of electrons' used in the scientific model of metallic bonding which is not based on quantum mechanics, they might conceptualize this sea as a vast excess of electrons, that actually would be charged and unstable (Taber, 2001). Another important

factor is the order of introducing the types of bonding. Teaching covalent bonding before ionic bonding is a common practice which could make students see ionic lattice as containing molecules, and moreover, students see all bonded materials as involving molecules (Taber & Coll, 2002)

CHAPTER THREE

METHODOLOGY

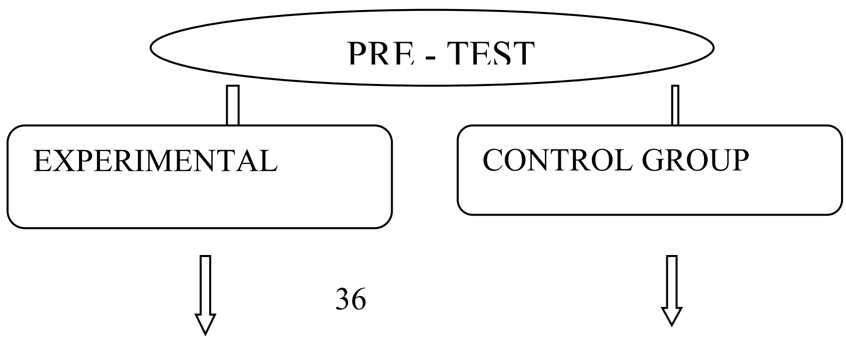
3.0 Overview

This chapter deals with the research design, population, sample and sampling technique, instrumentation, validation of instruments, reliability and method of data collection, data analysis and summary.

3.1 Research Design

The study made use of a Non-Randomized Quasi-Experimental pre-test and post-test control group design where students in the existing first year Science classes of Bishop Herman College were used. **There were two intact classes**, made up of 38 and 38 first year science students who were all taking Elective Chemistry, were used for the study. Both classes were given pre-test to determine their performance at the pre-intervention stage and the class with least mean mark was used as the experimental or treatment group while the other as the control group. After that, they were taught the same topics with the experimental group being exposed to the treatment whiles the control group was taught with different approaches of teaching such as lecture method. After the intervention, a post-test was given at the post-intervention stage.

Below is the flow chart of the design.



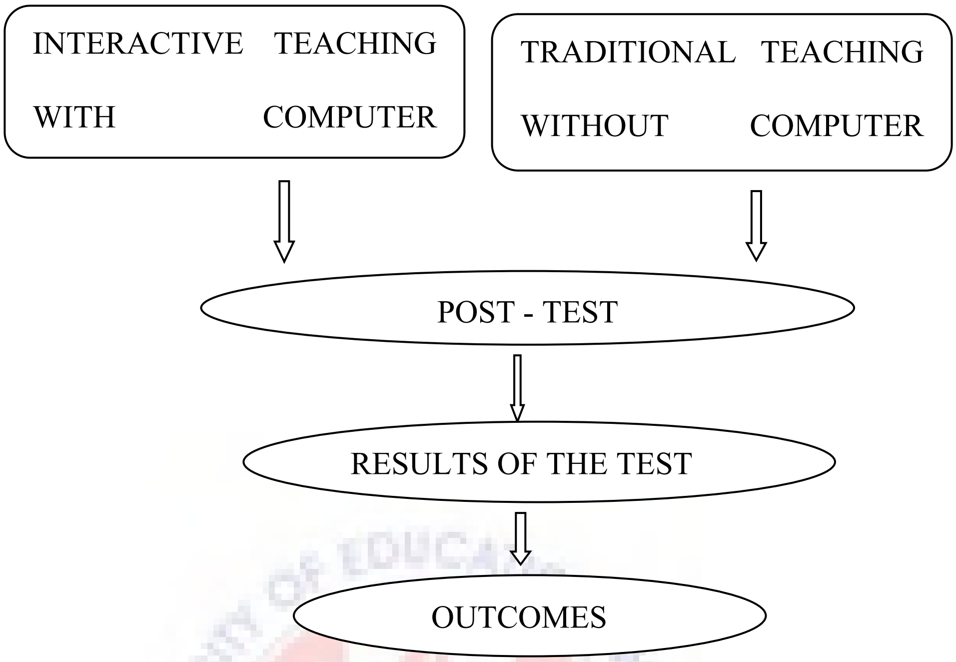


Figure 2. Flow chart of the Research Design.

3.2 Population of the Study

A research population is a large well-defined collection of individuals or objects having similar characteristics (Castillo, 2009). The accessible population of this study was all the seventy six (76) first year science students of Bishop Herman College in the Kpando Municipality of Volta Region.

3.3 Sample and Sampling Technique

The sample for the study was made up of two first year science intact classes of 38 and 38 students respectively. A pre-test was administered to the two classes. The results were analysed and the class with the lower mean mark served as the experimental group (EG) and the other with higher mean mark as the control group (CG).

Purposive sampling technique was used to select the sample for the study. Makhado (2002) supports the use of purposive sampling technique for quasi experimental design by stressing on the fact that it is important to select information rich case as this will help the researcher to address the purpose of the research. McMillan and Schumacher (2001) further recommended purposive sampling because the samples that are chosen are likely to be knowledgeable and well informed about the phenomenon the researcher is investigating. Purposive sampling may involve studying the entire population of some limited group.

3.4 Instruments

3.4.1 Development of Instruments

The instruments used were an achievement test which contained twenty multiple-choice test items and Opinionnaire for collecting data about the students after the intervention.

3.4.1.1 Test

According to Airasian (1991), a test is a formal, systematic, usually paper- and- pencil procedure for gathering information about pupil's behaviour. The test items were selected around the learning areas under the topic Chemical Bond (Atoms, Molecules and Compounds, Bond type, Molecular formulae & IUPAC naming, Intermolecular forces, Hybridization and shapes of molecules). The test items were adopted from the past final Chemistry examinations set by West African Examinations Council (WAEC: 1994 - 2006).

3.4.1.2 Opinionnaire

Opinionnaire is a type of data collection strategy used to measure the attitude or belief of an individual. It helps people to express their beliefs and feelings in the area of opinion.

Likert Scale is a **five** (or seven) point scale which is used to allow the individual to express how much they agree or disagree with a particular statement of an attitude, belief or judgement (McLeod, 2008). Opinionnaire was designed and used based on the purpose of the research.

The structured opinionnaire that was used for this study was adopted from Kotaka (2013) and slightly modified to suite this work. It was developed for only the experimental group. It had three sections namely section A, B and C. Section A sought the interest the of learners about chemical bond, while section B and C sought the attitude of learners towards the use of computer simulation and learning chemistry respectively.

For easy interpretation of the results, strongly agree (As) and agree (A) were identified as agree and disagree (DA) and strongly disagree (SD) as disagree (D). This gave a midpoint score of 3 which is the same as undecided (N).

3.5 Validity and Reliability of Instrument

3.5.1 Validation

Content validation was carried out by two chemistry teachers from Bishop Herman College who had 6 – 15years experience in the teaching of chemistry at SHS level. It was to ensure that the instruments were well structured, well planned and well organized based on the content of the learning area of the study. The test items were strictly based on Atoms, Molecules and Compounds, Molecular formulae, Bond type, oxidation numbers, Hybridization and IUPAC naming as the content of the Chemistry teaching syllabus demands.

3.5.2 Reliability

In most general terms, reliability is the extent to which data can be trusted to represent genuine rather than spurious phenomena. Joppe (2000) defines reliability as the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability. If the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable.

The instruments were pilot-tested for reliability using a different set of students at Kpando Secondary School, Kpando. The students used in the pilot were 20 second year science students, who had already completed the topic chemical bond. To ensure that the various measurement instruments utilized in the research were equivalent, it was necessary to perform the reliability test.

The Cronbach alpha Coefficient of Reliability value calculated for the opinionnaire was 0.827. This was in line with Gall, Borg and Gall (2007), suggestion that the coefficient of reliability values above 0.75 is considered reliable. Hence the instruments used for collecting data for this research work were reliable.

The internal consistency of the pre-test and post-test were high as the questions were adopted from the WASSCE past papers which means that they were set by experienced chemistry examiners, pre-tested and approved by WAEC (1994 - 2006).

3.6 Pilot Study

A pilot study was conducted to test the various instruments that were used in this research in order to detect any likely mistakes or oversights, and if questions were clear to the respondents and to determine the reliability as stipulated under instrumentation. Problems that arose during the piloting were sorted out by reframing any unclear questions, omitting some questions and merging questions that seemed similar. All the two instruments were found appropriate to obtain responses that would assist answer the questions of the study.

3.7 Method of Data Collection

The method of data collection was divided into three phases: pre- intervention/ treatment phase, intervention/ treatment phase and post- intervention phase.

3.7.1 Pre-Intervention phase

The pre-intervention involved the administration of the pre-test; it was administered to the targeted population. All the scripts were marked, recorded and the scores were collated for further processing.

3.7.2 Intervention/ Treatment phase

During the first week of the instruction, the researcher worked with the teachers in the ICT department of Bishop Herman College to install Computer Simulations' instructional packages from Sunflower and PhET on the computers at the school's ICT lab.

The control group was taken through the lessons in the classroom while the experimental group had the lesson at the ICT lab whenever they have chemistry on the time table during the research period. This was possible since the researcher is also a chemistry teacher in the same school.

The control group was taken through the various units of Chemical bond, (Ionic bond, Lewis dot structure, IUPAC naming, Covalent bond, Metallic bond, Hydrogen bond and Hybridization) under the section three (3) of the 2010 teaching syllabus for Chemistry.

The instruction was the traditional lecture method which is commonly used in most Ghanaian science classrooms and little amount of interaction between the researcher and the respondents through questions and answer without the use of any simulations.

The instruction of the experimental group was however based on constructivists approach developed from Ausubel's theory of learning. The constructivists' argue that students must be active participants and engaged in their own learning in order for meaningful learning to occur.

The experimental group was also taken through the same units under section three (3) of the syllabus just like the control group but they were guided by the researcher to manipulate the simulations on Chemical bond adopted from Sunflower and PhET instructional packages to construct their own knowledge based on the simulations, since each of them had a computer with pre-installed simulations in front of them.

The screen shots of the computer simulation instructional package for teaching chemical bond used by the experimental group can be seen at Appendix E

3.7.3 Post- Intervention/ Treatment phase

After the delivery of the lessons to the two groups by the researcher, the pre-test was reordered and administered as a post-test. This was to ensure that the level of difficulty for the post-test and the pre-test is maintained, and the tests being the same for the two groups.

