UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF MULTIMODAL INSTRUCTIONAL APPROACHES ON THE PERFORMANCE OF STUDENTS IN CHEMICAL BONDING

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DECLARATION

Student's Declaration

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

Signature: ……………………………….……

Date: ……………………………………..………

Supervisor's Declaration

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

Name of Supervisor: Prof. John K. Eminah

Signature: ……………………………….……

Date: ……………………………………..………

DEDICATION

I dedicate this research work to my elderly brother, Mr. Samuel Y. Mayeem and our late father, Ubor Mayeem Jangah.

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My first gratitude goes to God Almighty who has given me knowledge, health and the strength to complete this study. I also highly appreciate Prof. John K. Eminah my supervisor for his constructive criticism and fatherly love that he showed in guiding me through this work. I also acknowledge the support my beloved wife gave me throughout this study. My appreciation also goes to the Principal of Offinso College of Education, Very Reverend Joseph Nkyi Asamoah for his encouragement and support through this study.

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DEFINITION OF TERMS

Multimodal Instructional Approaches: The integration of different stimulus modes within the same text to represent scientific ideas, reasoning, and findings.

Traditional Designed Instructional Approach: Teaching method characterized by only verbal modal instruction such as teacher-centered.

Experimental Group: Refers to the group of students who were taught the chemical bonding concept by multimodal instructional approaches

Control group: This is the group of students who were taught the chemical bonding concept by traditional designed approach

Modes: These are stimuli and methods that are used to explain concepts during the teaching and learning process.

Trends in International Mathematics and Science Study: A worldwide assessment which takes place every four years and provides data about trends inmathematics and science achievement over time.

Foundation Development Course: A consolidation science course offered in the second semester by the students at the Colleges of Education.

Pre-Service Teacher**: A student at the College of Education being trained as a teacher.**

LIST OF ABBREVIATIONS

FDC-124:	Foundation Development Course / EBS 132: General Chemistry
MIA:	Multimodal Instructional Approaches
TIA:	Traditional Instructional Approach
TIMSS:	Trends in International Mathematics and Science Study

ABSTRACT

Continuous use of traditional instruction has resulted in unsatisfactory performance, misconceptions and poor attitudes towards chemical bonding for many students. This study was designed to determine the effects of multimodal instructional and traditional instructional approaches on selected colleges of education first year students' understanding of chemical bonding concept. Effect of the instruction between gender differences on understanding of chemical bonding was determined. The study took place in Offinso and Berekum Colleges of Education. Students were randomly selected into the groups. The sample of the study comprised of 120 first year students from the two colleges of education. Questionnaire interview schedule, pre and post-tests were used as the main instruments to collect data for the study. Statistical Package for the Social Sciences (SPSS), version 20.0, for windows was used to analyze the data. It was found out that 51.7% of student-teachers who participated in the study had no understanding of the concept of chemical bonding and with a lot of misconceptions and also exhibited negative attitudes towards learning the topic. The results indicated that there was statistically significant difference in performance between experimental and control groups. The experimental group performed better in post-test than control group. The result from data analysis showed that there was no statistically significant difference between male and female students. It was recommended that Offinso and Berekum colleges of education chemistry tutors especially those teaching EBS 132 should employ multimodal instructional approaches in teaching chemical bonding.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter comprises the background to the study, statement of the problem, purpose of the study, objectives and research questions. Also included are the significance of the study, limitations delimitations and organization of the study.

1.1 Background to the Study

The major problem facing science education, according to Bennett (2011) is the identification of the most effective and efficient pedagogical strategies for improving science literacy. One of the concepts in science literacy which learners always have difficulty with is chemical bonding (Coll & Treagust, 2000; Sitalakshmi, 2008). Learning chemical bonding entails learning the representational practices of abstract concepts to explain natural phenomena. The learning of this science concept is now understood as knowing how to interpret and construct the concepts of science (Norris & Phillips, 2003). Recent studies concerning science teacher education focus on content knowledge and pedagogy. The need to design instructional methods that would promote better understanding of scientific concepts is very important for the development of science education (National Research Council, 1996). The importance of this area is that there is a strong link between the students' content knowledge and the pedagogy that teachers use to teach.

Primarily, teachers' knowledge and instructional approaches have direct effects on how science literacy develops in the classroom, and this correlates with students' achievement (Tatto 2001). It is therefore reasonable to relate learning experiences of the learners to the teachers' instructional approaches. The quality of science education can be assessed by some outcome variables such as examination results. The poor performance of Ghana Junior High School students who are mostly taught by teachers from Colleges of Education in the TIMSS assessment in 2003 and 2007 (Anamuah-Mensah, Mereku, Ampiah, 2009) and number of candidates who fail in Integrated Science examinations at first and second cycle levels of education in Ghana has been a great concern of late. Large numbers of students who attend remedial classes and re-sit for examinations after completion of Junior High School and Senior High School of education are those who could not pass or had weak grades in science, It also observed that is one of the subjects students tend to dislike most. The students in the colleges are often referred to re-sit their science courses every year. Few students choose to answer bonding questions that demands reasoning and interpreting according to Chief examiners' report of FDC 114 science course. Several researches indicated that abstract teaching of scientific concepts among others contributes to lack of interest and poor performance of students in science.

To improve science literacy and interest of students at the college level, Japanese International Cooperation Agency (JICA) project established science resource centres at some colleges such as Akrokeri and Bagabaga Colleges of Education to produce science teaching and learning material to enhance teaching of science. Ghana Association of Science Teachers (GAST) and Ghana Science Association (GSA) through annual science conferences organize workshops for tutors. The Ministry of Education, Science and Sports (MESS) was also tasked to orient individuals at all levels of the educational system to enhance the teaching and learning of science and technology (MESS, 2004). These interventions are attempts of the Government of Ghana in its Vision 2020 which identified science and technology clearly as the bases of lunching Ghana into middle income earning country and a competitor with other developing nations in the 21st century comes to pass.

However, the Chief Examiner's Reports of the science course indicate that pre-service teachers, usually called teacher-trainees, output in semester examinations is poor especially their inabilities to interpret and construct chemical bonding concepts. This is a worrying situation since the future of many young scientists rest in pre-service teachers' hands (Anderson & Miller, 1994). With reference to Anamuah-Mensah, Mereku, and Ampiah (2009), teachers' difficulties in reading, comprehending, interpreting and writing some science concepts, and knowledge of teaching students with diverse style and abilities among, others are the problems of learning science.

At the college of education tutors identify poor performance of students‟ in chemical bonding in the chemistry aspect of integrated science and quite recently general chemistry as a major problem. The students' inability to interpret and comprehend science literature on bonding of atoms as accepted by chemistry community is quite alarming. These affect critical components of science literacy. The uses of different modes of representation and instructional techniques in the same text from literature have been found in some contexts to significantly influence the development of science literacy (Bennett, 2011). Multimodal instructions are also used to represent content knowledge in a way that interlocks with different learning styles that appeal to different modal preferences of the students. However, there still remains a considerable amount of research to identify how and to what extent these can improve a student's metacognition and science literacy (Yore & Treagust, 2006). There is therefore the need to identify the effective teaching strategies that would give learners timely knowledge on how to construct and interpret multiple scientific representations such as tables and diagrams. Students in colleges need to develop an understanding of different instructional modes, rather than rely on particular mode of instruction for specific topics, if they are to develop a strong understanding of both science concepts and teaching it (Saul, 2004). This is because particular modes of instruction have different strengths and weaknesses in terms of precision; extend of clarity and relative meanings. This study investigates the effect of multimodal instructional methods on the students of colleges of education studying B.Ed. primary education learning outcomes in Ghana.

1.2 Statement of the Problem

Chemical bonding is one of the key components of chemistry concepts which pose learning difficulties to students in Offinso and Berekum Colleges of Education in Ghana in integrated science and the recently introduced general chemistry. This concept helps to understand how atoms are put together for effective reaction and the production of materials. But a large number of students have difficulty in reading and writing, interpreting and comprehending bonding concepts in different representational modes. These affect critical components of science literacy (Norris & Phillips, 2003). The students' difficulties among others lie in pedagogy and the abstract nature of the topic. In teaching, basic approaches like different modal representation of the same concepts are not used in colleges of education in Ghana. Rather teachers rely on traditional teaching method such as lecture method which teacher -centered approach and pedagogical content knowledge termed as content-specific with the aim of completing the course outline giving by the affiliate university which helps students in passing their semester examinations only without grasping the actual concept. This makes students have difficulty in interpreting and comprehending concepts, or lack skills to fully articulate what they have learned from reading the literature. The purpose of introducing chemical bonding seems to have been compromised with several misconceptions at all levels of education in Ghana. This study therefore designed to determine the effect of multimodal instructional approaches on the students' understanding of chemical bonding in colleges of education in Ghana.

1.3 Purpose of the Study

The purpose of the study was to identify the causes of students' poor performance, effect of multimodal instructional approaches on students' understanding of chemical bonding concepts and the students' perceptions of teaching methods to provide opportunity for teachers to professionally develop appropriate pedagogical approaches and integrate in their teaching.

1.4 Objectives of the Study

The objectives of the study were to:

1. identify the causes of students difficulties during lessons on chemical bonding.
2. evaluate the effect of multimodal instructional approaches on the students' performance on chemical bonding.
3. determine the differential effects of multimodal instructional approaches on the male and female students' performance on chemical bonding.
4. identify students" perception of the use of multimodal instructional approaches to the learning of chemical bonding.

1.5 Research Questions

To achieve the stated purpose above, the study addressed the following research questions;

1. What are the causes of the difficulties students face during lessons on chemical bonding?
2. What is the effect of multimodal instructional approaches on the students' performance in chemical bonding?
3. What are the differential effects of multimodal instructional approaches on the male and female students' performance on chemical bonding?
4. What are the students" perceptions of the use of multimodal instructional approaches to the learning of chemical bonding?

1.6 Null Hypotheses

The following null hypotheses were also formulated for the study:

H_{01}: There is no significant difference between the mean of students taught chemical bonding using multimodal instructional approaches and that of their colleagues taught with traditional instructional approach.

H_{02}: There is no significant difference between the mean scores of male and female students who are taught chemical bonding using multimodal instructional approaches.

1.7 Significance of the Study

The findings of the study would be useful to all B.Ed primary education students in Offinso and Berekum colleges of education in Ashanti and Ahafo regions of Ghana respectively. The outcome of this study would be helpful to science teachers and educators to realize the importance of the multimodal instructional approaches so that they can integrate it in their teaching and learning processes. It could also help teachers to recognize factors that lead to students‟ difficulties in their learning process. It may be useful for the in-service training of teachers at the basic school level and training institutions, to identify and use multimodal instructional approaches in the classroom. The findings of this study may also help improve the students' understanding of chemical bonding concepts. The pre-service teacher could have the ability to critically analyze and interpret chemical concepts that are put in different modes of representations in internationally acceptable standard. The study would eliminate student‟s misconceptions about the forces that exist in covalent bond concepts of chemical bonding

The findings would also help motivate students to be involved in active learning since instructional approaches would cater for learning differences. This study could add to the existing literature on methods of teaching science concepts and as such will serve as a source of reference for researchers who would want to carry out research on how concepts should be taught and learnt in schools. Finally, the finding may serve as source of information for Ghana Education Service, Curriculum Research and Development Division, authors of books and other science education agencies to make structural changes in the literature of science education.

1.8 Delimitations of the Study

The research was basically on the concept of chemical bonding in integrated science course outlined for colleges of education in Ghana. The study was delimited to the interaction with the first-year students in Offinso College of Education and Berekum College of Education in Ashanti and Ahafo Regions of Ghana respectively. The students in other year groups were excluded. It was limited to using five different and integrated modes of instructional approaches to teach the concept.

1.9 Limitations of the Study

According to Best and Kahn, (1995) limitations are conditions that are beyond the control of the researcher that place restrictions on the validity of the study. The results of the research may be influenced by the followed limitations. Some of the students were absent from lessons during the study. They were likely not to understand the concepts taught very well. Other students also kept revising their old notes and textbooks on the topics; hence the treatment may not be solely responsible for their output in the tests. These observations notwithstanding the findings of this study would provide insights into the efficacy of multimodal instructional approaches for science lessons.