The purpose of the post-test was to evaluate the achievements of the two groups after learning about Chemical Bond. The post-test was also marked for the two groups and the marks recorded. The respondents from the experimental group also answered a structured

Opinionnaire in order to answer research question three. The introductory meetings with the students, the administering of the pre-tests, the lesson presentations and the writing of the post-tests as well as responding to the opinionnaire took three weeks for the groups involved in the study as indicated earlier.

3.8 Data collection procedures

Test administered to the sample was conducted under the laid down regulations regarding the conduct of end of term examinations in Bishop Herman College. All test papers were collected, scored and the scores of both pre-test and post-test were collated, recorded and processed using SPSS version 16.0.

22 item Opinionnaire was given to the students in experimental group to enable them express their opinion on the use of computer instructional simulation package for teaching and learning chemical bond as well as chemistry in general, by registering the extent of their agreement or disagreement with a particular statement.

3.9 Method of Data Analysis

The data from this study is quantitative and was analyzed quantitatively using the Statistical package for Social Science (SPSS) version 16.0 for windows 2007, due to the fact that the research is based on the collection and analysis of numerical data which were obtained using tests. Also, existing classes were assigned to either group (control and treatment) as indicated under sampling. Scores of the pre-tests and the post-tests for the two groups were analyzed statistically using paired sample t-test on both pre-test and post-test scores to determine if there was any statistically significant difference at a selected probability level of 0.05 between the two groups. The researcher did not intend to compare both pre-tests and post-tests concurrently of the two groups. Nevertheless, the mean scores of the pre-tests and post-tests of the two groups were individually compared to ascertain their knowledge gains after the lessons.

The results from the Opinionnaire were also analyzed and discussed based on the various responses of the students. To analyzed the students' Opinionnaire, tables were used to highlight findings from the data collected and narrative explanations were used for the analysis.

3.10 Ethical Issues

Respondents were not forced into completing a questionnaire but were simply encouraged; but the decision whether to be involved and when to withdraw from the research was entirely theirs (Cohen, Marion & Morrison, 2007).

Therefore the involvement of the classes chosen was based on the following among others:

- ✓ Their informed consent.
- ✓ Their rights to withdraw at any stage of the program.
- ✓ Their right not to complete particular item(s) in the questionnaire.
- ✓ The guarantees that the research will not harm them.
- ✓ The guarantees of confidentiality in the research.
- ✓ Not committing to an act which might diminish their self-respect.

- ✓ Not being exposed to questions which may be experienced as stressful or upsetting.

3.11 Summary

The chapter described the methodology of the entire study. How the instruments were developed, as well as how data was collected and analyzed. It also dealt with validity, reliability and ethical issues.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.0 Overview

In this chapter, data is presented and analyzed to arrive at results and then the results discussed. The analysis is to help answer the three research questions which read as follows;

4.1 Analysis of Test Scores

The results from both the pre-test and the post-test were analyzed using statistical tool as already indicated earlier. The scores for the two tests of the two groups can be found in appendix B. The scores analyzed were the final marks of the two groups as they performed in each of the tests. A Statistical Package for Social Sciences (SPSS) version 16.0 was used to compute the mean, the standard deviation and the t-test that helped the researcher to determine the level of significance of the different performance of the students in the experimental and control groups. The researcher further used the mean scores of the two tests within each group in order to be able to compare the performance of the learners from pre-test to post-test

4.2 Presentation of results, analysis and discussion

4.2.1 Research question 1: To what extent are the students' content knowledge levels prior to the formal teaching of chemical bonding?

To answer this question, a pre-test was conducted before the treatment to establish whether or not the two groups were of the same ability or are comparable in terms of the topic Chemical Bonding before the treatment started.

Table 1: ***Frequency Distribution of Pre-test Scores of Students in the Control Group***

Scores	Frequency	Percentage (%)
0 – 5	0	0
6 – 10	9	23.7
11 – 15	15	39.5
16 – 20	14	36.8
TOTAL	38	100

The pre-test was scored over 40 marks as shown in appendix A. From Table 1 above, of the students scored between zero (0) and five (5). 9 participants scored between 6 and 10 representing 23.7%, 15 scored between 11 and 15 representing 39.5% while 14 students scored 16 and 20 representing 36.8%. This implies that the participant have some knowledge about chemical bonding from their Junior High Schools.

Table 2: ***Frequency Distribution of Pre-test Scores of Students in the Experimental Group***

Scores	Frequency	Percentage (%)
0 – 5	0	0
6 – 10	9	23.7
11 – 15	19	50
16 – 20	10	26.3

TOTAL	38	100

From the Table 2 above, none of the students in the experimental group scored between zero (0) and five (5). 9 students scored between 6 and 10 representing 23.7%, 19 participants had between 11 and 15 representing 50% and 10 students scored between 16 and 20 representing 26.3%. This is an indicative that majority of the participants in the experimental group had just a little idea about chemical bonding.

From Table 3 and 4 below, it was observed that the total number of participants involved in the research was 76, thus (38 for control and 38 for experimental group). The mean score and the standard deviations are, M = (14.26), S.D = 3.485) for the control group and M = (13.32), S.D = (2.722) for the experimental group. This implies that the participants have some knowledge on chemical bonding prior to the formal teaching session, with the mean of the control group slightly higher than that of experimental group as shown in Table 3 and 4 below.

Table 3: ***Mean scores of pre-test and post-test of the Control group:***

	Mean	N	Std. Deviation	Std. Error Mean
post-test	20.47	38	4.012	.651
pre-test	14.26	38	3.485	.565

Table 4: mean scores of pre-test and post-test of experimental group:

	Mean	N	Std. Deviation	Std. Error Mean
pre-test	13.32	38	2.722	.442
post-test	37.05	38	3.654	.593

Testing of Null Hypothesis One

Ho_1: There is no statistically significant difference in the content knowledge of students prior to the teaching of chemical bonding.

From Table 5 below, t (37) = 1.216, p = 0.232. If Sig (2-tailed) value or *p*-value is greater than 0.05, it can be concluded that there is no statistically significant difference between the two groups. Since $p > 0.05$, it implies that there is no statistically significant difference between participant in the experimental group and those in the control group even though the Control group recorded a slightly greater mean mark of 14.26 compared to the Experimental group who had a mean mark of 13.32 as shown in Table 3 and 4 above. Hence the Null hypothesis is sustained.

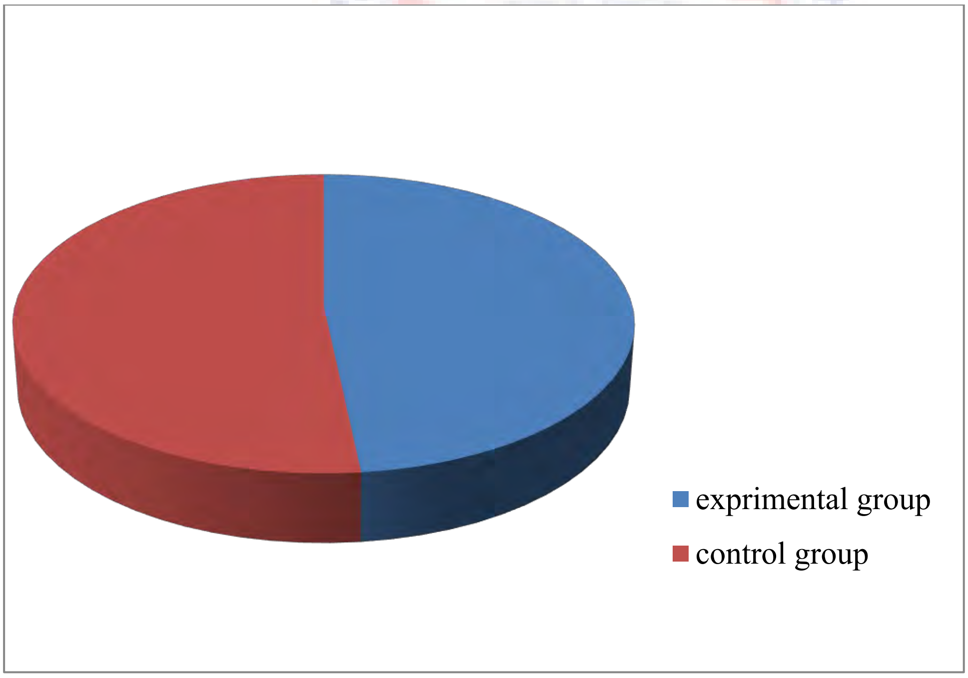


Fig 3: Distribution of mean marks of Pre-test Scores of Students in Experimental and Control Group

Table 5: ***Paired T-test Results of pre-test of Control and Experimental group***

	Mean	Std. Deviation	Std.Error Mean	t	df	Sig.(2-tailed)
Control group Experimental	.947	4.804	.779	1.216	37	.232*

* = Not Significant; $p > 0.05$

4.2.2 Research question Two: What are Students' cognitive achievements in chemical bonding when they are taught using Computer Simulations?

Table 6: ***Frequency Distribution of Post-test Scores of Students in the Control Group***

Scores	Frequency	Percentage (%)
0 – 5	0	0
6 – 10	0	0
11 – 15	1	2.6
16 – 20	25	65.8
21 – 25	7	18.4
26 – 30	5	13.2
TOTAL	38	100

From Table 6 above, 25 participants in the control group scored between 16 and 20 marks in the post- test representing 65.8% and only 5 students scored between 26 and 30 representing 13.2%. This implies that the students in the control group gained just a little knowledge after they were taught chemical bonding through the traditional method of teaching in most Ghanaian schools.

Table 7: ***Frequency Distribution of Post-test Scores of Students in the Experimental Group***

Scores	**Frequency**	**Percentage (%)**
16 – 20	0	0
21 – 25	0	0
26 – 30	6	15.8
31 – 35	0	0
36 – 40	32	84.2
TOTAL	38	100

Through careful observation of Table 7, it is revealed that only 6 participants, representing 15.8% scored between 26 and 30 marks in the post-test and 32 students representing 84.2% scored between 36 and 40 in the post-test.