1.10 Organization of the Study

This research report is organized into five chapters. Chapter one comprised of a brief introduction, background to the study, statement of the study, purpose of the study, objectives and research questions. The others are design of the study, limitation, delimitation, significance of the study and finally, organization of the study. Chapter Two comprises literature review of the study. It comprises the state of science Education reforms, science literacy in education reform, learning in science, writing to learn in science, multimodal representation in science literacy, connection between the literature and the study, misconceptions in chemical bonding and significance of the literature to the research study. Chapter Three is methodology of the study. This comprises research design, population and sample selection, research instruments, pilot-testing, pre-test, intervention and post-test, and the data analysis plan. Chapter

Four comprises with the presentation of the results, findings, discussions and evaluating of the interventional process as a whole. Chapter Five comprises the summary, conclusion and recommendations of the study.

CHAPTER TWO

REVIEW OF THE RELATED LITERATURE

2.0 Overview

The literature review focused on the theoretical framework for the study, the state of Science Education Reform in colleges of education and the nature of chemical bonding concept. The review also included difficulties students encounter in learning chemical bonding, pedagogy and conceptualization, the mode of representations of chemical bonding concept, multimodal representations of concepts, and instructional techniques in teaching chemical bonding. In addition, it focused on the mode of instruction, the nature of multimodal instructional approaches, and use of multimodal instructions to learn chemical bonding, facilitating metacognition, and differential impact of multimodal instruction on male and female students Perception of the use of Multimodal Instructional Approaches. Finally, it focused on the link between collected previous research works to the study and summary of the findings.

2.1 Theoretical Framework of the Study

Three major theoretical frameworks informed this study. The first is transmediation, which is the transfer of information from one symbolic representation system to another (Suhor, 1984). In transmediation a student transfers key concepts and ideas from one text and creates a new text incorporating those key themes and ideas. Charles Pierce first examines this idea to deeply examine how symbols are used to create meaning and he suggested that a symbol simply does not stand for something, rather its meaning is culturally mediated (Siegel, 1995). Symbols come to be understood by the individual based on his or her experiences with the world. According to Pierce, a symbol is simply not a substitution for an object, rather a symbol tells something about the meaning of the relationship between the sign and the object. And therefore, it requires an interpret ant (Short, 2004). Students act both as interpreters and creators while they constructed these multimodal projects.

The study is also framed by current theoretical accounts of both the nature of science discourse and learning as re-representation. Both perspectives are compatible with one another in that they link theories of science as a subject to how science can be learnt effectively and also what should count as this learning. Science should be understood historically as the development and integration of multimodal discourses (Kress, Jewitt, &Tsatsarelis, 2001; Norris & Phillips, 2003; Lemke, 1998, 2004). As noted by Lemke (2003), the integration of these different modes is a key feature of the development of scientific knowledge. This is where analogy, Symbolic, realia, verbal, and graphic modes of instructions have been used individually and in coordinated ways to represent the knowledge claims of science discourse.

2.2 The State of Science Education Reforms in Colleges of Education in Ghana

The Ministry of Education and Ghana Education Service over the years have made many attempts to reform teacher education to enhance the quality of teaching and learning of science in the basic school level in Ghana (Ghana Education Service, 2007). These reforms could have been because of the way science literacy has become very important that a heavy emphasis is put on students to become scientists. It could also be because of the significance of science and technology in everyday life as well as its pertinence to the global society (Dalsah & Coll, 2007; Ghana Education Service, 2007). The focus of this reform could have been due to the fact that science educators were concerned about identifying and removing obstacles to teaching student to be amateur Scientist (Bennett, 2011). The reform by Ministry of Education and Ghana Education Service could have been informed by the nationwide drift from science by many students (Ghana Education Service, 2007), and the poor performance of Junior High School students in an international study such as TIMSS 2003 and 2007 (Anamuah-Mensah, Mereku, & Ampiah, 2009). Researchers have shown that reforms in syllabus and approach of learning occur when there is a steady understanding from the science education community that a content-driven approach to teaching is not meeting the desired learning goals (DeBoer, 2000). In 2006, apart from the fifteen out of thirty-eight Teacher Training Colleges set aside to run diploma progammes in Science and Mathematics in Ghana, all the other colleges were upgraded to run diploma programmes. Therefore, the name was changed from Teacher training College to College of Education. With regards to that, special syllabi and course outlines were designed for use in science for the colleges in order to achieve the national goal and to solve poor performance of basic school pupils. This was also a new wave of reform initiated elsewhere to broaden the way science educators were defining the problems of science literacy and how to address them (Laugksch, 2000). The science syllabus is quite unique in that there are divisions into science content, methodology and practical activities. These sections were done to ensure that by the end of the programme the teacher trainee would acquire the' relevant content knowledge and competencies with respect to Junior High School science teaching (Ghana Education Service, 2007).

In fact, the main objective of current science teaching is to assist students to develop understanding of scientific concepts that is broadly agreed with conceptual scientific view (Calik, Ayas, & Coil, 2007). The new course outline and syllabus therefore place emphasis on teacher-trainee's understanding, science process skills and attitudes towards science through learner-centered approaches. For that matter, science teachers are the key players of the teaching process. Their knowledge in the subject matter and methods of teaching is a very essential component in the learning process. Imperatively, training teachers who would help their students to learn science effectively, science educators must help pre-service teachers to develop the requisite knowledge of the subject matter devoid of misconceptions.

It was therefore expected that after the introduction of the new reform, teachers of pre-service would than change their methods of teaching and place more emphasis on pre-service teacher understanding than just to memorize science concepts. However, this remained untested as agreed that learner -centered approaches enhance students' understanding of science concepts in the classroom.

2.3 The Nature of Chemical Bonding

Chemical bonding is one of the key concepts in chemistry and one of the most fundamental ones that students learn. In fact, Hurst, (2002) reported that bonding is a central concept in the teaching of chemistry. A thorough understanding of it is necessary for understanding of every other topic in chemistry such as carbon compounds, proteins, polymers, acids and bases, chemical energy and thermodynamics. The concept of chemical bonding and structure, such as covalent bonds, molecules, ions, giant lattices and hydrogen bonds are highly abstract. Due to the abstract nature of bonding, it is considered by teachers, students especially teacher-trainees, and chemists to be a very complicated concept to understand (Robinson, 2003; Taber, 2001). Chemical bonding is an area in the physical sciences which understanding is developed through diverse models which learners are expected to interpret through the use of different range of symbolic representations and modes (Taber, 2001). Levy, Mamlok-Naaman, Hofstein and Taber (2010) argued that in order to fully understand these concepts, learners of chemical bonding must be familiar with mathematical and physical concepts and laws that are associated with the bonding concept such as orbital, electro-negativity, electron repulsions, and polarity. Learning about chemical bonding also allows the learner to make predictions and give explanations about physical and chemical properties of all substances.

Sanchez Gomez and Martini (2003) discussed that the most advanced models available to chemists for understanding the structure of matter are those that might be-judged as best approximations to 'reality' of the current state of knowledge deriving from quantum chemistry. However, Sanchez Gomez and Martin also suggested that the majority of chemists were quite content to work with models that largely predated developments in quantum chemistry. This is considered to provide support and explain current knowledge of matter. It means that most chemists are using set of models and modes that are now understood to be limited representational meaning of the structure of matter. Chemists understand substances as clusters of sub-microscopic particles formed by chemical bonds (Levy, Mamlok-Naaman, Hofstein & Taber, 2010).

The chemical bonds between these particles are used to explain many of the chemical and physical properties of substances and chemical phenomena (Hurst, 2002; Levy Nahum, Hofstein, Mamlok-Naaman & Bar-Dov, 2004). Since bonding is a central concept in teaching chemistry, a thorough appreciation of its nature and characteristics is necessary for the learners Chemical bonding is also explained to be what holds atoms together in molecules and crystals (Gillespie, 1997). Gillespie stated that it is one of six most important key concepts that should be included in every high school chemistry syllabus. This suggestion by Gillespie among others might have been the reasons why chemistry courses or concepts were introduced in the colleges.

This importance has led to the inclusion of chemical bonding in course outline of colleges of education in Ghana. In addition, the concept is very much related to the understanding of many important and fundamental biological aspects such as molecular biology of living organism; e.g. the nucleic acids such as DNA and RNA (Levy et al, 2004). Notwithstanding essential importance from several literatures, bonding is well-thought-out by learners to be a very complex and difficult concept to be understood (Gabel, 1996; Levy, Mamlok-Naaman, Hofstein & Krajcik, 2007). This thought of learner about chemical bonding notwithstanding several interventions to solve the problem is still observed at all levels of schooling (Taber, 2009). It is therefore imperative through research studies to determine which approach of instructions would assist learners to understand the concept.

2.4 Difficulties Students Encounter in Learning Chemical Bonding

The students' difficulties to interpret and construct concept of chemical bonding comes from in human teaching and learning process and the intrinsic nature of the content (Bennett, 2011). The human teaching and learning process involve how instructional approaches make it difficult for learners to understand what they are to learn. Curricular models of chemical bonds presented in school science are based on the fact that there are physical forces between different particles in substance. In classroom learning situation, these forces are taught as being electrical in nature. The nature of the force in matter creates some learning difficulties in learners. According to Wightman, Green and Scott (1986), due to the presentation of bonds as physical forces students considered the linkage between particles in matter to be like elastic or based on shapes interlocking. Wightman *et al* added that if the interactions between particles are compared to a magnetic attraction, a force familiar to the learners, their conceptions have a tendency to be unclear. Learners would intend to keep in mind the material aspects of bonding. Learners will conceive that the interaction is like a string between the atoms holding it all together. According to Wightman et al, part of the student's difficulties is getting a model of bonding phenomenon which explains how melting and vaporization occur and can also describe bonds formation when particles become close. Students are often complained in their comments on how the bonds are formed, back after melting and vaporization (Levy, Mamlok-Naaman, Hofstein & Taber, 2010).

The explanation is that when the particles slowed down the bonding is then able to form, between the particles because it is a bit easier to keep slower things together (Wight Green, & Scott, 1986). But according Vaughan and Bruce (2008), there is the need for further research in the following areas: the identification of effective scaffolding strategies to give students timely knowledge on how to construct and interpret multiple scientific representations of bonding phenomena, such as tables diagrams; the identification of the features students attend to in their interpretation and construction of these representational models; and the design of professional learning programs and methods to support teacher understanding of how to maximize learning opportunities. However, Papageorgiou and Johnson (2005) is of the view that in introducing the particle model of matter the notion of bonding should rather be introduced as particles having the ability to hold on to each other instead of talking of attraction.

Griffiths and Preston (1992) said that typical diagrams which show the molecules touching each other without spaces between cause learning difficulties about chemical bonding. The learners sometimes think the concept of bonding have little to do with forces of attraction. Griffiths and Preston explained in their study that some students think molecules were not bond due to inherent interactions between atoms, but were held together by something external to the molecules. Cros, Maurin, Amouroux, Chastrette, Leber, and Fayol (1986) found that the interactions between atoms in molecules are often unknown or poorly known, and often students are not even aware that such interactions existed: Students sometimes think bonding between atoms is due to the attraction of the presence of electrons. Nicoll (2001) attempted to elucidate and pointed out the types of misconceptions relating to bonding, electronegativity, electrons, and molecular geometry that undergraduate chemistry major hold. Nicoll discovered that some students tried to explain chemical bonding in terms of electrons attracting one another. She reported a category of incorrect explanations for bonding phenomena or incorrect explanations for why bonding occurs and quoted one student who explained it that "When you have two electrons, they're negatively charged ions. They don't want to come together. But sometimes they do, and that's a chemical bond" (p.717). In view of these learning difficulties, there is the need to research and identify more scaffolding instructional strategies for effective teaching and learning to take place.

According to Kind (2009), it is not so necessary to think that the learning difficulties of chemical bonding comes from curriculum science, the representations of scientific knowledge prescribed in the curriculum, as true. Rather, when considering understanding of chemical bonding it is important to recognize that curriculum science comprises a set of models that should be understood. These modes are developed to provide an authentic representation of the models used by chemists at a level which is accessible to learners (Gilbert, 2004). Somehow it is said that this complicates judgments of the correctness of students' conceptions, and that both the nature of the scientific models and the way the topic is taught contribute to students' learning difficulties in the topic (Levy, Mamlok-Naaman, Hofstein & Taber, 2010).

There are several reasons for displeasure among the chemistry teaching community about current teaching and learning of chemical bonding. The main component ways that call for these dissatisfactions are; the traditional pedagogical approach used mainly in chemistry textbooks or literature, syllabus, and the assessment methods (high stakes testing) used worldwide. For instance, semester examination just like other examinations elsewhere influences teachers' instruction approach and students' learning on the bonding concept. It is so because teachers' main objective is to prepare their students for the Semester Examination questions and answers, leading to insincere teaching which results in misconceptions and pseudo-conceptions (Levy et at, 2004).