From table 4, the mean score of the participant after they were taught chemical bonding using Computer Simulations was M = 37.05, S.D = 3.654 compared to the mean mark of the Control group's post-test score: M = 20.47, S.D = 4.012. This gives an indication of a mean mark difference of 23.73 for the Experimental group. From Table 3, it was found that the mean score difference between the pre-test and the post-test marks of the Control group is 6.21. This implies that the Control group made a slight gain in Knowledge after they were taught Chemical bonding without using Computer Simulations.

The mean score difference of 23.73 between the pre-test and post-test marks for the Experimental group is an indicative that the significant gain in knowledge was due to the use of the Computer Simulations in the teaching of Chemical bonding since there was no statistically significant difference the control and the experimental group before the treatment.

Testing of Null Hypothesis Two:

Ho: There is no statistically significant difference between the cognitive achievements of the students taught using computer simulation and those taught without the computer simulations.

A paired sample t-test was conducted to compare post-test scores of Experimental group and control groups. Table 8 shows that there was a statistically significant difference between the mean scores of the experimental group (M = 37.05, S.D = 3.654) and control (M = 20.47, S.D = 4.012); t(37) = -18.582, p = 0.000) group, since $p < .05$. The null hypothesis 2 which sought to find out whether there is any significant difference in cognitive achievement between the student taught through computer simulation and those taught without computer simulation was rejected at 0.05 significant levels. This means that the achievement in chemical bonding by the experimental group differ significantly. Furthermore, learners in the experimental group were much more motivated and showed enthusiasm and interest when taught using computer simulations. This is in line with Sanger (2000) who also reported in a study that computer simulations assist in improving conceptual understanding of science.

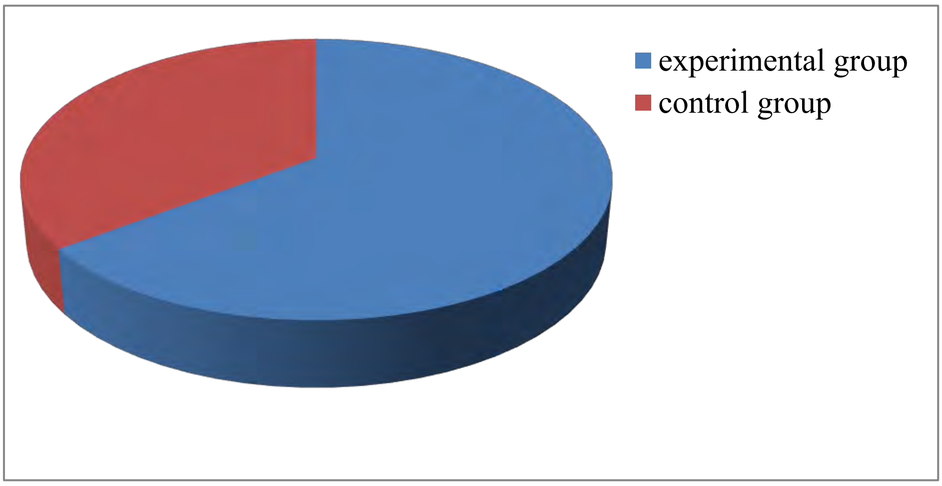


Fig 4: **Distribution of mean marks of Post-test Scores of Students in Experimental and Control Group**

Table 8: ***Paired sample T-test Results of post-test of control and experimental group***

	Mean	Std. Deviation	Std.Error Mean	t	df	Sig.(2-tailed)
Control group Experimental group	-16.579	5.500	.892	-18.582	37	.000*

* = Significant at $p < 0.05$

4.2.3 Analyzing the Responses to the Opinionnaire

The opinionnaire was meant to assess the responses of students in the experimental group in order to answer research question three. There were twenty two statements on a five-point Likert scale requiring students to indicate their opinions about chemical bonding, use of computer simulations instructional package and chemistry as subject.

The opinionnaire consisted of three Sections, **section A** sought to solicit the attitude of the students towards chemical bonding, S**ection B** is about the use of computer simulation instructional package and **Section C** sought the attitude of students towards chemistry.

4.2.4 Research question 3: What are the effects of using Computer Simulations' Instructional package on students' attitude towards chemical bonding after the teaching session?

From Table 9A, it can be deduced that the respondents have positive attitude towards the topic chemical bond. Specifically, for statement four: I find questions on the topic easy had a mean response of 4.00 which is an indicative of the positive attitude of respondent towards chemical bonding. Also for statement one: I find chemical bonding as a challenging and difficult topic; had a mean response of 2.66 which implies that the participants were not in agreement with the statement.

Statement two also had a mean response score of 2.18 giving an indication that the respondents were not in agreement with the statement that chemical bonding is too abstract.

Statement three which states that Chemical bonding lessons are boring, also had a mean response score of 2.39 which implies that the respondent did not see the topic to be boring but rather interesting. It can be observed again from Table 5A that respondents were neutral to some of the statements, specifically state eleven which states, Chemical bond topic should be removed from the syllabus, the respondents had a mean score of 3.21 on this question giving an indication they were neutral to the question.

Table 9A: ***Attitude of students in the experimental group towards chemical bonding***

	N	Mean	Std. Deviation
I find chemical bonding as a challenging and difficult topic.	38	2.68	1.254
Chemical bonding is too abstract.	38	2.18	1.087
Chemical bonding lessons are boring.	38	2.39	1.152
I find questions on the topic easy.	38	4.00	.615
The chemical bond topic was like a foreign language to me.	38	3.53	1.179
I like to learn chemical bonding more than any other topic.	38	4.26	.446
Learning chemical bond was so easy.	38	3.29	1.137
The content of chemical bond in the syllabus should be reduced.	38	2.71	1.228
I am confident that I learnt the chemical bond topic well.	38	3.84	.789
Chemical bond is an interesting topic.	38	4.08	.359

Table 9B shows that respondents had positive attitude towards the use of computer simulations' instructional package in teaching and learning chemical bonding. The means of the students' response to item one and two were 3.84 and 3.66 respectively.

Item three which reads; Simulation package helped me to improve upon my understanding of chemical bond, had a mean response of 4.34 indicating that the respondents have positive attitude towards the use of the computer simulations in teaching and learning chemical bonding.

Table 9B: ***Attitude of students in the experimental group towards the use of computer simulation***

Items	N	Mean	Std. Deviation
The simulation motivates me to understand chemical bond.	38	3.84	1.053
The software covered all the topics under chemical bond in the first year chemistry syllabus.	38	3.66	.815
Simulation package helped me to improve upon my understanding of chemical bond.	38	4.34	.534
It is time consuming to use computer simulations in learning chemistry.	38	3.03	1.150
I get confused during the learning of chemistry when the simulations are used.	38	3.32	1.254

Table 9C: ***Attitude of Students in the experimental group towards chemistry***

	N	Mean	Std. Deviation
Chemistry classes are interesting	38	3.87	.906
I don't like chemistry and it scares me to study it	38	2.84	1.103
Chemistry makes me feel uncomfortable, restless and impatient	38	2.58	1.106
I like chemistry more than other subjects	38	4.26	.644
I will study chemistry in my further education	38	3.63	.852
Valid N (listwise)	38		

The results from Table 9C above revealed that the participants in the experimental group have positive attitude towards chemistry. Specifically, item four in Table 9C seek to solicit the attitude of participant towards chemistry in relation to other subjects. This recorded a mean of 4.26 indicating that the participants have positive attitude towards chemistry and this could be due to the use of computer simulations during the teaching session. For item two and three, mean scores of 2.84 and 2.58 were respectively observed. This is an indicative that the participants did not agree with the two statements. It implies that the participants like chemistry and are comfortable studying it.

Table 10: ***students in experimental group's response to the Opinionnaire reorganized into agree and disagreed***

Item no.	SA 5	A 4	U 3	D 2	SD 1	Agreed (%)	Disagreed (%)
One	3	2	1	26	6	5 (13.2)	32 (84.2)
Two	11	17	2	8		28 (73)	8 (21)
Three	1	9	2	18	8	10 (26.3)	26 (68.4)
Four	5	30	1	2		35 (92.1)	2 (5.3)
Five	2	8	3	18	7	10 (26.3)	25 (65.8)
Six	5	10	2	21		15 (39.5)	21 (55.3)
Seven	10	28				38 (100)	0 (0)
Eight	3	20	2	11	2	23 (60.5)	13 (34.2)
Nine	7	14		17		21 (55.3)	17 (44.7)
Ten	5	26	3	4		31 (81.6)	4 (10.5)
Elven	1	15	1	17	4	16 (42.1)	21 (0.6)
Twelve	4	33	1			37 (97.4)	0 (0)
Thirteen	8	24		4	2	32 (84.2)	6 (15.7)
Fourteen	3	24	6	5		27 (71.1)	5 (13.2)
Fifteen			1	23	14	0 (0)	37 (97.4)
Sixteen	4	12	1	21		16 (42.1)	21 (55.3)
Seventeen	3	11		20	4	13 (34.2)	24 (63.2)
Eighteen		6		25	7	6 (15.8)	32 (84.2)
Nineteen	3	17	1	17		17 (44.7)	20 (52.6)
Twenty		13	1	19	5	13 (34.2)	24 (63.2)
Twenty one	13	23	1	1		36 (94.7)	1 (2.6)
Twenty two		6	5	24	3	6 (15.8)	27 (71.1)

From Table 10 above, 92.1% (35) of the participants in the experimental group agreed that they found questions on chemical bonding concept easy after the intervention. All the participants (100%) agreed to item seven (7) of the Opinionnaire that they would like to learn chemical bonding more than any other topic in chemistry.

It was also found out that 84.2% of the participants agreed that the simulation motivates them to understand chemical bond. Also, 27 participants representing 71.1% disagreed that they do have a feeling of dislike when the word "chemistry" is mentioned.

4.3 Discussion

The discussion is undertaken with respect to each of the three research questions.

Research Question 1: To what extent are the students' content knowledge levels prior to the formal teaching of chemical bonding?

Examination of Table 1, 2, 3 and 4 revealed that there is no statistical significant difference in the cognitive achievement between the students in the experimental group and that of those in the control group prior to the formal teaching of chemical bonding. This implies that students in both groups have similar knowledge level about chemical bonding from Junior High School.

Research Question 2: What are students' cognitive achievements in chemical bonding when they are taught using computer simulations?

Table 4 revealed that the mean mark for the experimental group's pre-test scores was 13.32 but after they were taught chemical bonding through the use of computer simulations instructional package, the mean mark for the post-test scores was 37.05, implying that the simulations had a lot of influence on the understanding of the students on the concept chemical bonding. It also motivated the students intrinsically to learn abstract concepts such as chemical bonding. This is in line with Cox (2000), who observed that computer simulations and visualization tools can serve as tools to help learners attain level of potential development because the simulation tools enable the learners to comprehend beyond what they ordinarily have been able to comprehend. Also according to Rutten et al. (2012) and Donnelly et al. (2012), using computer simulations increase learners' gains up to a maximum effect. It was also in line with the argument made by Miller (2001) that the use of technology in the classroom increases Knowledge and expands the understanding of learners. The findings also gave credence to Tavukcu (2008) who stated that computer-based learning approach in science training affect students' positively and improve students' scientific skills.

Research Question 3: What are the effects of using Computer Simulations' Instructional package on students' attitude towards chemical bonding after the teaching session?

Responses of students in Table 9 revealed that students generally have positive attitude toward chemical bonding. Students' results from the study indicated that they found lessons on chemical bonding interesting and they would like to study it more than any other topic. They also indicated that they found questions on chemical bonding easy to answer. These responses of students were in consonance with the findings of Hokanson and Hooper (2000) that students are expected to learn more through computer use, test scores can raise and students would learn at a faster rate. From Table 10, 94.7% of the participants in the experimental group agreed that they like chemistry more than any other subject.

CHAPTER FIVE

SUMMARY, CONLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

5.0 Overview

This chapter summarizes the findings in the entire research concerning the effects of using Computer Simulations to teach chemical bonding on the cognitive achievement of SHS one Students. This chapter also includes a conclusion derived from findings of the study. Additionally, the recommendations based on the findings of this study and suggestions for further studies have also been discussed in this chapter.

5.1 **Summary of Findings of the Study**

This section focuses on the summary of the major findings of this study. It deals with the summary of the differences in performance between: the experimental and control groups. From the study, the performance of the control group was slightly better than that of the experimental group at the pre-intervention stage but statistically there was no significant different in the performance of the two groups.

The performances of the experimental groups were significantly better than that of the control group at the post-intervention stage, signifying that SHS students exposed to the computer simulations instructional approach performed significantly better than their counterparts exposed to the traditional instructional approach. This indicates that the computer simulations instructional package appear to have a positive influence on students' understanding of the concept of chemical bonding. It was also observed that the students who were taught through the use of computer simulations instructional approach have positive attitude towards the use computer simulations instructional approach, chemical bonding and chemistry as a subject.

5.2 CONCLUSION

The results of the study imply that students exposed to the computer simulations instructional approach to the teaching and learning of chemical bonding performed significantly better than their counterparts exposed to the traditional instructional approach, this is line with what Kotoka (2013) also found in Her study. This research has shown that the use of computer simulations instructional approach has a great potential in turning around the poor performance of students in chemistry if it is used effectively.

Generally, the conclusion of the study was that computer simulations instructional approach had a positive effect on the cognitive achievement of the students in the experimental group.

Hence the study of the effect of the use of Computer Simulations in teaching chemical bonding on the achievement of students, revealed that for teaching and learning to take place effectively in chemistry lessons at Bishop Herman College and Ghanaian schools as a whole, integration of ICT in chemistry lessons should not be overlooked.

5.3 Recommendations

1 Innovative and more effective learner-centered instructional strategies, such as computer simulations instructional packages, should be used by chemistry teachers to promote meaningful learning of difficult chemistry concepts like chemical bonding. Appropriate computer simulations packages should therefore, be developed or adopted for use in the Ghanaian school systems.

2. Schools should purchase good computers along with projectors or large screen monitor and have them networked. This allows students participations using the available technology.

3. Curriculum planners and developers should be empowered by the findings of the study to introduce innovative instructional strategies, such as, computer simulations instructional approach, in the elective chemistry programme to encourage chemistry teachers incorporate computer simulations packages in their classroom instructions to enhance students' performance in chemistry.

4. The Ministry of Education (MoE), GES and other stakeholders involved in science education should organize regular workshops and in-service training sessions for chemistry teachers on the effective use of computer simulations instructional packages to enhance the effective application of the computer simulations instructional packages in the classroom.

5. The MoE, GES, CRDD and other stakeholders associated with science education should also push for structural modifications in science education to promote the use

of computer simulations instructional packages in the teaching and learning of chemistry at the SHS level.

5.4 Limitations of the study

The study should have covered all SHSs in the Kpando Municipality but due to financial and time constraints, it was limited to only Bishop Herman College where the researcher happens to be a chemistry teacher.

Also, due to the recent power crisis that the country is going through, the lesson with the experimental group was frequently interrupted by power outages; however, the researcher was able to take the participants through the intervention stage.

Last but not the least, the simulation software used was meant for teaching science, it was not tailored strictly according to the Ghanaian chemistry curriculum but had to be used to conduct the study as stated earlier.

5.5 Suggestions for further research

In light of the findings of the study and their educational implications, the following suggestions are made for further research with respect to the effect of the use of computer simulations on cognitive achievement of students at the SHS level:

1. It is suggested that the study be replicated using computer simulations instructional packages on other difficult chemistry concepts, such as, rate of chemical reactions, oxidation reduction reactions, chemistry of carbon (organic chemistry), etc.

2. The research was conducted in a single sex school, it is therefore suggested that further studies be carried out in a mixed school to determine the effect of the use of computer simulations instructional package on the gender of students.

3. The studies was limited to only Bishop Herman College in the Kpando Municipality, it is suggested that similar study be carried out in other schools in the Municipality and beyond to see whether similar results will be achieved

4. It is also suggested that the research should be carried out in Grade A, B, C and D schools to compare the effect of the use of computer simulations in teaching on the achievements of students in the above grade schools.

Reference

Agwai, V. (2008). Strategies for improving students interest in learning scientific concepts. *Journal of Research in Education, 2:225-230.*

Agogo, P.O. (2003). A practical guide to the teaching of difficult in Nigerian secondary school. *Knowledge Review: A Multi-disciplinary Journal, 6(3):32-34.*

Airasian, P.W. (1991). *Classroom assessment.* New York: McGraw-Hill.

Akpan, J. P., & Andre, T. (2000). Using a computer simulation before dissection to help student learn anatomy. *Journal of Computers in Mathematics and Science Teaching*, 19 (3), 297-313.

Ameyibor, K., & Wiredu, M. B. (1999). *Chemistry for Senior Secondary Schools* (2nd Ed.). Accra: Unimax Publishers Limited.

Anamuah-Mensah. & Apafo, N. (1989). Students' perceived difficulties with ordinary Level chemistry topics. *Chemistry and industry Proceedings, 38-39*

Atkins, P. W. (1994). *Physical chemistry* (5th ed.). Oxford: Oxford University Press.

Bayraktar, S. (2000). A Meta analysis study on effectiveness of computer assisted instruction in science education. Unpublished PhD dissertation presented to The Faculty of the College of Education University of Ohio, Colombia

Best, J.W., & Kahn , J.V. (1989). *Research in education.* New Delhi: Pergamon Press

Berg, C., Bergendahl, V., Lundberg, B. & Tibell, L. (2003). Benefiting from an open-ended experiment? A comparison of attitudes to, and outcomes of, an expository versus an open-inquiry version of the same experiment. *International Journal of Science Education,* 25*,* 351-372.

Brown, A. L., & Cocking, R. R. (2000). *How People Learn.* (J. D. Bransfford, Ed.) Washington, D.C.: National, J. M Academy Press.

Castillo, J.M. (2009). *A problem solving/Response to Intervention model as System. Communique,* 35(8), 34-40

Chalmers, A. (1998). Retracing the ancient steps to atomic theory. *Science & Education, 7*, 69-84.

Chandler, P. (2004). The crucial role of cognitive processes in the design of dynamic visualizations. *Learning and Instruction, 14*(3), 353-357.

Chang, R. (2005). *Chemistry* (8th ed.). Boston: McGraw-Hill.

Chen, G. D., Nurkhamid, N., Wang, C.Y., Yang, S.Y., Lu, W.Y., & Chang, C.K. (2013). Digital learning playground: Supporting authentic learning experiences in the classroom. *Int Learn Environs*, 38(2): 159–174.

Chung, C., & Newman, K.S.S. (2000). Computer Animations and Simulations in General Chemistry. From http://www.science.uwaterloo.ca/~cchieh/cact/trios/simulation.html (Retrieved on March 5, 2015).

Clark, J.M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review, 3*(3), 149-170.

Clement, J.M. (2005). Effectiveness of multimedia, was interactive Engagement Has Many Form. Discussion in an internet forum. Retrieved May 30, 2015, from http://www.physlrnr@listserv.boisestate.edu.

Cohen, L., Manion, L. & Morrison, K. (2007). *Research methods in education (6th ed)*. London: Routledge.

Cox, M. (2000). Information and Communications Technologies: their role and value for Science education. In M. Monk & J. Osborne, (Eds), *Good practice in science teaching – what research has to say.* Buckingham, England: Open University press.

Demirci, N. (2003). *Bilgisayarla etkili ogretme stratejileri ve fizik ogretimi*, Ankara: Nobel Yayincilik.

De Vos, E., Gebretnsae, S., Grayson, D., Harris, L., Roodt G., & Schreuder, B. (2012). *Platinum Physical Sciences. (CAPS edition).* Cape Town: Maskew Miller Longman. Pages 52-70.

di Sessa, A. A. (2001). *Changing Minds: Computers, Learning, and Literacy.* Cambridge: MIT Press.

Donnelly, D.O., Reilly, J., & McGarr, O. (2012). Enhancing the student experiment experience: Visible science inquiry through a virtual chemistry. *Res Sci Educ*, DOI10.1007/s11165- 1012-9322-1.

Douglas, J. E.. (1990). Visualization of electron clouds in atoms and molecules. *Journal of Chemical Education*, *67*, 42-44

Duffy, T., & Jonassen, R. (Eds.). (1992). *Constructivism and the technology of instruction: A conversation*. Hillsdale, NJ: Lawrence Erlbaum.

Edomwonyi-otu, L. & Avaa, A. (2011). The challenge of effective teaching of chemistry: A case study. *Leonardo Electronic Journal of Practices and Technologies,* 10 (18), 1-8.

Gaither, P. V. (2000). Interactive Software as a Tool for increasing student Comprehension of Basic Chemistry Concepts. Action Research Project: From Concept to Practice: Beginning Teachers' Reflection on the Education of Linguistically-Diverse Students, retrieved from < http://gse.gmu.edu/research/Imtip/vol2/> (30th August, 2014)

Gall, M.D., Borg, W.R., & Gall, J.P. (2007). *Educational Research*: *An introduction.* USA: Longman Publishers.