There is no doubt that there is confusion between what some people call Children science and scientist's science or for that matter teachers' science which need to be avoided. According to Gilbert, Osborne and Fensham (1982), there are important reasons to avoid this confusion: In the school science teaching, it would often be wrong to consider current „state of the art' scientific models as suitable target knowledge to inform the planning of teaching and the assessment of student learning according to them. Reasonably there is a two-stage process of transformation between scientific knowledge and the learning material set out for students to learn in school (Levy et al., 2010). The first stage of transformation occurs at a system-wide level that is beyond particular schools or classrooms. In this stage the educational systems prescribed curriculum or a set of reference point. This process provides the models of science which inform the development of curricula models that take into consideration the suitable teaching and learning approach for a particular age group of students. These representations of scientific knowledge are intended to be authentic representations of the science in a simple suitable level. This process of curricula model development is mostly undertaken by groups or committees of educationalists who are not themselves scientists who discover, develop .and apply the scientific models in their discovery work. There is certainly an interpretation in process which may lead to aspects of the scientific models to be misconceived and distorted. The committees rely on certain types of arguments to inform them to develop the curriculum science such as chemical bonding. In order to teach chemical bonding well, Gillespie (1997) stated that:

"All chemical bonds are formed by electrostatic attractions between positively charged core and negatively charged valence electrons. Electrostatic forces are the only important force in chemistry. Bonds are not formed by the overlap of orbital, as we read not infrequently; this is just a model admittedly a very useful one and essential for the chemistry major, but I don't think it is essential for students at the introductory level. We can obtain a very good understanding of chemistry without it; indeed, many chemists make little use of it. It distracts attention from the real reason for bond formation: the electrostatic attraction between electrons and nuclei. We can simply describe ionic bonds as resulting from the electrostatic attraction between ions, and covalent bonds as resulting from a shared pair of electrons' attractions for the two atomic cores. The corresponding Lewis structures tell us how many bonds an atom will form. In my opinion, these concepts constitute what is needed to discuss at the introductory level of chemical bonding"(p.862).

From the above passage, the idea of bonds is presented or viewed in two ways by Gillespie. Bonds in term of overlap of orbital is labeled as just a model while as idea of bonds in terms of the electrostatic attraction between electrons and nuclei is presented as more than a model- the way things actually are, which should have been better considered as also a model. It is also obvious that it is not possible to explain all chemical bonds to students to understand purely in electrostatic terms. For instance, covalent bonds are described as resulting from a shared pair of electrons' attraction for the two atomic cores whiles it has been informed that negatively charged electrons are considered to occur in pairs-something that a purely electrostatic approach may not be simply understood.

The combination of the traditional pedagogical approach of curriculum developers worldwide and the demands imposed by the common semester examination questions generated a body of pedagogical content knowledge (PCK) (Kind, 2009) regarding chemical bonding concept is overly simplified; it is not in line with the up-to-date scientific knowledge and fails in developing conceptual understanding. According to Magnusson, Krajcik and Borko (1999):

> "PCK is a teacher's understanding of how to help students understand specific subject matter. 'It includes knowledge of how particular subject matter topics, problems, and issues can be organized, represented, and adapted to the diverse interests and abilities of learners, and then presented for instruction" (p. 96).

The traditional pedagogical knowledge PCK (also termed content-specific, by Magnusson *et al.* (1999) on bonding concept has been developed during recent times in colleges of education chemistry. This contents specific pedagogical knowledge is now a guide to many teachers in their classrooms teaching at the expense of teachers' professional capabilities. Taber (2002) explained that one of the professional capabilities of the teacher is to find ways to make complex ideas accessible to learners, but this should balance with presenting material in a way that is scientifically valid, and also provide suitable platform for future learning. It means that teachers need to use appropriate ways of simplifying concepts to suit learners' understanding but it must not undermine their future needs. Over the years, the traditional pedagogical knowledge approach became progressively simplistic with clear-cut definitions to facilitate students' learning. However, the resultant of this approach of teaching is that students often do not gain in-depth understanding of these concepts, reflected in their misconceptions and in their pseudo-conceptions (Vinner, 1997). The difficulties of learning chemical bonding concepts arising from contents specific are confirmed in Levy *et al*., (2007) cited in Levy. Mamlok-Naaman, Hofstein, & Taber, (2010) as they wrote that:

> The way that this topic is taught is highly based on the definitions of the key concepts. Based on the syllabus and the textbooks, and according to the Matriculation Examinations demands, teachers tend to define these concepts in certain ways and to use "rules" and classifications that are not in alignment with the scientific theoretical models. (p315).

The traditional approach of teaching is characterized by clear-cut definitions and rigid distinctions, which do not facilitate rationalization of current chemical knowledge. This problem might be amplified by traditional assessment methods, in which the superficial study of classification and 'rules' by rote is rewarding to both students and teachers because it allows for an efficient evaluation process based on clear-cut answers to well-defined questions (Levy *et al.,* 2007).

2.5 The Chemical Bond: Pedagogy and Conceptualization

There are various internal and external factors that can generate students' difficulties in learning chemical bond. If so, how often are such difficulties generated, by the textbook"s contents and the teachers? Can teaching strategies and the manner which concepts are presented in textbooks mislead students? A review of the research works which relate to difficulties that result from students' misconceptions of science concepts indicated that there are common features. Students are often strongly resistant to traditional teaching and form coherent, though mistaken, conceptual structures (Tami, Avi, Rachi, & Ziva, 2004). Literature indicated several external factors that can cause learning difficulties regarding the concepts of chemical bonds. It is proper to analyses the current textbooks presentations of concepts because they are the most widely and frequently used teaching aids at all levels of education (Stinner, 1995; Sutton, 1996). Analysis of science textbooks or teaching materials have shown that they present science as complete facts, collection of true and in the form of generalizations, and mathematical formulations or manipulation of letters as if are read directly from nature (Tami, Avi, Rachi, & Ziva, 2004).

Some curriculum developers, teachers and students religiously use as accurate and precise definitions from the textbooks as possible without mindful of the evolving nature of those definitions. For instance, many chemistry textbooks classified elements as metals or nonmetals with a few semi-metal perhaps mentioned. In many cases this difference among elements is used to give a dichotomy classification of bonding in compounds: In covalent is non- elements and ionic is between metal and non-metal. Yifrach (1999), textbooks and teachers often present the classification of chemical bonds in a manner that seems everything is simple and clear is deceptive and misleading. In the scientific point of view, ability to classify intelligently to avoid future misconceptions is an important skill in chemical bonding lesson. Yifrach then suggested that it is important to teach students to classify bonds by themselves in order expand their understanding. This would also make them perceive concepts from different perspectives. This sharpens their thinking abilities; make them develop understanding of the relation between content in different modes, and scientific process. The research study on students' difficulties to comprehend chemical bonding-is due to the fact that in bonding elements could be categorized severally. Taber (1995) reported that in further learning elements that can be categorized on an electronegativity scale, and bonding may be in terms of their polarity even though some compounds may still be considered having bonding types that are the same as ionic and covalent models. In these cases, ions may be polarized and then making their ionic compounds showing some degree of covalent character. Covalent compounds exhibit some degree of ionic character when there are differences in electronegativity between the elements.

The bonding between elements may also be intermediate state between ionic and covalent (Taber, 2002). Because most materials have bonding which cannot be considered as purely covalent or ionic or metallic due to their varying degrees of mixed characters of covalent and ionic, they are precisely described as intermediate. The idea of bond polarity indicates that the Covalent and ionic dimension should be viewed as a range and not as a dichotomy. According to Gillespie (1997), to explain chemical bonding; "Electrostatic forces are the only important forces in chemistry" (p. 862). But Taber (2002) confirmed that that although electrical forces cannot be used to explain every aspects of chemical bonding, they do provide a comprehensive basis to understand bonding phenomena. Therefore, any teaching model that is be used to introduce chemical bonding should be based on the effect of electrical forces.

Gilbert (1998) held a different view by stating that it is not at an introductory level that ideas used to understand chemical bonds are accessible. Rather curricula models and instructional approach need to make the topic simple for learners. Most students do not know the meaning of covalent bond due to the deficiency of curriculum modes and teaching strategies. (Taber, 2002). They therefore construct meaning of it in a range of contexts as they progress through introductory and more advance college chemistry education. According to Taber (2002) cited in Tami, Avi, Rachi, and Ziva; (2004):

> "A young student who has just learnt the term of a covalent bond in a very limited context does not share the same set of meanings for the term as teachers. This is not a case of the teacher being right and the student wrong, but of them having a different concept of covalent bond. The teacher and the student use the same word, but... the teacher's meaning is not only extended, it is more sophisticated, more subtle, and more deeply integrated into a framework of chemical ideas"(p. 56).

At the end learners do not normally possess the actual meaning of the term as the way teacher do. This explained the fact that there is a gap between students and their teachers regarding a student's conceptualization of the bonding concepts.

According to Robinson (2003) the gap is created because teachers often use instructions methods that provide algorithmic formulae to solve problems rather than requiring students to use reasoning combined with an understanding of the concepts through instructions. Carter and Brickhouse, (1989) state: „„What are particularly interesting are responses in which there is a large discrepancy between faculty members' view of the difficulties of general chemistry and that of their students. It appears the two groups at times live in two different worlds (p. 224).""

This can be attributed to lack of effective communication through the use of instructional approach between students and teachers which sometimes result to a mismatch between what is taught and what is learned (Erduran, 2003). In the context of science lessons, symmetry between the nature of teachers' understanding of a particular science topic and students' ideas regarding this topic is critical, because such a match indicates who scientific knowledge is being taught and learned in the classroom (Tami, Avi, Rachi & ziva, 2004).

It is observed that teachers and textbooks simplify chemical concept by using anthropomorphic explanations. Such explanations involve using words or phrases such as atoms "want to have octets" or "full outer shells", and that chemical processes often occur to allow atoms to achieve that (Taber, 1998). Most school textbooks incorrectly illustrate and refer to eight electrons in the third or higher shells as a full shell. The term "sharing" is also often used to describe the covalent bond by students to describe interactions. The shared paired electrons are tempted to be seen as still belong to specific atoms and so the bonding is assumed to be hemolytic, since each atom would "want" to get "its own" electron back. This way of teaching students is not helpful.

It is disagreed that teachers teach only by the use of "octet framework", in order to avoid learning holdups (Taber, 2002). If not, the existence of certain bonding which does not result to atoms having full octet shells would be a mystery to most students or reject anything that does not exhibit octet as being chemical bonding; hydrogen bonding and Van-Der-Waals forces cannot be readily understood by students, for that matter the difference between inter-molecular and intra-molecular bonding. Shulman (1986) described PCK as "The most useful forms of content representation..., the most powerful analogies, illustrations, examples, explanations, and demonstrations in a word, the ways of representing and formulating the subject that makes it comprehensible for others" (p.9).

2.6 The Mode of Representations of Chemical Bonding

The understanding of the topic 'Chemical structure and bonding can be developed through diverse instructional models in order to aid built on a range of physical principle. It is viewed that students are expected to interpret different symbolic representations used for explaining the concepts of chemical bonds (Taber & Coll, 2002). Evidently, Johnstone, (1991) stated that matter and its activities can be represented on three levels; the macroscopic (phenomena), microscopic (particles), and the symbolic levels (chemical language and mathematical models). According to Gabel (1996), teachers unconsciously often move from levels to another in their teaching. The problem is that they are not able to assist students to integrate these levels of which at each level concepts could be interpreted in more than one way (Tami, Avi, Rachi, & Ziva, 2004). Thus, students rather become more confused easily in the learning process. Robinson (2003) on his part has suggested that to avoid the confusion students must first be taught thoroughly to understand how to convert a symbol into the meaningful information it represents.

Bodner and Domin, (1998), the knowledge to distinguish between and determine the relationship of internal representation, which is the information stored in the brain, and external representation, which is the physical manifestation of this information is important: A student with different internal representation of concepts might end up writing similar external representations. The instructors in classrooms write down symbols represent a concept phenomenon to explain physical reality. But most often, students write, letters, symbol lines, diagrams and numbers which have no physical meaning to them and to the scientific community. In order for students to understand chemical structure and bonding, there is the need for them to be conversant with the multiplicity of terms, with the meaning of scientific models, as well as the difference between the macroscopic and the sub-microscopic worlds.

2.7 Multimodal Representations of Concepts

One of the key factors that influence teaching and learning process in science identified by many researchers and writers in recent times is mode representations factor. It is so because science is not solitary endeavour, its participants have to communicate with one another on a regular basis and to the learners in order to contribute to development or explain the nature phenomenon.

Scientists perform research and communicate their findings through using more than one modes of representation to one another to publish their result (Bennett, 2011). Most of these results are to solve human problems and must be communicated to learners through all senses for them to understand the findings well. Communication among scientists to understand results is very important that the argument has been made that science is impossible without language playing central role. During research presentations at professional meetings and laboratory meetings among co-workers or teachers and students, scientists use language in very specific and constructive ways. Language is used by scientists to explain, and interpret meaning from their finding, to make sense their results in the context of chemistry. The language dependency is the groundwork for fundamental sense and derived sense in science literacy. However, the process of conceptualizing and communicating scientific ideas and findings science instructors must be able to use a variety of methods (multimodal instructional strategies) to communicate for better understanding. In classroom, teachers are expected to use figures, graphs, diagrams, mathematical equations, chemical equations and even non-verbal gestures, experiment and videos illustrations when giving accounts of the scientific concepts, ideas and findings (Bennett, 2011). All these modes are used to facilitate understanding, but how come that there are difficulties in learning science? According to Bennett, all of these methods of representing ideas and concepts are different modes of representation of concepts and ideas that do not fully explain any scientific concept. It is not surprising seeing in any professional science publication or textbook, readers confronted with figures, graphs, tables, and all manner of modal representations. Just as scientists represent ideas and discoveries in modes to communicate with others; it is the same way that science students learning about those ideas and discoveries use the same forms of representation to understand nature. Once students are inducted into these forms of communication, they must be helped to be fluent in them if they are to be successful in the chemistry classroom (Lemke, 2000).

The importance of representing scientific concepts in multiple modes to gain bonding literacy means that it must necessarily be considered by science educators as well. When students encounter difficulties with learning the same ideas, concepts, and reported scientific findings that the professional researchers put in different modes they will go to their instructors for help. So, students must be exposed to the same or similar modes of concepts representations in different instructional approaches for them to appreciate and understand it (Bennett, 2011). According to Bennett, in some topics it is not possible to separate a scientific concept from its modes of representation. For that matter, for a student to understand the concept better teachers need to use multiple- modes of instructions. Most of the proposed models are represented by symbols, graphs, diagrams, etc. and cannot be communicated without them. From the chemical structure and bonding in chemistry the modes used as representations to communicate the concepts became a part of the language of science. The problem is that science students are normally faced with the challenges associated with learning the language of science along with its modes of representation. Science educators need to consider the process of student learning through multi-modal representation by developing instructional multiple modals in the same context to solve these challenges. Science education researchers also need to investigate the link between the multiple modes of representation in science and teaching by multi-modal representation strategies of learning in science literacy (Sankey, Birch & Gardiner, 2010).

2.8 Instructional Techniques in Teaching Chemical Bonding

Chemical bonding is a topic that is understood by the development of diverse models built on series of physical principles, and where learners are expected to interpret a disparate range of symbolic representations standing for the concepts (Taber & Coll, 2002). The bonding of particles results to the formation of various kinds of matter. This matter can be represented on three levels: macroscopic (physical phenomena), microscopic (particles), and symbolic representational (chemical and mathematical language) according to Johnstone (1991) and Gabel (1996). The symbolic representations play a key role of mediating between the phenomenological-descriptive level of what students can recognize, and, the abstract conceptual level of theoretical entities. For instance, H_2O could stand for both molecules and substance. But when teaching chemical bonding, teachers repeatedly and impulsively move from one level to another in their teaching without making it known to the learners. The inability to help the students integrate the levels has the possibilities of confusing them with reference to the symbol (Taber, 2009). According to Lunetta and Hofstein (1981), curriculum developers and researchers views on learning believe that the modals used can enhance chemical learning. However, they indicated that students are poor at modeling than are expected by teachers. Students also think that models are scale replicas or incomplete drawings of actual objects, and therefore attach no importance to the purposes in the model form (Levy, Mamlok-Naaman, Hofstein, & Taber, 2010).

Imperatively, Harrison and Treagust, (2000) think that models are more than communicative tools which are used to link the methods and product of science during learning. They suggested that students who listen to common analogical models for atoms, molecules, and chemical bonds actually used these models more effectively. In recent times computer technologies such as web-based teaching and learning have gained momentum in teaching and learning of sciences. Various studies have noted the benefits of web-based learning and its wide potential to empower teaching and learning in terms of its visualization, accessibility, and flexibility (Clark, 2004; Linn, Clark & Slotta, 2003; Carpi, 2001; Mistler-Jackson, 2000). With the notion of visualization to support students' learning the chemical bonding concept, Clark, (2004) noted that it is important to integrate computer-based visualizations in learning abstract concept and phenomena.

Apart from the web-based teaching, molecular models, simulations, and animations have been identified to have the potential to contribute to the learning and better understanding of the chemical bonding concept (Kozma & Russel, 2005). Justi and Gilbert, (2002) reported that the use of computerized models is a way to improve students' understanding of chemical phenomena by translating information expressed in different representations. The use of computer-based models in learning improves students' visualization in chemistry (Banea & Dori, 2000). Frailich, Kesner and Hofstein, (2009) stated that the web-based learning activities that have integrated visualization tools with active cooperative learning strategies provide students with opportunities to construct their knowledge on the abstract concept of chemical bonding. They suggested that as science ideas evolve, a more integrated of multiple instructional approach of teaching science should be researched to identify which combination of multiple modes is effective for learning which topic.

2.9 Modes of Instruction in Chemical Bonding

The learning of science concepts and methods entails understanding and conceptually linking multiple representation and multimodal instructions (Russell & McGuigan, 2001). Multiple representations refer to the same concept being shown in different forms such as verbal, numerical, graph and symbolic illustrations (Vaughan & Bruce, 2008). Multiple representations are used by researchers and scientist to communicate their concepts, principle and low in different forms for people to understand them. For instance, in chemical bonding, the concept is communicated to learners and among scientist by using different representations; that is using 'dash' and 'dot' illustrations, word representations, graphical representation etc. to show how bonds are formed. In the classroom, teachers assist students by using modes of instructions for them to be able to translate their understanding from one representation to another in order for them to be able to represent their knowledge. According to Vaughan and Bruce, multimodal refers to the integration of different modes within the same text to represent concepts or ideas, reasoning and finding. A mode is explained as a type of stimulus presented to learners for them to react to; it could also be any situation or condition that elicits responses from learners.

2.10 The Nature of Multimodal Instructional Approaches

Teachers sometimes tend to focus on resources and students' learning styles rather than on modal diversity, and also confusing modes and resources. For example, according to Vaughan and Bruce (2008), some teachers perceive a specimen from nature to be a representational mode in itself They also indicated that teachers tend to think that different learning styles dictate the type of many different modes that should be used for the same topic on the assumption that particular modes worked better for some students than others. In this view, teaching is mainly about matching the right modes to a specific learning style of each individual, and that learners' engagement of one mode of representation is not sufficient for learning a concept.

Volkmann and Abell (2003) suggested that teachers had not considered assessing systematically the kind, range, and sequence of modes and their effects on learning scientific concepts. Various studies have addressed students' learning through different representational modals in the classroom at the basic and senior secondary school levels (Dolin, 2001; Russell & McGuigan, 2001). Some of these include the use of analogies for learning science (Coll & Treagust, 2000), the role of scientific modals in learning science (Treagust, Chittleborough, & Mamiala, 2002) and the perception of teachers in the use of multimodal representation of concept (Vaughan & Bruce, 2008). Several of the studies tried to explain how teaching and learning should be done for students to be able to better understand and interpret scientific principles and concepts in the classroom. Teaching and learning in science involves understanding and conceptually between link multiple and multimodal representations in the classroom (Ainsworth, 1999; Dolin, 2001; Russell & McGuigan, 2001). Multiple instructional representations of concepts refer to the same concept being shown in different forms, including verbal, graphic, numerical, and embodied modes, as well as repeated teachers' representations of the same concept to learners. For instance, teachers can represent the formation of sodium chloride crystal first in 3-dimension, then in 2-dimension, such as captioning a diagram and then in a pen" and-paper test at the end of the topic. When teachers translate the understanding of a particular concept from one mode to another, or refine a past understanding using the same mode, they are engaged in re-representing the knowledge known as multimode representation. Multimodal approaches of teaching refer to the integration of different modes within the same text or topic to represent scientific ideas, reasoning, and findings in order for understanding of it by learners (Vaughan & Bruce, 2008).

There is a diversity of possible representational modes; verbal (oral presentations, guest speakers), graphic and visual (Internet, computer simulations, videos, posters, diagrams, tables, charts, power point presentation), written (worksheets, menus, texts, project assignments, scripts, pamphlets, concept maps), numerical (mathematics), embodied (role-play, class presentation), and three-dimensional modes (models, experiments). This variety of modes is used as resources to promote interest in topics or cater for individual differences in learning styles, rather than as different representations of science methods, concepts, and symbols.

There are several classifications of modes that have been proposed to aid learning of science concepts. These classifications are broadly agreed and categorized into the forms which include the categories such as descriptive (verbal, graphic, tabular), experimental, mathematical, figurative (pictorial, analogous, and metaphoric), symbolic and kinesthetic or embodied gestural understandings or representations of the same concept or process. It is also confirmed in the literature that students need to develop an understanding of different modes, rather than relying on particular modes for specific topics, if they are to develop a strong and better understanding of both science concepts and how they can be represented (Saul, 2004). Dolin (2001) perceived that some representational modes in learning are not used the teaching strategies. Confirming improving learning through re-representing the same concepts, Nuthall (1999) stated that students need more than two experiences in order to develop long-term knowledge of a concept. This is due to the fact that particular modes have different strengths and weaknesses in terms of precision, clarity, and associative meaning, and that teachers and learners need to understand these aspects of representations.

Lemke (2004), the running verbal text would make no sense to learners without the integrated mathematical equations. Hence Lemke pointed out that modal interdependence is typically a key feature of scientific explanation in the classroom. Dolin (2001) also observed that some representational modes in learning has not been utilized and should be effectively included in the classroom practices. It means that representational modes may be identified but the important thing is that how it is incorporated into classroom practices for learner to understand a topic. Teachers can enhance learning through re-representing the same concept in different modes.

Children in the process of learning require three or more different experiences such as concrete, video, illustration or abstract experiences to be able to establish long-term knowledge of a concept (Nuthall, 1999). When children are taken through these experiences in the same text it puts them in a better position mentally to generate varying representation of a concept. In using this approach with college students for them to be able to re-represent the same idea, Russell and McGuigan, (2001) reported that students need to generate different representations of a concept and recode the representations in various modes. This helps them to refine and make more explicit their understanding of a particular concept. In their classroom learning process, both teachers and students produce various representations of particular concepts, and knowledge 'construction 'as seen as the process of making and transforming these different representational mod's. Some other researchers claim that some modes may be more convenient and supportive of student learning than other modes. For instance, a student can "draw to learn “effectively, where the "visual media is used affords specific advantage over the textual media" (Gobert & Clement, 1999; pp. 49-50).

It is suggested that teaching and learning practices should incorporate the use of accepted representations as well as student-generated multiple and multimodal representations for learning topics. For example, students can learn about chemical bonding through engagement with 3D objects, concept maps, diagrams, verbal accounts, role-play, computer animations and CD-Rom illustrations such as video presentation. This approach is used for the students to understand, integrate, reconstruct and explain these modes through their own learning styles to show that proper learning has taking place. In fact, learning science did not always involve (a) systematic focus on conceptually linking 'multiple representations' within all topics and (b) building on students' own representations of topics through guided exposure to, and interaction with, teacher-presented representational options. It has been seen that presenting material in a variety of modes may encourage students to develop a more versatile approach to their learning (Hazari, 2004) findings in the field of cognitive science suggested: Multiple intelligences and mental abilities do not exist as yes-no entities but within a continuum which the mind blends into the manner in which it responds to and learns from the external environment and instructional stimuli. Conceptually, this suggests a framework for a multimodal instructional design that relies on a variety of pedagogical techniques, deliveries, and media (Picciano, 2009, pp.11). The effective and systematic use of multiple modes in teaching within a topic can make student learn chemical bonding with ease.