Gokhale, A.A. (1996). Effectiveness of computer simulation for enhancing higher order thinking. *J. Indusl Teach Educ,* 33(4): 36-46.

Greenbowe, T. (1994). An interactive multimedia software program for exploring electrochemical cells. *Journal of Chemical Education*, *71*, 555-557

Hammer, D., Elby, A., Sherr, R. E., & Redish, E. F. (2005). Resources, framing and transfer. In J. Mestre (Ed.), *Transfer of learning from a modern multidisciplinary perspective (pp. 89-120).Greenwhich, CT: Information Age Publishing*

Harrison, A. G., & Treagust, D. F. (1996). Secondary students' mental models of atoms and molecules: Implications for teaching chemistry. *Science Education*, *80(5)*, 509-534.

Hokanson, B., & Hooper, S. (2000). Computer as cognitive media: Defining the potential of computer in education. *Computers and Human Behaviour, 16(5), 537-552.*

Howe, C., Devine, A., Tavares, J.T. (2013). Supporting conceptual change in school science: A possible role for tacit understanding. *Int. Journal of Science Education*, 35(5): 864–883.

Hsu, Y.S. & Thomas, R. A. (2000). Research report; The impacts of a web-aided instructional simulation on science learning. *International Journal of Science Education, 24(9), 955-979*

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

İsman, A., Baytekin, C., Balkan, F., Horzum, B., & Kiyici, M. (2002). Fen bilgisi egitimi ve yaklasim. *The Turkish Online Journal of Educational Technology – TOJET*, 1(1), Article 7.

Jackson, S., Krajcit, J., & Soloway, E. (2000). Model-IT: A Design Retrospective. In Jacobson, M. & Kozman, R. (Eds.), Advanced designs For the Technologies of Learning: Innovations in Science and Mathematics Education. Hillsdale, NJ: Erlbaum.

James, S. (2010). Psycho Hawhs. Retrieved July 20, 2015, from https://www.psychohawks.wordpress.com/2010/11/3/theories-of-cognitive-development- -vygotsky.html lev

Jegede, S. A. (2007). Students' anxiety towards the learning of Chemistry in some Nigerian secondary schools. *Educational Research and Review,* 2 (7), 193-197.

Johnstone, A.H. (1993). The development of chemistry teaching. *Journal of Chemical Education, 70*, 701-705.

Joppe, M. (2000). *The research Process.* Retrieved July 15, 2015, from

http://www.ryerson.ca/-mjoppe/rp.htm

Kaheru, S. J., Mpeta, M., & Kriek, J. (2011). The use of interactive computer simulations with regard to access to Education– a social justice issue. *J Educ Stud,* 10(2): 89-106.

Karamustafaoglu, O., Aydin, M., & Ozmen, H., (2005). Bilgisayar destekli fizik etkinliklerinin ogrenci kazanimlarina etkisi: basit harmonik hareket ornegi. *The Turkish Online Journal of Educational Technology – TOJET.* 4 (4) Article 10

Kerr, M. S., Rynearson, K., & Kerr, M. C. (2004).Innovative educational practice: using virtual labs in the secondary classroom, *The Journal of Educators Online*, 1(1), 1-9

Koch, J. (2005). *Science stories: science methods for elementary and middle school teachers.* (3rd ed.) New York: Houghton Miffin Company.

Korau, Y.K. (2006). Educational Crises Facing Nigerian Secondary Schools and Possible Solutions being a paper presented at Faculty of Education, University of Ibadan

Kotoka, L. (2013). *Effect of Computer simulation on teaching of Atomic Combinations to Grade 11 Physical Science learners*: Unpublished Master of Science Dissertation, presented to The faculty of Mathematics, Science & Technology Education. University of South Africa.

Kozhevnikov, M., Hegarty, M., & Mayer, R.E. (2002). Revising the visualizerverbalizer dimension: Evidence for two types of visualizers. *Cognition & Instruction, 20*(1), 47-77.

Kumar, R. and Lightner, R. (2007) 'Games as an Interactive Classroom Technique: Perceptions of Corporate Trainers, College Instructors and Students', *International Journal of Teaching and Learning in Higher Education*, 19(1): 53–63.

Lagowski, J. J. (Ed.). (1997a). *Macmillan encyclopedia of chemistry: Vol. 1.* New York, NY: Macmillan Reference USA.

Lagowski, J. J. (Ed.). (1997b). *Macmillan encyclopedia of chemistry: Vol. 2.* New York, NY: Macmillan Reference USA.

Lagowski, J. J. (Ed.). (1997c). *Macmillan encyclopedia of chemistry: Vol. 3.* New York, NY: Macmillan Reference USA.

Lewis, N. S. (1993). The caltech chemistry animation project. *Journal of Chemical Education*, *70*, 739-740.

Lewis, R. J., & Hawley, G. G. (Eds.). (2007). *Hawley's condensed chemical dictionary* (15th ed.). Chichester: Wiley.

Makhado, N. D. (2002). *Challenges educators experiences in the provision of Environmental education at schools in curriculum 2005.* Johannesburg: Rand Afrikaans University.

Mayer, R. E. (2009). *Multimedia Learning (*2nd ed.*)*.New York: Cambridge University Press.

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

McLeod, S.A. (2008). *Simply Psychology: Likert Scale.* Retrieved July 20, 2015, from http://www.simplypsychology.org/likert-scale.html

McLeod, S.A. (2007). Simply psychology; Lev Vygotsky. Retrieved 15 July 2015, from http://www.simplypsychology.org/Vygotsky.html

McMillan, J.H., & Schumacher, S. (2001). *Research in education: a conceptual introduction (5th ed.).* New York, London.

Menn, D. (1993). Multimedia in education. *PC World*, M52-M60

Michael, K.Y. (2001). The effect of a computer simulation activity versus a hands-on activity on product creativity in technology education. *Journal of Technology Education,* 13(1): 31-43.

Ministry of Education, (2010).Teaching Syllabus for Chemistry (SHS 1-3), Accra, Ghana: Curriculum Research and Development Division.

Ministry of Education, Youth and Sports (MESS) (2004). *White Paper on Report of the Educational Reform Review Committee.* Accra; Ministry of Education, Youth and Sports. Accra, Ghana

Miller, S. (2001). Technology: *What's it good for. Learning and Learning With Technology, 28(6), 42-45.*

Mintz, R. (1993). Computerized simulation as an inquiry tool. *School Science and Mathematics, 93*(2), 76-80.

Moizer, J., Lean, J., Tower, M., & Abbey, C. (2009). Simulation and games: Overcoming the barriers to their use in higher education. *Active Learning in Higher Education, 10(3), 207-224.*

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

Ozdener, N., & Sayin, H. (2004). Evaluation of an education software developed for macromedia flash education in terms of integrity and the methods used, *The Turkish Online Journal of Education Technology, Volume 3, Issue 2, Article 24.*

Özmen, H. (2009). The effects of conceptual change texts accompanied with animations on overcoming 11th grade students' alternative conceptions of chemical bonding. *Comp and Educ*, 52(3): 681–695

Parker, S.P. (Ed.) (1997). *McGraw-Hill dictionary of chemistry*. New York, NY: McGraw-Hill.

Piaget, J. (1954). *The Construction of Reality in the Child*. New York: Basic Books. (Original French education, 1937)

Piaget, J. (1952). The origins of intelligence in children. New York: International Universities Press.

Pollard, A.,Triggs, P., Broadfoot, P., McNess, E. & Osborn, M. (2000). *What Pupils Say: Changing Policy and Practice in Primary Education.* London: Continuum.

Quellmalz, E., Timms, M., Silberglitt, M., & Buckley, B. (2012). Science assessment for all: Integrating science simulations into balanced state science assessment systems. *J of Res Sci Teach*, 49(3): 363-393.

Redish, F. E., Jeffery S. M., & Steinberg R. N. (1997). *On the effectiveness of active engagement microcomputer based laboratories.* Department of Physics, University of Maryland College Park, MD20742

Rieber, L.P., Tzeng, S.C., & Tribble, K. (2004). Discovery learning, representation, and explanation within a computer based simulation: Finding the right mix. *Learning and Instruction, 14*(3) 307-323.

Roach, R. (2003). Penn State Researcher Touts Simulation Software As Effective Teaching Tool. *Black Issues in Higher Education*; 14, 20, 13. Academic Research Library, p. 30.

Russell, J. W., Kozma, R. B., Jones, T., Wykoff, J., Marx, N., & Davis, J. (1997). Use of simultaneous-synchronized macroscopic, microscopic, and symbolic representations to enhance the teaching and learning of chemical concepts. *Journal of Chemical Education*, *74*, 330-334.

Rutten, N., van Joolingen, W. R., & van der Veen, J. T. (2012). The learning effects of Computer simulations in Science education. *Computers & Education,* 58(1), 136–153.

Saage, O. (2009). Causes of Mass Failures in Mathematics Examination among Students, A Commissioned Paper presented at Government Secondary School. Karu Abuja.

Sahin, S. (2006). Computer simulation in science education: implications for distance education, *Turkish online Journal of Distance Education*-TOJDE, 7(12), 132-146

Samba, R.M.O. & Eriba, J.O. (2012). Background information on teaching difficult science concepts. In Samba RMO and Eriba JO. (Eds). Innovative Approaches in teaching difficult science concepts (pp.15) Makurdi, Nigeria: Destiny Ventures.

Sanger, M. J. (2000). Using particulate drawings to determine and improve Students' conceptions of Pure substances and Mixtures. *Journal of Chemical Education,* 77, 762-766.

Silberberg, M. S. (2003). *Chemistry: The molecular nature of matter and change*. New York, NY: McGraw-Hill Higher Education

Strangman, N., & Hall, T. (2003). Virtual Reality/Simulations. Wakefield, MA: National Center Accessing the General Curriculum. From <http://www.cast.org/ publications/ncac/ ncac_vr.html> (Retrieved on June13, 2015)

Strangman, N., & Hall, T. (2000). Background knowledge. Retrieved: July3, 2015, from http://www.cast.org/system/galleries/download/ncac/ncac BK.pdf

Sung, W. T., & Ou, S, C (2002). Learning computer graphics using virtual reality technologies based on constructivism – case study of the web-degrator system. *Interactive Learning Environments*, 10(3), 177–197

Svec, M., T., & Anderson, H., (1995). Effect of microcomputer-based laboratory on students graphing interpretation skills and conceptual understanding of motion. *Dissertation Abstracts International*, 55(8), 2338-A.

Taber, K. S. (2001). Building the structural concepts of chemistry: some considerations from educational research. *Chemistry Education: Research and Practice in Europe, 2*(2), 123-158

Taber, K. S., & Coll, R. (2002). Bonding. In J. K. Gilbert, O. D. Jong, R. Justy, D. F., Treagust, & J. H. Van Driel (Eds.), *Chemical education: Towards research based practice* (pp. 213-234). Dordrecht: Kluwer

Taber, K. S., & Watts, M. (1996). The secret life of the chemical bond: students' anthropomorphic and animistic references to bonding. *International Journal of Science Education, 18*(5), 557-568.

Taber, K. S., & Watts, M. (2000). Learners' explanation for chemical phenomena. *Chemistry Education Research and Practice, 1*(3), 329-353.

Tavukcu, F. (2008). Fen Egitiminde bilgisayar Destekli Ogrenme Ortaninin Ogrencilerin Akademik Basari, Bilimsel Surec Becerileri ve Bilgisayar Kullanmaya Yonelik Tunuma Etkisi. Yayinlanmis Yuksek Lisans Tezi. TKU Sosyal Bilimler Enstitusu.

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

White, R., & Gunstone, R. (1992). Probing understanding. *London and New York: The Falmer Press.*

Winberg, T.M., Berg, C.A.R. (2007). Students' Cognitive Focus During a Chemistry Laboratory: Effects of a Computer-Simulation Prelab. *Journal of Research in Science Teaching.* 44(8), p.1108-1133

Windschitl, M., & Andre, T. (1998). Using computer simulations to enhance conceptual change; The roles of the constructivist instruction and student epistemological beliefs. *Journal of Research in Science Teaching. 35,145-160*

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

Yunus, F.W., & Ali, Z. M. (2013). Attitude towards Learning Chemistry among Secondary School Students in Malaysia. *Journal of Asian behavioural studies, vol.3, no.11, July/August 2013.* Retrieved: February 20, 2015 <http://www.myjurnal.my/public/issue- view.php?id=4318&journal_id=279

Zacharia, Z. C., & Anderson, O. R. (2003). The effects of an interactive computer-based simulation prior to performing a laboratory inquiry-based experiment on students' conceptual understanding of physics. *American Journal of Physics*, 71,618-629.

APPENDIX A

PRE-TEST ON CHEMICAL BONDING

40 MARKS

BISHOP HERMAN COLLEGE, KPANDO

S/NO. …………………… Date: ………………………..Class: ……

Duration: 40min.

Part l: Multiple choices (2 Marks each)

INSTRUCTION: Circle the letter that best completes the statement or answers the question.

1. What is the name of the ion HCO_3^-?

   a. Hydrogen carbon oxide

   b. Hydrogen carbon trioxide

   c. Hydrogen carbon oxygen

   d. Hydrogen carbonate ion

2. In the Lewis structure, what do the dots represents?

   a. Protons

   b. Neutrons

   c. Valence electrons

   d. Shell

3. Which of the following is an example of a diatomic molecule?

   a. HCl

   b. Br_2

c. CO

d. NaCl

4. Which of the following has the greatest electronegativity?

a. H

b. Cl

c. O

d. F

5. Which one of the following is NOT true about elements that form cations?

a. The atoms lose electrons in forming ions

b. The elements are metals

c. They are located to the left of the periodic table

d. They have high electron affinities

6. Which of the following pairs of atoms are least likely to form an ionic compound?

a. Ni, O

b. Na, F

c. Cu, Cl

d. Li, Mg

7. What kind of bond results when electron transfer occurs between atoms of two different elements?

a. Ionic

b. Covalent

c. Nonpolar

d. Single

8. What is the correct formula of phosphorus pentachloride?

a. PCl_3

b. PCl_5

c. P_2Cl_5

d. P_5Cl

9. The nucleus is very ________ compared to the atom as a whole.

a. small

b. large

c. similar

d. light

10. All of the following are examples of compounds except …?

a. table salt, NaCl

b. vinegar, H_3COOH

c. ozone, O_3

d. laughing gas, N_2O

11. Write the formula of sodium carbonate.

a. NaCO

b. $NaCO_3$

c. Na_2CO

d. Na_2CO_3

12. Which type of bond would you expect to find when two non-metals are combined?

a. Covalent bond

b. Ionic bond

c. Physical bond

d. Metallic bond

13. What are the two principal types of bonding called?

a. Ionic bonding and covalent bonding

b. Ionic bonding and polar bonding

c. Metallic, ionic and covalent bonding

d. Polar bonding and covalent bonding

14. Write the chemical formula of sodium phosphate.

a. Na_3PO

b. Na_3PO_4

c. Na_4PO_3

d. $NaPO_4$

15. Name the two classes of element which are most likely to form an ionic compound if they are allowed to react with each other.

a. Metal and metal

b. Metal and non-metal

c. Non-metal and non-metal

d. Semimetal and non-metal

16. What is the name of Cu_2O?

a. Sodium phosphate

b. Copper (II) oxide

c. Copper dioxide

d. Copper (I) oxide

17. What is the oxidation number of Mn in $KMnO_4$?

a. + 5

b. + 6

c. + 7

d. + 8

18. Provide the name of CCl_4.

a. Carbon Chloride

b. Carbon (IV) Chloride

c. Carbon tetrachloride

d. Carbon Chloride tetra

19. Give the formula of the compound whose name is Dinitrogen pentoxide.

a. N_2O

b. N_2O_5

c. NO_5

d. N_5O_2

20. Which of the following best describes a covalent bond?

a. Transfer of electrons from one type of atom to another

b. The attraction between a positive ion and a negative ion

c. Sharing of a pair of electrons between two atoms

d. Gravitational force between the nuclei of two atoms

APPENDIX B

POST-TEST ON CHEMICAL BONDING

40 MARKS

BISHOP HERMAN COLLEGE, KPANDO

S/NO. …………………… Date: ………………………..Class: ……

Duration: 40min.

Part l: Multiple choices (2 Marks each)

INSTRUCTION: Circle the letter that best completes the statement or answers the question.

1. Which of the following is a condition for ionic bond formation?

    a. High ionization energy

    b. Low electron affinity

    c. Low ionization energy

    d. Small size of cation

2. An ionic compound formed between calcium and fluorine can be represented as

    a. CaF

    b. CaF_2

    c. Ca_2F

    d. Ca_2F_2

3. Which of the following is an example of a diatomic molecule?

    a. HCl

    b. Br_2

c. CO

d. NaCl

4. Which of the following has the greatest electronegativity?

a. H

b. Cl

c. O

d. F

5. If the oxidation number of an element X is +3, what is the formula of its oxide?

a. X_3O

b. X_3O_4

c. X_3O_2

d. X_2O_3

6. Which of the following pairs of atoms are least likely to form an ionic compound?

a. Ni, O

b. Na, F

c. Cu, Cl

d. Li, Mg

7. What kind of bond results when electron transfer occurs between atoms of two different elements?

a. Ionic

b. Covalent

c. Nonpolar

d. Single

8. In which of the following chlorides is the bonding covalent?

a. CCl_4

b. NaCl

c. $MgCl_2$

d. $ZnCl_2$

9. The nucleus is very ________ compared to the atom as a whole.

a. small

b. large

c. similar

d. light

10. All of the following are examples of compounds except …?

a. table salt, NaCl

b. vinegar, H_3COOH

c. ozone, O_3

d. laughing gas, N_2O

11. Write the formula of sodium carbonate.

a. NaCO

b. $NaCO_3$

c. Na_2CO

d. Na_2CO_3

12. A chemical bonding in which both shared pairs of electrons are provided by only one of the atoms is

a. Covalent

b. Dative

c. Electrovalent

d. Metallic

13. What are the two principal types of bonding called?

a. Ionic bonding and covalent bonding

b. Ionic bonding and polar bonding

c. Metallic, ionic and covalent bonding

d. Polar bonding and covalent bonding

14. The most polar of the following bond is

a. H-Cl

b. H-F

c. H-Br

d. H-I

15. Name the two classes of element which are most likely to form an ionic compound if they are allowed to react with each other.

a. Metal and metal

b. Metal and non-metal

c. Non-metal and non-metal

d. Semimetal and non-metal

16. What is the name of Cu_2O?

a. Sodium phosphate

b. Copper (II) oxide

c. Copper dioxide

d. Copper (I) oxide

17. What is the oxidation number of Mn in $KMnO_4$?

a. + 5

b. + 6

c. + 7

d. + 8

18. The two types of bonds in NH_4Cl are

a. Covalent and ionic

b. Co-ordinate and covalent

c. Metallic and ionic

d. Polar covalent and ionic

19. Give the formula of the compound whose name is Dinitrogen pentoxide.

a. N_2O

b. N_2O_5

c. NO_5

d. N_5O_2

20. Which of the following pairs of molecules can form hydrogen bonds?

a. C_2H_5OH and H_2O

b. H_2O and HCl

c. CH_4 and H_2S

d. NH_3 and HCl

APPENDIX C

Answers to pre-test and post-test items

Pre-test

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

Post-test

1	C	11	D

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

APPENDIX D

OPINIONNAIRE FOR THE EXPERIMENTAL GROUP (EG) ON USING COMPUTER SIMULATIONS IN TEACHING CHEMISTRY

Please responses from this opinionnaire are intended for academic use only. Your answers to the statements will be treated confidentially. Thank you.

Class…….

Instruction: please rate how strongly you agree or disagree with each of the following statements by placing a check (√) mark in the appropriate box.