Klein (2003) supported the view that the most effective use of different representational modes in learning science is to seek to match particular modes to specific preferred student learning styles. Students sometimes feel more comfortable and perform better when learning in environments that cater for their prime learning style (Cronin, 2009). While there is recognition that the exposure to diverse modes can promote student interest in a topic and cater for individual differences and learning styles, there is also more interest area such as how students make sense of science concepts and methods across modes (Vaughan & Bruce, 2008). From a pedagogical perspective it is assumed that student engagement with, and integration of, diverse representational modes enhanced learning by encouraging students to make explicit their knowledge of underlying science concepts.

The current research works have focused on teachers and students using diagrams construct and give explanations to science concepts (Ainsworth & Iacovides, 2005), understanding concepts through multiple modes representations in different topics (Parnafes, 2005; Tytler, Peterson & Prain, 2006), and the role of visualization in textual interpretation (Florax & Ploetzner, 2005). Instead of putting emphasize on a particular representation or one classroom instructional approach, this study focused on the effect of the use of multimodal instructional approaches of re-representing the same concept for effective learning chemical bonding. Rather than trying to identify an exemplary representation or mode which authorized as proven to provide an accelerated key to better learning, the research work was interested in how students appreciate re-representing of the same concepts in different modes.

This representational approach of chemical bonding concepts is consistent with conceptualists' approaches to learning science. This is to involve learners more instead of only emphasizing on the restricted representational forms which are found in textbooks or the usual chalkboard illustration practices. The recent research findings have explained the need to study multimodal instructional approach. Tytler, Waldrip, and Griffiths (2004) and Tytler (2003) indicated that mostly, students learn effectively in science and engage more on the subjects when they are challenged to develop meaningful understandings. They suggested that effective learning occur where individual learners' learning needs and preferences are catered for or a range of assessment tasks are used or the nature of science depicts its social, personal, and technological dimensions. Tytler (2003) claimed that effective learning occurs when links are made between class programme and local or broad community which the wide relevance and social implications of science. In short, the explicit focuses on learners' engagement with interpreting and representing concepts in different modes through multimodal approach in classroom for promoting students' learning.

2.11 Use of Multimodal Instructions to Learning Chemical Bonding

In recent times, attention has been focused on learning with more than one representation and methods, stemming from the fact that 'two representations are better than one' (Ainsworth, 2006). This strategy is used for the purpose of overcoming the students' difficulties previously pointed out. The instructional strategy makes students interpret and analyze chemical bonding concepts in diverse forms to meet the fast-evolving science literacy. It appears complex chemistry concepts have been discovered daily, yet the same instructional approach of teaching is still being used every day. Discussion on the instructional strategies skills indicated that teachers are required to develop understanding of the processes involved in building up this knowledge which goes beyond the traditional discursive practices are important in this era. Driver, Newton and Osborne (1999) confirmed it by stating that to understand the symbolic world of science it is necessary for students to have experiences which are not only with finished products, but also with meaning-making processes based on the use of words, diagrams, realia etc. stemming from the scientific culture. Ogborn, Kress, Martins & McGillicuddy (1996), could not put it better than as: "We have tried to go further, and to look at all the activity of the classroom-talk, gesture, pictures graphs, and tables, experimenting, doing demonstrations as a way of making meanings" (p. 42).

The study of how different instructional approaches were being used in the teaching and learning of scientific content in the classroom has been fertile field of research. Quite a number of articles on the instructions have been published in the science educational literature (Piccinini 2003; Jewitt & Scott, 2002; Roth, 2002; Kress Martin & Ogborn, 1998). These authors questioned the supremacy of verbal language (mode) that features mostly teaching and learning process. They explained that other languages mediate the construction of knowledge in the classroom and that these other languages (ways of presenting concepts) are worthy of research.

Lemke (1998) called attention to the beginning and integration of different languages (multiple modes) used in communication during science teaching and learning. Lemke explained that verbal instructions (lecture) are always accompanied by gestures and facial expressions, and that written languages are accompanied by pictures, tables and graphs. Attention has to be paid to the visual instructions that always accompany with verbal language and written languages to bring about a holistic approach of learning chemical bonding. Research has also exposed that significant increases in learning can be accomplished through the well-versed use of integrated visual and verbal multimodal learning (Fadel, 2008). Students may feel more comfortable and perform better when they are provided with learning environments that cater for their predominant learning style (Cronin, 2009; Omrod, 2008).

It is also observed that teaching concepts in multimodal instructions can encourage students to develop a versatile approach to their learning (Hazari, 2004). Multimodal learning environments allow instructional elements to be presented in more than one sensory mode (visual, aural, written). Sequentially, materials that are presented in a variety of modes may lead learners to recognize that it is easier to learn and improve attention, thus resulting to improved learning performance especially for lower-achieving students (Chen & Fu, 2003; Zywno, 2003). Mayer (2003) stated that students learn more deeply from a combination of words and pictures than from Words alone, this, Mayer-described as 'multimedia effect'. The significance of using multimodal learning environment cannot be understated.

According to Shah and Freedman (2003) cited in (Sankey, Birch & Gardiner, 2010), benefits of using visualizations in learning environments include: promoting learning by providing an external representation of the information; deeper processing of information; and maintaining learner attention by making the information more attractive and motivating, hence making complex information easier to comprehend. Fadel, (2008) stated that, "students engaged in learning that incorporates multimodal designs, on average, outperform students who learn using traditional approaches with single modes" (p. 13).

Picciano, (2009) also identified the benefit of it as allowing students to experience learning in ways that they are mostly comfortable and also challenges them to experience and learn in other ways as well. As a result, students can become more self-directed, interacting with the various elements in these environments. So, depending upon their chief learning style, students may self-select the learning object or representation that best suits their modal preference (Doolittle, McNeill, Terry & Scheer, 2005). This is explained by some researchers as different modes of instruction might be most favorable for different people because different modes of presentation exploit the specific Perceptual and cognitive strengths of different individuals (Pashler, McDaniel, Rohrer & Bjork, 2008).

The use of multiple representations, particularly in computer-based learning environments has now been recognized as a very powerful way to facilitate understanding (Moreno, 2002). For example, when the written word fails to fully communicate- a concept, a visual representation can often provide remedy for the communication problem (Ainsworth & Van Labeke, 2002). Some simple examples of multiple representations include, using audio enhanced PowerPoint slides as mini lectures, usually using point-form text or images, interactive diagrams with accompanying transcripts and voiceovers, video presentations, interactive graphs and forms, audio explanations of concepts, and still images. In these examples, the multimedia elements (visual, aural, and interactive elements) present additional representations of the information also provided in text-based explanations. This approach caters for a range of different modal preferences and provides students with choice in how they can access key content, and thus may be considered a more inclusive response or stimulates metacognition to the needs of non-traditional learners. Kress et al called for attention to the functional specialization to the use of different modes to communicate concepts to learners. According to them a mode may develop better understanding than another in certain directions and will therefore have greater potential for meaning-making or impose further limitations. Different modes play specific roles in the construction and representation of concepts in the classroom (Lemke 2003; Jewiit *et al*., 2001). The teacher specialty in the skill of modes of communication may make it appropriate for given relevant instructions in the classroom, as Lemke (1998) stated:

> We can indicate modulation of speed or size, or complex relations of shape or relative position, far better than we can with words, and we can let that gesture leave a trace and become a visual-graphical representation that will sit still and let us re-examine it at our leisure. (p.3).

Learning with multiple mode representations of concepts in the early research concentrated on the ways that presenting pictures alongside text to improve learners' memory for text comprehension (Levin, Anglin & Carney, 1987). In the recent times, the explosive increase in multi-media learning environments have widened the debate to include combinations of representations such as diagrams, equations, tables, text, graphs, animations, sound, video, and dynamic simulations (Ainsworth, 2006). Several researches attempted to discuss the importance of multiple external representations during lessons. Dienes, (1973) argued that perceptual variability of the same concepts represented in varying ways provides learners with the opportunity to build abstractions about concepts. According to cognitive flexibility theory, the ability to interpret, construct and switch between multiple perspectives of a domain is fundamental to successful learning (Spiro & Jehng, 1990). Nevertheless, study on the benefits of providing learners with more than one representation has produced mixed results. While some studies have found that learners benefit from multiple representations (Cox & Brna, 1995; Mayer & Sims, 1994; Tabachneck, Koedinger & Nathan, 1994), others do not find these as beneficial to learners (Van Someren, Reimann, Boshuizen, & de Jong, 1998; Chandler & Sweller, 1992).

2.12 Facilitating Metacognition

Sometimes teachers may try to design learning environment and teaching methods for all the different types of learning styles in class. Inevitably limitations to these approaches arise such as many students do not even realize they are favoured in one way or the other. because nothing external tells them they are any different from anyone else (DePorter, 1992 cited in Sankey, Birch, & Gardiner, 2010), It is therefore observed that when designing learning environments to cater for an array of different learning styles, it is necessary to understand students' metacognitive needs too. Apart from this, helping individual students become aware of their own preferred approach to learning needs to also be considered.

According to McLoughlin, (1999), teaching students on how to learn and how to monitor and manage their own learning styles is crucial to academic success. When students become aware of their individual strengths and weaknesses as learners, they can be more motivated to learn (Coffield, Moseley, Hall & Ecclestone, 2004). The impact of this awareness is that students can question their long-held beliefs, or behaviours, and can be taught to monitor the diverse strategies that can be used to assist them to learn on their own (Sadler-Smith, 2001). This strategy has also been shown to increase the confidence, the interest and the academic performance in terms of grades of students, by helping them to choose the most of the learning opportunities that have been designed to match their preferred modality (Coffield, et al., 2004). Students are therefore encouraged to complete some learning styles inventory forms to able them determine their most learning teaching methods, Teacher should also engage students in many teaching methods to determine the learning instructions that fit better for a class or level of learners

2.13 Differential Impact of Multimodal Instruction on Male and Female students

There are differences across gender in the way students learn concepts. According to Sankey, Birch and Gardiner, (2010), male students have a multimodal learning style with no visual modes compared to their female counterparts. But the females are more evenly distributed across multimodal learning styles. Lau and Yuen (2010) indicated that females have higher preference for concrete sequential and abstract modes compared with males. However, in terms of what stimulus that is presented for learners to react to, there is growing evidence to show that differences of learning, styles in terms of gender are: socially constructed in the science among other disciplines or fields (Milgram, 2009 cited in Lau & Yuen, 2010). These learning styles of student determine the kind of different modes to use in teaching a text. For Hade (2005), the males and females are similar in learning science instead of difference in most psychological variables including mathematical ability. That is to say, the observable difference between males and females are not innate (Lau & Yuen, 2010). Thus, the basic statement wealth noting is that if the gender numerical divide is mainly due to nurture instead of nature, it is then important for educators to nurture a gender sensitive and friendly, instructional environment to engage in active participation and learning if more female or males are in class. It is also clear that there are relatively learning styles between males and females. Nonetheless, much effort has not been made into investigating the possible impact of the gender differences in multimodal instructional approaches on teaching and learning concepts. This study also aims at examining the male and the female differences in multimodal instructional approaches of understanding chemical bonding.

Using the Myers-Briggs Type Indicator, Nuby and Oxford (1996) found some significant difference in learning preferences. From these African American male and female students indicated a worm preference for using different dimensions of instructions to teach concept. Also, Native American male and female students indicated a preference for the intuition and perception dimensions. Regardless of the populations concerned, female students indicated a much stronger preference for the feeling dimension in a study, Wehrwein, Lujan and DiCarlo (2007) investigated gender differences in learning style preferences in a group of undergraduate physiology students. This consisted learning modes preferences in visual (V; learning from graphs, charts, and flow diagrams), auditory (A; learning from speech), read-write (R; learning from reading and writing), and kinesthetic (K; learning from touch, hearing, smell, taste, and sight). The finding from Wehrwein, Lujan and DiCarlo indicated that most male students preferred multimodal instruction, specifically, four modes (VARK), whereas most female students preferred single mode instruction, in particular, the K mode. In another Keri (2002) indicated that more males showed a preference for applied learning instruction that involves the use of everyday life experience as a basis for learning, whereas females tended to be more abstract in that they opted for copious reading assignments, organized learning materials and instructors' knowledge, for learning.

2.14 Student Perception of Multimodal Instructional Approaches

According to Sankey, Birch, and Gardiner (2010), students perceived learning resources with additional modal representations of content, assist them in their comprehension, understanding and retention of content. It also makes lesson more interesting and enjoyable. In particular, students expressed a strong preference for a combination of learning options use in class. Given these findings, it is important for improving student progressive and retentive memories through causing a joy of learning, leading to life-long learning. They therefore suggested that educators and researchers should be encouraged to continue to explore the use of educational technology and modes for developing style multiple representations of content. They also viewed that audio and video enhanced PowerPoint presentations and interactive diagrams with transcripts and audio, in particular, were valued by learners in engaging students through multimodal learning environments.

However, the study of Sankey *et al*. (2010) did not indicate perception of the use of multimodal instructional approaches on learners‟ abilities interpret and comprehend diverse concept representations to avoid, various misconceptions in learning science today. There are students who are multimodal learners and they normally learn across a range of conditions such as aural, visual and realia. The literature has also indicated that multimodal learning may be of greater benefit to lower-achieving learners, while higher achieving learners perform well regardless of how the content is presented, this may be one factor that explains the lack of impact of multiple representations of content on learning performance (Zwyno, 2003).

Teachers face considerable challenges in focusing on multimodal instructions in learning in science. Catering for differences in students' learning experiences and outcomes, developing appropriate assessment methods, and providing effective timely scaffolding for different learner needs entailed a range of complex implementation issues according to Vaughan and Bruce (2008). However, in their study it is confirmed that teachers developed similar practices and viewpoints in relation to the value of focusing on multimodal instructions to enhance student learning. The focus on this approach caters very effectively for student diversity and has the potential to promote deeper learning.

Vaughan and Bruce explained that the focusing of this approach is not open to a tightly structured sequential approach but required flexibility in responding to emerging learning opportunities and diverse student needs, capabilities, and curiosities. The approach also provides opportunities to revisit concepts which are crucial to enhancing student learning. Its translational process enabled students" multiple pathways for conceptual clarification. However, the effective scaffolding is crucial to enabling students to cope with the increased demands of translation work. It is observed that there are complexities in choosing appropriate modes to enhance learning for students with different capabilities because of the differences within individual representational modes. These differences in using modal options influenced the views on effective assessment. In a study of teacher perceptions in using multi-modal representations to support student learning in science, Waldrip, Prain, and Carolan, (2006) noted that this focus could promote deeper learning, but it is not easily accommodated within a tightly structured sequential learning process. Therefore, teachers needed to be flexible to use different modal instructions to be able to emerge learning opportunities and diverse student needs and capabilities. To succeed with this approach, students also needed to be familiar with the nature of the representational conventions in different modes in order to represent and translate concepts across modes. From this research works, it is obvious that the concentration is on the modal representations of concepts. But little is said about the modal instructions to enhance better learning.

The modal focus is perceived as challenging the students to develop meaningful understandings and as catering for individual learning needs, preferences, and skills (Vaughan & Bruce, 2008). But it is to be noted that this focus could entail a broad range of assessment tasks, where links could be made between the classroom program and the local and broader community. Findings seemed to suggest that a cross-modal focus provides a generative framework for developing effective teaching and learning to positive perceptions about teaching methods.

2.15 Empirical Review

The question that science education research must then answer is: how is multimodal instructional approach of concept representation connected to learning chemical structure and bonding? In answering this question, science education researchers must begin to look at how teachers, students and scientists are able to integrate and coordinate the multiple modes of representation in their investigation and conceptualization processes (Bennett, 2011). There is no division between text with diagrams, equations and symbols illustration and text with words in the science literature and textbooks. Every science literature presents concepts in a mixture of modes working together as one comprehensible coherent language (Jewitt, Ogborn & Tsatsarelis, 2001). For students learning chemistry, multiple modes instructional approach of concepts representation can place a high demand on their cognitive processes. This is confirmed as Lemke (2000) stated that what it meant to be able to use a scientific idea and to understand it in the way that scientists do is to be able to easily integrated the verbal, mathematical, and visual/graphical aspects, applying whichever is most appropriate in the moment and freely translating back and forth among them. This ability for teachers to use and manipulate different modal and modes for students to translate the concepts across is the hallmark of student understanding of science concepts instead of rote learning or memorization of the end product in literatures.

The exposure of students to multimodal instruction will let them understand the limitations and implications of each mode that is used, point to the development of the student's chemical bond literacy skills (Jewitt, *et al*., 2001). It is a fact that the introduction of several modes, each being unique in their own way, to communicate a concept solves all learning problems. There are the possibilities that the modes used to represent the concept will be needless or insufficient to capture a complete meaning or the specific meaning intended by the writer (Jewitt, *et al*, 2001). Most concepts demand more than one thought or mode of instruction. Also, many scientific equations, symbols, and theories, in chemical bonding have complex relationship which cannot be taught and summarized with just one mode. For that matter, if teachers and students are to entirely articulate the concept for assessment both local and international then more than one mode of instruction will be required.

Multimodal instructional representation of concept in science covers the entire educational experience that science students can participate in learning process Teachers should be able to integrate a number of modes during teaching to develop a rational understanding of science concept in students. Sometime, teacher writing composition processes in which different modes are used to express the knowledge to learners help them constitute new knowledge which is coherent with those modes.

During a science class, teacher might be using lecturing a concept such as covalent bonding but show a diagram of illustration on the chalkboard and pictures compounds in their textbook or charts, or video illustrating a relationship between the variables. With that short time in the lesson students are overriding a number of different modes of instructions almost simultaneously into a single unified concept for students to understand it. Sometimes there is the demand of many different types of modes to represent concepts that the students are required to follow in a context. If the students have any difficulty in assimilating the information from particular mode to another, then it is likely that they will develop either a partial or flawed interpretation of that concept. When students are able to gain the competency to follow multiple modes in their correct purpose, it may invent an important learning landmark for the student (diSessa, 2004).

In some cases, a student might not understand a concept properly through the use of particular modal. The student in mind will be deeply investigating other modal options to understand that concept by this when different instructional approaches of representations are used at that point the student through the mental investigation may find relationship that can be compared to the his/her schema, resulting to actively learning abound the concept in a way such as forming new or stronger connections within or between concepts (Prain & Waldrip, 2006).

The students may be faced with a particular diagram illustration process, picture, etc. which is so different from what they have seen before. Involving in multimode can make them to reconsider their prior conceptions of the topic. When students are given opportunities or cue through instructions to reconsider their prior conceptions, they are likely to form new connections: add to their previous experiences that will allow them think and communicate about the content more clearly (Vaughan & Bruce, 2008). Interpretation and translation of concepts by students can occur in two ways; teaching approaches use from teachers and ability of a student to learn. During lesson presentation, students are expected to listen, ask questions to clear their doubts or difficulties and give responses to questions in order to express their understanding of the science concepts. Mentally, students compare multi-modal representation approach to be able to articulate their ideas and understanding of the concept and translate it into a new form to give positive response. Students may face difficulties when scientist or teachers consider the important aspect of the content and use a mode that seem not to be most appropriate and convenient to them in order to effectively communicate their ideas as well. The students have difficulty to completely express the entire scope of their conceptions with only one mode of representation or instructions at a time (Waldrip, Prain & Carolan, 2006). The more complex a concept, the more wording and/or multiple modes of instructions the teachers will have to use in order to fully express concepts.

This knowledge establishment of a science concept using multimodal instructional approach is the critical point on which multiple modes of representation intersect with chemical structure and bonding. Teachers must not only insist that students understand and interpret content within a modal representation but must also be able to use multiple modes of teaching to enable students translate between modes when synthesizing a written composition. However, students who are not familiar with any conceptual link between the modes do not translate their understanding across different types of modal-representation (Vaughan & Bruce, 2008). It is obvious from the above-mentioned studio that learners who are able to recognize the conceptual link between different modes of the same concept are able to articulate their understanding of the science concept. Equally, teachers according to the study do not teach their students about clear conceptual connections across the modes or use them significantly as an assessment strategy. Hence little links between multiple modes were made than probably could have if more of the teachers' scaffolding had been provided.

Proper communication in science using modal representation involves that the teachers and students have a good grasp of the rhetorical task and the strategies needed to satisfy it. At the college level students failed to communicate clearly and consistently in class using interpretations diagrams and equation on bonding concepts; they give ambiguous definitions and terms. This ambiguity in communication causes problems among the students when they try to find out meanings among their peers the meaning of equations. Mostly students relied totally on previous examples scaffold by the teachers and are often found not having appreciably increased in their understanding of the Chemical bonds content as a base of interpreting the equations (Bennett, 2011). This finding is troubled with the inclusion of multi-modal representations as a part of classroom curriculum. Bennett explained that just exposing students to multi-modal representation rhetorical tasks may not be a sufficient bridge to reach the level of scientific literacy expected by scientists. There is interesting distinction why students and scientists interpret the graphs differently. Students are mostly motivated to answer questions related to the graphs based upon an external motivation of doing well in examination whereas the scientists depend on personal knowledge from actual investigations in science that come from internal motivation. The differences in motivation are found to be important because the students approach solving the graphical problems in an analytical approach that are not related the concepts in the course whereas the scientists are applying their knowledge from experience in legitimate inquiries in the content domain and therefore provide more interpretations of the graph that are grounded in science content knowledge.

Also, students are motivated to learn when they are involved in concepts through representations and re-representation than the use of traditional method (Vaughan & Bruce. 2005). The repetition as an intervention used does not only allow for additional time on task but practice with the content and practice with the modes of representation. This discovery supports the work of multi-modal representation that focused on the assessments of which modes are to be used in conjunction with representing the original concept. Students are found to perform better in science when they understand that there k no single modal representation that explains the entire concept. These students are to be encouraged to only include modal representations that were clear, unambiguous, gave minimal but sufficient information, and are comprehensive to its rhetorical purpose (diSessa, 2004).

However, students who do not perform as well lack an adequate understanding of who and where to use certain modes to clearly communicate their understanding. These students who struggle with the concepts and rhetorical tasks needed more practice and scaffolding of teaching method from teachers to be competent in that area. This competence could also be interpreted to mean that students who have a greater repertoire of modal representation are more fluent in the language of their science (Bennett, 2011). That is, students with a broad range of representational competence are able to read and write science more accurately and sufficiently. In fact, the students with profound, modal representational knowledge of science concepts are more literate in science (Chemical structure and bonding), and teachers with adequate multimodal instructional approach of concept representation are competent teachers.

2.16 Summary

The literature so far showed a discrepancy between what is termed as scientific knowledge and students' knowledge in chemical bonding. This difference was observed to be among others things, the methodologies used to direct learning process.

Chemical bonding is highly abstract in nature, therefore it is considered by chemist and learners as very complicated concept to understand (Robinson, 2003; Taber, 2001). Diverse modes of concept representations are used to explain and interpret the process of bonding. Disperse essential importance from several literature and multiple modes or representations of chemical bonding, learners still think it is a very complex and difficult concept to be understood. It is therefore necessary to consider the instructional approach that can be used to teach this topic.

However, Bennett (2011) indicated that learners' difficulties to interpret and construct a concept depend on human learning process such as instructional approach and the intrinsic nature of the content. Both the nature of the scientific models and the way a topic is taught contributes to students' learning difficulties (Levy, Mamiok-Naarnan, Hofstein, & Taber. 2010). When the right instructional approach is not used, creates learning difficulties. But Multimodal Instructional Approach (MIA), in some contexts, significantly influences learning multimode representations in curriculum materials. However, there still remains a considerable amount of research to identify how and to what extent can the approach improve a student's metacognition and science literacy is a matter of concern (Yore &Treagust, 2006). Also, identification of effective scaffolding teaching strategies that will give students timely knowledge on how to interpret and construct multiple scientific concepts such as chemical bonding is needed (Vaughan & Bruce, 2008). In recent times, the use of pedagogical content knowledge which teachers are supposed to have is the knowledge of a particular topic, problem, how to organization issues, and represent them. They are to adapt in their methodologies to suit diverse interest and abilities of learners. This approach over simplifies ideas, not in line with up-to-date scientific knowledge, and failed to develop conceptual understanding (Kind, 2009).

It is used at the expense of a professional capability such as providing suitable platform for future learning. Multimodal representations of concepts are what scientists used to communicate ideas and findings among themselves can be best explained through using multimodal instructions (Bennett, 2011). It is because every mode and modal approach does not fully explain any scientific concept. When learners face difficulties in learning representational modes, they consult teachers who need to use multiple modal instructional strategies to help them out. Apart from using multimodal approach in the same topic, there is the need to investigate the link between the multiple modes of representation in science and teaching by multimodal instructional approach of learning science literacy (Sankey, Birch, & Gardiner, 2010).