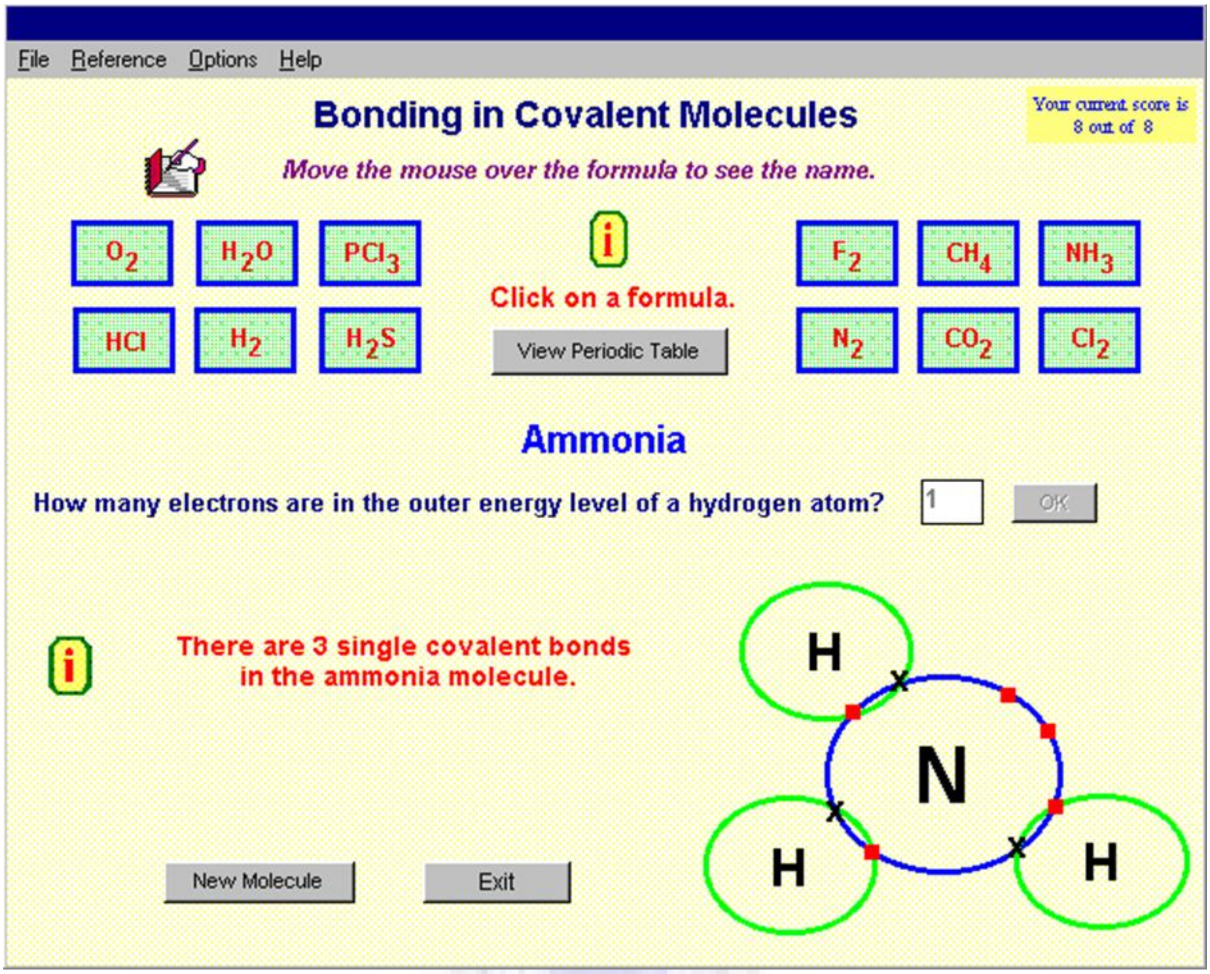
Strongly agree = SA, Agree = A, Undecided = U, Disagree = D, Strongly disagree =SD.

ITEM	SA	A	U	D	SD
A. **Attitude towards chemical bond** 1. I find chemical bonding as a challenging and difficult topic.					
2. Chemical bonding is too abstract.					
3. Chemical bonding lessons are boring.					
4. I find questions on the topic easy to pass					
5. The chemical bond topic was like a foreign language to me.					
6. Chemical bond is one of the difficult topics in the syllabus.					
7. I like to learn chemical bonding more than any other topic.					
8. Learning chemical bond was so easy.					
9. The content of chemical bond in the syllabus should be reduced					
10. I am confident that I learnt the chemical bond topic well.					
11. Chemical bond topic should be removed from the syllabus.					
12. Chemical bond is an interesting topic to learn					

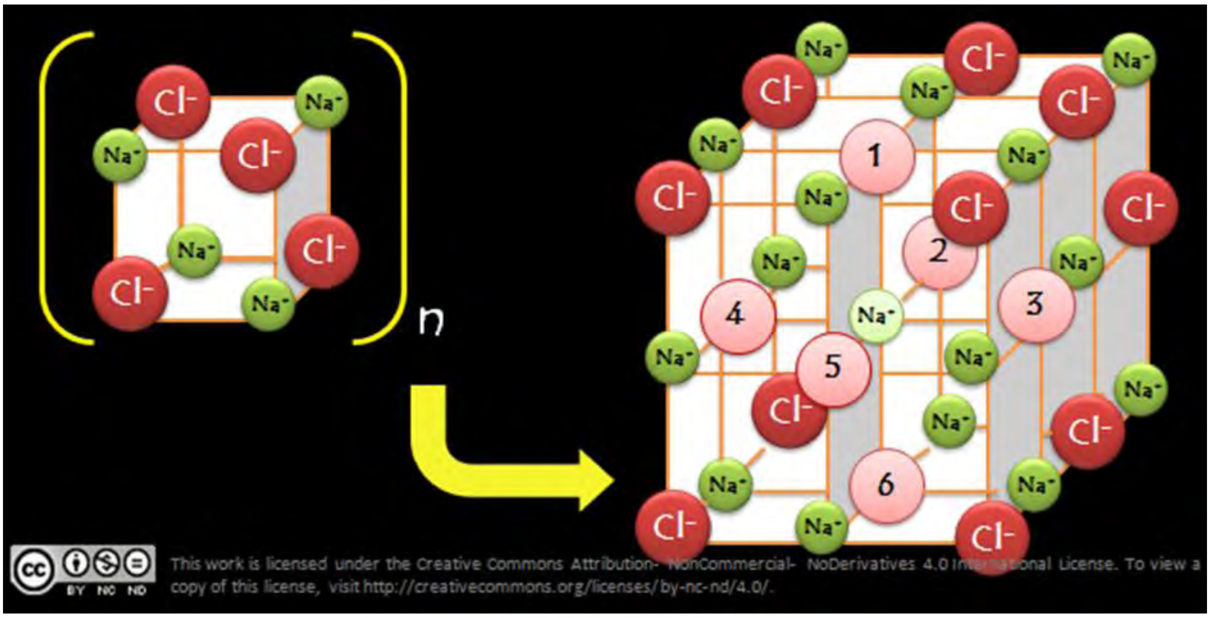
ITEM	SA	A	U	D	SD
B. Attitude towards use of computer simulations 13. The simulation motivates me to understand chemical bond.					
14. The software covered all the topics under chemical bond in the first year chemistry syllabus.					
15. The simulation package helped me to improve upon the understanding of chemical bond.					
16. It is time consuming to use computer simulations in learning chemistry.					
17. I get confused during the learning of chemistry when the simulations are used.					
C. Attitude towards chemistry 18. Chemistry classes are interesting.					
19. I don't like chemistry and it scares me to study it.					
20. Chemistry makes me feel uncomfortable, restless and impatient.					
21. I like chemistry more than other subjects.					
22. I will study chemistry in my further education.					

APPENDIX E

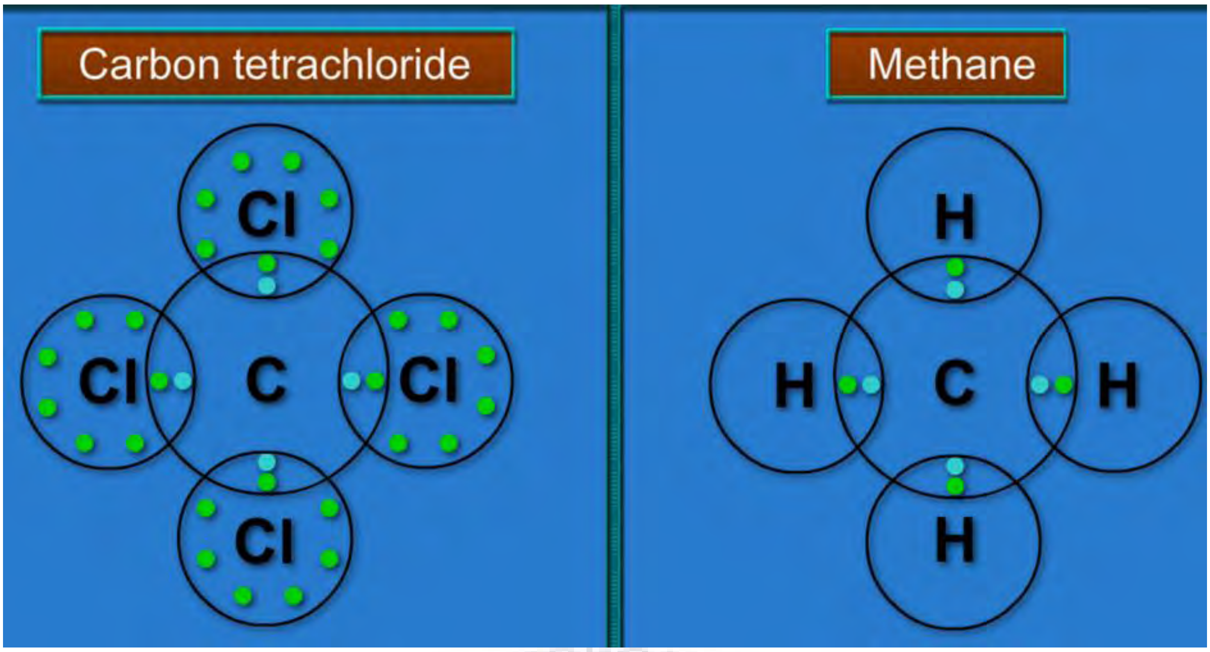
Screenshots of chemical bonding



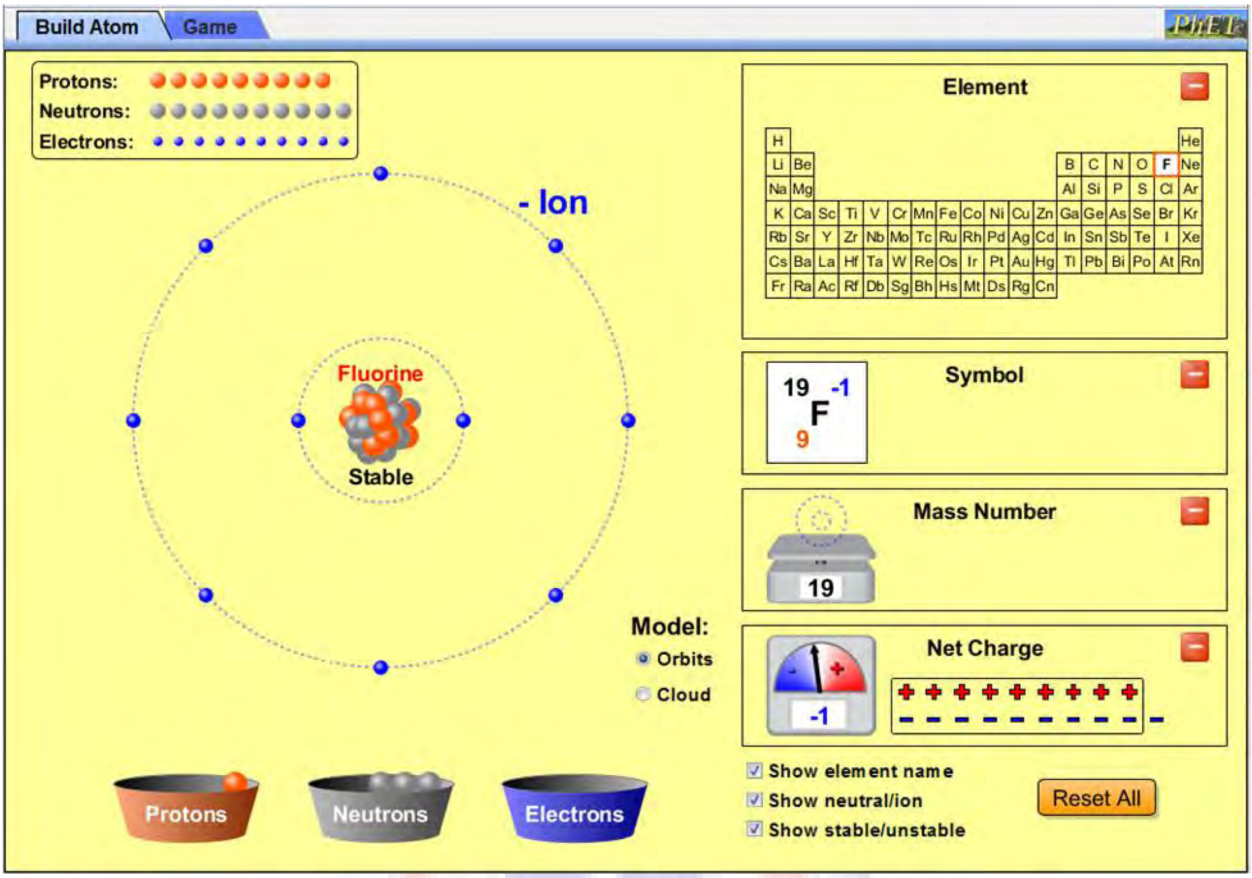
Screenshot from Sunflower software



Screenshot from Sunflower software



Screenshot of covalent bonding



Screenshot from: https://phet.colorado.edu.

APPENDIX F

Sample score sheet for pre-test and post-test

22/40

40 MARKS

BISHOP HERMAN COLLEGE, KPANDO

S/NO: ....5...... Date: .... Class: Science 1

Duration: 40min 2 Marks each

INSTRUCTION: Circle the letter that best completes the statement or answers the question.

1. What is the name of the ion HCO_3^-?

a. Hydrogen carbon oxide

b. Hydrogen carbon trioxide

c. Hydrogen carbon oxygen

(d.) Hydrogen carbonate ion ✓

2. In the Lewis structure, what do the dots represent?

a. Protons

b. Neutrons

c. Valence electrons

(d.) Shell

3. Which of the following is an example of a diatomic molecule?

a. HCl

(b.) Br_2 ✓

c. [illegible]

d. NaCl

4. Which of the following has the greatest electronegativity?

a. H

b. Cl

(c.) O

d. F

5. Which one of the following is NOT true about elements that form cations?

a. The atoms lose electrons in forming ions

b. The elements are metals

c. They are located to the left of the periodic table

d. They have high electron affinities

6. Which of the following pairs of atoms are least likely to form an ionic compound?

a. Ni, O

b. Na, F

c. Cu, Cl

d. Li, Mg

7. What kind of bond results when electron transfer occurs between atoms of two different elements?

a. Ionic

b. Covalent

c. Nonpolar

d. Single

8. What is the correct formula of phosphorus pentachloride?

a. PCl_3

b. PCl_5

c. P_2Cl_5

d. P_5Cl

9. The nucleus is very ______ compared to the atom as a whole.

a. small

b. large

c. similar

10. All of the following are examples of compounds except ...?

a. table salt, NaCl

b. vinegar, H_3COOH

c. ozone, O_3

d. laughing gas, N_2O

11. Write the formula of sodium carbonate.

a. NaCO

b. $NaCO_3$

c. Na_2CO

d. Na_2CO_3

12. Which type of bond would you expect to find when two non-metals are combined?

a. Covalent bond

b. Ionic bond

c. Physical bond

d. Metallic bond

13. What are the two principal types of bonding called?

a. Ionic bonding and covalent bonding

b. Ionic bonding and polar bonding

c. Metallic, ionic and covalent bonding

d. Polar bonding and covalent bonding

14. Write the chemical formula of sodium phosphate

a. Na_2PO

b. Na_3PO_4

c. Na_2PO_3

15. Name the two classes of element which are most likely to form an ionic compound if they are allowed to react with each other.

a. Metal and metal

b. Metal and non-metal

c. Non-metal and non-metal

d. Semimetal and non-metal

16. What is the name of CuO?

a. Sodium phosphate

b. Copper (II) oxide

c. Copper dioxide

d. Copper (I) oxide

17. What is the oxidation number of Mn in $KMnO_4$?

a. +5

b. + 6

c. + 7

d. + 8

18. Provide the name of CCl_4.

a. Carbon Chloride

b. Carbon (IV) Chloride

c. Carbon tetrachloride

d. Carbon Chloride tetra

19. Give the formula of the compound whose name is Dinitrogen pentoxide

a. N_2O

b. N_2O_5

c. NO

e. N_2O_2

20. Which of the following best describes a covalent bond?

a. Transfer of electrons from one type of atom to another

b. The attraction between a positive ion and a negative ion

c. Sharing of a pair of electrons between two atoms

d. Gravitational force between the nuclei of two atoms

40/40

POST-TEST ON CHEMICAL BONDING

40 MARKS

BISHOP HERMAN COLLEGE, KPANDO

S/NO. .... Date.................. ......Class 2 Science 2

Duration: 40min. 2 marks each

INSTRUCTION: Circle the letter that best completes the statement or answers the question.

1. Which of the following is a condition for ionic bond formation?

   a. High ionization energy

   b. Low electron affinity

   c. Low ionization energy ✓

   d. Small size of cation

2. An ionic compound formed between calcium and fluorine can be represented as

   a. CaF

   b. CaF_2 ✓

   c. Ca_2F

   d. Ca_2F_2

3. Which of the following is an example of a diatomic molecule?

   a. HCl

   b. Br_2 ✓

   c. CO

   d. NaCl

4. Which of the following has the greatest electronegativity?

a. H

b. C

c. O

d. F ✓

5. If the oxidation number of an element X is +3, what is the formula of its oxide?

a. X_2O

b. X_3O_4

c. XO_2

d. X_2O_3 ✓

6. Which of the following pairs of atoms are least likely to form an ionic compound?

a. Ni, O

b. Na, F

c. Cu, Cl

d. Li, Mg ✓

7. What kind of bond results when electron transfer occurs between atoms of two different elements?

a. Ionic ✓

b. Covalent

c. Nonpolar

d. Single

8. In which of the following substances is the bonding covalent?

a. CCl_4

b. NaCl

c. $MgCl_2$

d. $ZnCl_2$

9. The nucleus is very _______ compared to the atom as a whole.

a. small

b. large

c. similar

d. light

10. All of the following are examples of compounds except ...?

a. table salt, NaCl

b. vinegar, H_3COOH

c. ozone, O_3

d. laughing gas, N_2O

11. Write the formula of sodium carbonate.

a. NaCO

b. $NaCO_3$

c. Na_2CO

d. Na_2CO_3

12. A chemical bonding in which both shared pairs of electrons are provided by only one of the atoms is

a. Covalent

b. Dative

c. Electrovalent

d. Metallic

13. What are the two principal types of bonding called?

a. Ionic bonding and covalent bonding

b. Ionic bonding and polar bonding

c. Metallic, ionic and covalent bonding

d. Polar bonding and covalent bonding

14. The most polar of the following bond is

a. H-Cl

b. H-F

c. H-Br

d. H-I

15. Name the two classes of element which are most likely to form an ionic compound if they are allowed to react with each other.

a. Metal and metal

b. Metal and non-metal

c. Non-metal and non-metal

d. Semimetal and non-metal

16. What is the name of Cu_2O?

a. Sodium phosphate

b. Copper (II) oxide

c. Copper dioxide

d. Copper (I) oxide

17. What is the oxidation number of Mn in $KMnO_4$?

a. +5

b. +6

c. +7

d. +8

18. The two types of bonds in NH_4Cl are

a. Covalent and ionic

b. Co-ordinate and covalent

c. Metallic and ionic

d. Polar covalent and ionic

19. Give the formula of the compound whose name is Dinitrogen pentoxide

a. N_2O

b. N_2O_5

c. NO_3

d. N_2O_2

20. Which of the following pairs of molecules can form hydrogen bonds?

a. CH_3OH and H_2O

b. H_2O and HCl

c. CH_4 and H_2S

d. NH_3 and HCl

APPENDIX G

Reliability Statistics on Opinionnaire

Case Processing Summary

		N	%
Cases	Valid	10	83.3
	Excluded[a]	2	16.7
	Total	12	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.827	.817	12

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q1	28.20	45.956	.430	.	.818
Q2	28.60	46.933	.369	.	.823
Q3	27.80	41.956	.622	.	.801
Q4	27.90	46.322	.362	.	.825
Q5	27.80	43.289	.664	.	.798
Q6	28.00	46.444	.394	.	.821
Q7	28.10	40.989	.811	.	.784
Q8	27.80	43.067	.682	.	.797
Q9	27.90	50.100	.223	.	.831
Q10	27.60	50.267	.211	.	.832
Q11	28.60	50.044	.231	.	.830
Q12	28.30	41.344	.717	.	.792