But the problem found from the research works is that Teachers often attempt to use multiple resources for teaching and learning rather than on modal diversity for teaching in class. Again there are research works on how effective teaching method such as only verbal modes or combination of two instructional modes has impact on learning (Sankey, Birch & Gardiner, 2010). But there has not been research on the effect five multimodal instructions on students' understanding of concepts. Teaching and learning in science should involve the understanding and conceptual link between multiple representations in curriculum materials and multimodal representation of the same context (Dolin 2001; Russel & McGuigan, 2001). Multiple instructional representations are showing the same concept in different form such as verbal, graphical and chemical equations in the curriculum material. Multimodal instructional approach is integrating different modes within the same topic to explain scientific concepts for learner to understand it better. Multimodal engages learner in more than one sensory mode to make learning easier, improve attention and performance especially for low-achiever (Che & Fu, 2003). Diverse modal promotes learners' interest and cater for individual learning styles, and enable students interpret concept and construct ideas in different modes for effective communication (Sault, 2004). Nuthall, (1999) indicated that students need more than two experiences in order to develop long-term knowledge of a concept. However, some modal representation of concepts is not utilized and must be effectively included in the classroom practice. The reason is that students engage in learning that incorporates multimodal designs on average outperform students who learn using traditional approaches with single modes (Fadel, 2008).

From the literature reviewed, a lot of research has gone into how to effectively instruct the concept of chemical bonding but no investigation is carried out on the effectiveness of the multimodal instructional approaches in teaching and learning of chemical bonding. Researchers who have used the approach never used five multimodal approaches or tested it in the colleges of education in two different regions of Ghana. Researchers in this area did not also use different test items with equal difficulty levels in their investigation. It is therefore obvious that more research is needed in this direction. The researcher therefore deemed it necessary to investigate the effect of multimodal instructional approaches on the Offinso and Berekum colleges of education in Ashanti and Bono regions of Ghana students' understanding of chemical bonding.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter consists of the research design, the population, the sample and sampling technique. Also, the research instruments, pre-treatment, treatment procedure of data collection and method of data analysis are also described in this chapter.

3.1 Research Design

In this study, the quasi-experimental design was used. It involved assigning the research subjects between two groups, a control group and an experimental group. This design permitted the two groups to be pre-tested and post-tested with different test items of the same difficulty level. The ultimate difference was that the students of Offinso College of Education who were the experimental group received the treatment. However, Berekum College of Education students did not receive the treatment since they were used as the control group. Both groups were taught by the researcher during the study. The traditional instructional approach was used to teach the students of Berekum College of Education who represented the control group, whiles multimodal instructional approach was used to teach the students of Offinso College of Education assigned as the experimental group. The lesson involved step-by-step procedures beginning from the introduction through exploration, explanation and solution, and taking action.

This design was used because it allowed a number of distinct analyses and gave the researcher tools to screen out experimental and confusing variables. Also, the internal validity of the design was strong because the pre-test ensured that the groups were equivalent in achievement level. The design analyses of the various performances at each test levels are shown in Figure 1 below

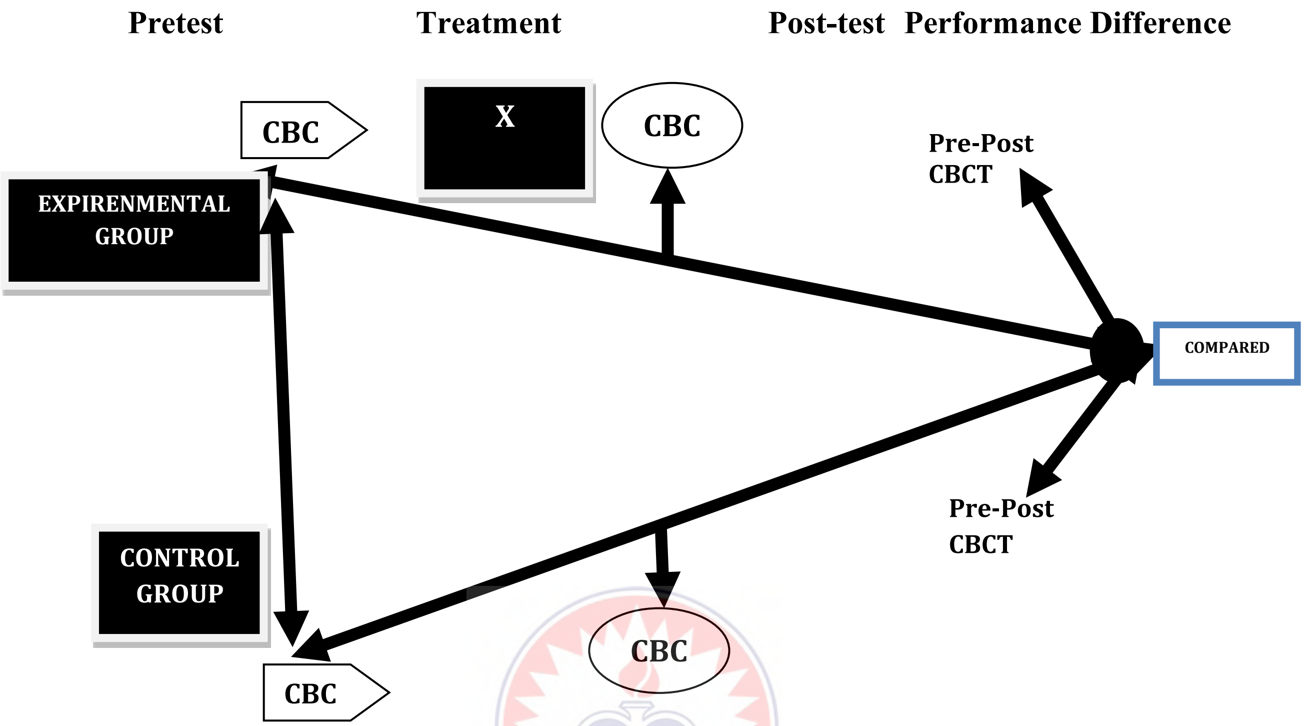

Figure 1: Pretest post-test experimental design
(CBCT: Chemical Bonding Content Test, and X; exposure to treatment)

X indicates the exposure of an experimental group to multimodal instructional approaches after the both the control and experimental groups have responded to pre-testing items. The two groups were randomly selected and designated as experimental group and control group. Only the experimental group received the treatment and also responded to the questionnaire. However, both groups took part in the post-test activity.

Martyn, (2009), the design allows the researcher to compare the final post-test results between the two groups which give the researcher an idea of the overall effectiveness of the treatment. Again, it enables the researcher to find out how both groups changed from pretest to post-test, and whether only one improved, and to what extent after the lesson. If the control group showed a significant improvement, then it will inform the researcher to look for what accounted for that. The design would also allow the researcher to compare the test scores of the two pretest groups, to ensure that the randomization process was effective. Apart from evaluating the effectiveness of randomization, it would also help to determine whether the treatment group showed a significant difference.

The treatment (X) used each in the experimental group is the five multimodal instructional approaches. These approaches emphasize the integration of five different modes (methods) of instructions. The modes of instructions used here were; realia, visual, analogy, symbols and verbal interaction as shown in Figure 2 below

Figure two illustrates how the five modes of instructions mentioned above are related in other to ensure effective delivery of content.

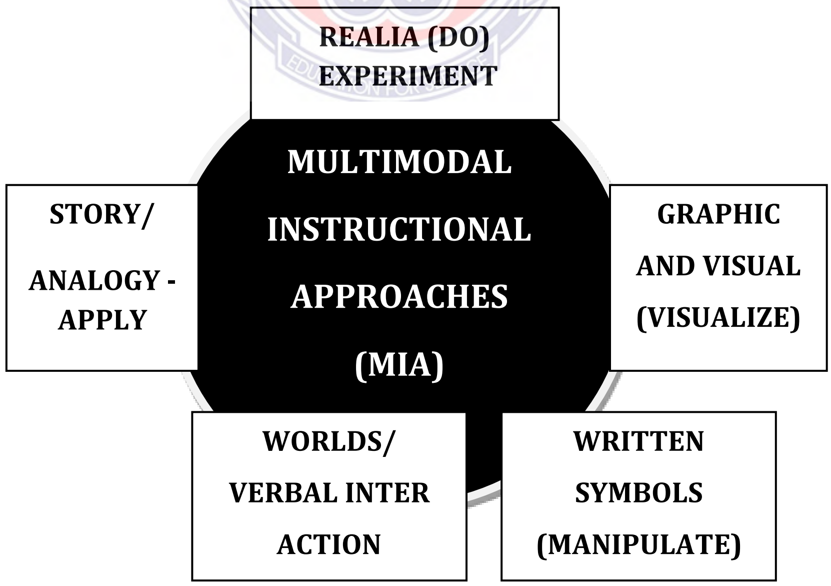

Figure 2: The five modes of instructions

This Pent-Multimodal instructional approaches Framework was an extension of the Think Board consisting of four modes introduced by Hay (1984). The extension includes more modes and uses words that are easy to understand by the target students. Symbol manipulation mode; this was the most predominant mode of instruction used because chemical bonding concepts are taught mostly by symbolic representations. Also, many science curricula all over the world include a large amount of work on manipulations of symbols, such as simple alphabets and numbers. However, many students find symbolic manipulations difficult and meaningless, and they fail to appreciate the power that symbols play in science thinking. Hence it was integrated with the other modes of representation to promote the understanding of bonding. Verbal interaction mode; Words are essential in communicating science ideas and in thinking about them. As -a mode of instructions, it includes word or phrases- and sentences. Students often confuse the meanings of the same word when used in everyday situations and in science. This problem becomes more severe when students learn science in foreign languages.

In classroom teaching, the teachers wrote on the board the key words and phrases to be learned, ask students to read them aloud and copy them in their notebooks. The teacher explains their scientific meanings as clearly as possible to learners. Teachers explain science terms precisely and consistently. This helped many students who failed to link the spoken sounds with the written words or symbols. Students were encouraged to use the proper words when talking about bonding.

Visual and Diagram-Visualize, This mode of teaching includes diagram illustrations, charts, and computer animations. They appear in textbooks, chalkboard drawings, and computer screen displays. Diagrams come in various degrees of abstraction, and carry scientific ideas in an interesting ways, and constitute a crucial mode of processing. Drawing diagrams is an important problem solving heuristic which many scientists use.

Realia: This mode of teaching refers to the use of concrete manipulative such as concrete object. This is based on the psychological theories of Piaget and Bruner (1964). It is related to the principle of learning by doing: I hear and I forget; I see and I remember; I do and I understand. Foundation abstract chemical bonding ideas in concrete situations, students may develop the mental models that provide meaning to the abstract 'symbols which will reduce anxiety towards chemistry. The cross-over from practical activities to formal abstraction, however, is not easy (Johnson, 2004). Teachers need to work harder to facilitate this transition through careful questioning, discussion, prompting, and explanation.

Story/ analogy -Apply; Chemical bonding has important applications in everyday situations and in the study of other subjects. Linking real-world applications to "curriculum representation" not only reinforces concepts but also enhances motivation The Story mode includes traditional word problems and problems related to everyday situations and reports.

3.2 Research Population

A research population is a large well-defined collection of individuals or objects having common characteristics (Castillo, 2009). According to Castillo (2009), there are two types of populations: the target population and the accessible population. The target population also known as the theoretical population refers to the group of individuals to which researchers are interested in generalizing the conclusions. Whiles the accessible population which is also known as the study population is the population which is available for the researcher and to which the researchers can apply their conclusions. The target population for this study was all first-year students of Integrated Science of 2020/2021 academic year in two colleges of education in Ghana. The first-year students were chosen because chemical bonding is studied in the first semester of first year and the students had been introduced to some concept of bonding at the Senior High School level. However, the accessible population was all first-year students in Offinso College of Education and Berekum College of Education. These institutions were chosen because they run the same programmes, which are general courses, and have the bonding teaching materials. Also, they were selected due to the convenient reached of the researcher and the willingness of the institutions to accommodate the study.

3.3 Sample and Sampling Technique

A sample is a true representative group selected from the population for observation in a study (Ary *et al*., 2002). The sample for the study was 120 first year students of Offinso and Berekum Colleges of Education in the Ashanti and Bono Regions respectively. Sixty students (30 males and 30 Females) were also randomly selected from Offinso College of Education as the experimental group and were instructed using multimodal instructional approaches. Whiles the students in Berekum College of Education were assigned as the control group and were instructed using traditional designed approach. These two schools were used in order to avoid interactions between the control group and the experimental group. Additionally, when one institution is used, the human interactions may occur as a result of students' group discussion after normal classes or during prep hours. The classes of each of the colleges were chosen due to the fact that researcher wanted a fair representation of male students and female students. Thirty students with equal number of male and female were selected from each class by randomly selecting their index numbers without the student been aware the consent of the students in both groups were duel sought.

3.4 Instrumentation

The study used both quantitative and qualitative data gathering instruments. These were questionnaire, semi-structured interview guide, and Chemical Bonding is Concept Test (CBCT). Questionnaire is used for collection of data in educational research when information is to be widely used for large number of subjects. It is also effective for getting factual information about opinion, practices and attitudes of a subject (Amedeker, 2000). The test and the students, perception scale questionnaire constituted the quantitative part of the research instruments while the interview schedule constituted the qualitative part of the research instruments.

3.4.1 Questionnaires

A questionnaire was designed based on the purpose of the research questions to obtain the views of learner‟s perception about the use of multimodal instructional approaches. According to Hannan (2007), questionnaires are straight forward written questions which require an answer by ticking the appropriate box; an efficient way of collecting facts. They are also employed as tools to gather information about people's opinions through asking the respondents to indicate how strongly they agree or disagree with a statement given. It is done by providing respondents space in which they formulate their own responses.

All the items on the questionnaire used for the study were closed-ended type. The items were Likert-type of scale. Likert-type scale was used because it is easy to construct and more reliable than-others scales (Tittle & Hill, 1967). The scale also provides the researcher the opportunity to use frequency and percentage as well as means scores to compute the data. Likert scales are often observed to give data with relatively high reliability (Gabel & Wolf, 1993).

The questionnaire consisted of demography of the students and the close-ended items to demand specific responses to be expressed on a five-point Likert scale. Items on the questionnaire which were not clear to respondents were explained to them in order to elicit the right responses. A detail of the questionnaire is found in Appendix D.

3.4.2 Chemical Bonding Concept Test (CBCT)

A test is a tool or procedure for measuring a sample of behaviours. To measure the performance level of students in the chemical bonding questions which were developed by the researcher. The content was determined by examining literature developed according to the course outline and instructional objectives for the chemical bonding in the text unit. During the development of the test, instructional objectives of chemical bonding topic were determined to find out whether the sampled students achieved the objectives of chemical bonding and purpose of this study. The questions were reviewed by the researchers supervisor and pilot tested. This test contained twenty content test items. Each question in the test had one correct answer and three distracters. The researcher also set questions parallel to the past questions for FDC 114 and EBS 132 examinations conducted by the Institute of Education, University of Cape Coast. An Appendix B indicates the detail marking scheme of the CBCT. The test was administered twice during the study; that is before the treatment as pretest and after the treatment as post-test to the two groups as in Appendix A.

3.5 Interview

Kvale, (1996) stated that interview is an interchange of views between two or more people on a topic of mutual interest, seen as central of human interaction for knowledge production emphasizes the social situation of research data. Interviews are systematic way of talking and listening to people to collect data as well as gain knowledge from individuals. The researcher used semi-structured interview schedule for the study to get insight into student‟s conceptual understanding of the use instructional methods. The interview was scheduled for student only. It was used to seek student‟s views about multimodal instructional approaches. The interview was the instrument used to gather qualitative data. The interview items are found in Appendix C.

3.6 Validity of the main Instruments

Validity of a research instrument is how well measures what it is intended to measure (Patton, 2007). The test items and questionnaire were examined by experienced chemistry teachers who have taught for six years based on the cognitive levels of students and the instructional objectives outlined in the course plan for colleges of education. The instrument was vetted by the researcher's supervisor to determine the extent to which the test measures a representative sampled of the domain of tasks with respect to the chemical bonding topic. The interview items were given to the researcher's supervisor to find out if they elicit appropriate information from the participants.

3.7 Reliability of the main Instruments

Reliability concerns with the extent to which a questionnaire, test or any measurable procedure produces the same results on a repeated trail. That is, it is the consistency of score over time. To ensure reliability of the instrument, the instruments were tested using test-retest reliability method. The instruments were first administered and then re-administered on the same respondents after one week. The result of the first test and second test outcomes were compared to ascertain the reliability of instruments. The reliability of the test using Cronbach alpha reliability coefficients was calculated to be 0.72. The reliability coefficient of the pretest and post-test were calculated to be 0.76 and 0.79 respectively using Cronbach alpha reliability test.

3.8 Pilot Test

The research instruments were pilot-tested personally by the researcher at Wesley College of Education, Kumasi which was not part of the accessible population. The instruments were administered to 20 students of the college. The results were analyzed to determine the validity of the instruments. Items that needed revision were revised. This piloting process was important because it improved the content validity and reliability of the test and improved the formats.

3.9 Pre- Treatment Activity

This phase consisted of two activities which were done to ascertain the level of students' performance and understanding of chemical bonding concepts in the two colleges of education. The first activity was to interact with students to identify them by names and also revised with them some of the concepts learnt in the previous term. The purpose of this first activity was to create a cordial relationship between the researcher and the students. It also informed the researcher about the students' previous knowledge on bonding. The second phase was the administration of pre-test of CBCT items which were determine the level of students' understanding and their ability to interpret and comprehend chemical bonding concepts in chemistry. This test was conducted to help establish the basis as to whether the use of MIA could improve students' understanding of learning concepts. Besides lesson plans were prepared for the two groups. The lesson plans guided the researcher to teach the topics according to course objective and methods systematically.

3.10 Treatment of the Groups

The treatment process was conducted over a four-week period. Offinso College of education was assigned as the experimental group and instructed through the use of multimodal approaches and Berekum College of education was instructed using the traditional instructional approach.

3.11 Data Collection Procedures

An introductory letter was taken from the Head of Science Education Department of University of Education, Winneba to seek permissions from the Principals of the two colleges to use their institutions. Data of this study was collected in four stages. The first stage was the pre-test data collected from Chemical Bonding Concept Test (CBCT). The second stage was collection of data from the post- test CBCT which was conducted after exposing experimental group and to control group to determine students' performance. The third stage was the data collected from questionnaire. The questionnaire was only administered to experimental group. The final stage was collecting data from personal interview with the experimental group. It was scheduled and conducted at the end the intervention when chemical bonding was completely taught, to obtain the students' perception about the use of multimodal instructional approaches in teaching and learning process. The questionnaire and interview administration were conducted on the same day that post-test data was collected. This was done so to allow students respond according to their feelings about the approaches. This was on the assumption that the feeling about the approach was fresh in students' mind. The interview between the researcher and the respondents were recorded with an audio device. Interviews and questionnaires were the basis for subsequent qualitative data analysis.

3.12 Method of Data Analysis

The researcher analyzed the data collected by using both quantitative and qualitative methods of data analysis. Date from questionnaire and tests were analyzed quantitatively whiles data from the interview was analyzed qualitatively. Analyses of the results obtained from the study were carried out in four (4) phases.

The statistical analysis of the tests (pretest and post-test) was carried out first. The descriptive statistics such as means, mean difference, standard deviation and t-test of both experimental and control groups were computed by computer Statistical Product and Service Solutions (SPSS) version 20.0 programme. These descriptive statistics were used to summarize the general, trends in student performance. The purpose of descriptive statistics is not only to describe the data from a study but also to help find pattern within the data described and to inform inferential statistics as well. Study of central tendency indicated the overall performance of students in the groups; different groups and different academic performance levels. Inferential statistics was used to identify significant difference within the quantitative data for the purpose of answering the research questions. Inferential statistics such as students‟ t-test was performed at the 0.50 level with 2 tails. The inferential statistics used in this study was used for answering the quantitative aspect of the research questions as well as testing hypotheses stated earlier in the first chapter of the study.

The second stage was analysis of questionnaire data. Descriptive statistics such as frequency tables and percentages were employed to compute the results for analysis. This qualitative data analysis contributed to both descriptive and inferential interpretations from the quantitative data. Together, the results of the study provided the basis for the significance and implications of the study as well as possible future research.

Qualitative data was used to analysis the student interviews and questionnaire. An in-depth qualitative analysis such as the constant comparison method was used to answer the research question on the students' perception about the multimodal instructional approaches. The qualitative data was used to assist the quantitative data in the interpretation of result.

The data collected were on the assumptions that;

a. There was no interaction between the two groups.
b. The tutor was not biased during the treatment.
c. The tests were conducted under standard conditions.
d. The participants sincerely answer the questions in the instruments.

3.13 Ethical Issues

The researcher needed to protect the identity of the students and the institutions, develop a trust with them and promote the integrity of the research. During the process of data collection all the students in the class and the two groups benefit from the use of MIA. The students who were interviewed were assured of confidentiality. The researcher respected the research site by not allowing the treatments to interfere with the institution's programmes and disturb them after the study. For data analysis and interpretation, the researcher ensured the anonymity of individual students by the use of aliases and pseudonyms for individuals. The researcher also provided accurate account of the information from the data collected.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents the results, findings and discussions of findings of this study to provide an understanding of the effects of the use of multimodal instructional approaches used to instruct college students on chemical bonding. The results and discussion were presented in the order of the research questions and the null hypotheses. The guiding research questions of this study were to determine whether the student in the colleges of education should perform well academically in chemical bonding or not when they are taught by Multimodal Instructional Approaches (MIA). The primary source for data about chemical bonding literacy was the academic performance in the pretest and post-test scores for both students instructed by Multimodal Instructional Approaches (MIA) and Traditional Instructional Approaches (TIA). The student t-test analyses of the collected data were performed alongside with the discussion. Additional qualitative observation and interviews were collected as well in order to help explain the nature of quantitative results and to also determine the attitudes students towards this study were intended to complement one another MIA and TIA. All the data from this research were to evaluate the effects of using MIA on the students' in order to provide evidence for the understanding and perception on the concept. Major findings of the study are discussed below the tables in line with available literature.

4.1 Background Information on the Research Subjects

The number of samples used in the study is 120 students (teacher-trainees) of Offinso and Berekum Colleges of Education. The two colleges were sampled with equal number of students and each also had equal number of male and female students (50% males and 50% females). The students' ages were between 19 and 25 years.

Table one contain frequency and percentage distribution of sampled students and the programs they read at Senior High School level.

Table 1: Courses offered by sampled students

Programme	Frequency	Percentage
Science	6	10.0
General Arts	15	25.0
Agricultural Science	4	6.7
Business	20	33.3
Languages	6	10.0
Vocational	9	15.0
Total	**60**	**100**

Figure three contain frequency and percentage distribution of sampled students and the programs they read at Senior High School level.

The courses that the students offered at Senior High School level are 10% science, 25% Arts, 6.4% Agriculture Science, 33% of Busines, 10% Languages and 15% Vocational Science.

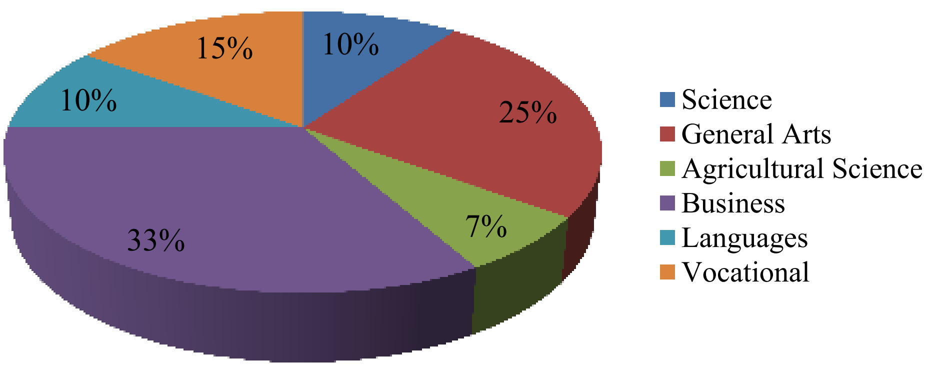

Figure 3: Programmes offered by sampled students

4.2 Presentation of the Results According to the Research Questions and Hypotheses

Research Question 1: What causes the difficulties students face during lessons on chemical bonding?

The findings observed from the study did reveal a number of factors that cause students' difficulties in learning chemical bonding in schools. These results were determined in relationship with the type of instructional methods used to teach chemical bonding concepts. It was observed after the pre-test scores that the students could only memorize definitions of terms rather than able to interpret and comprehend the concepts. Considering the total sampled group used for the study, the mean score (X = 7.1833) showed that the overall performance was below average performance (marks within 8-14). This was because the questions were to test students' abilities to interpret, comprehend and construct the abstract concepts which they could not do. It was also observed that during teaching of the topic that the alternative-knowledge (misconceptions) and even the teachers' misconceptions on the concept cause learning difficulties for students. When analogy was used to explain a concept, some students either became confused or misinterpreted the concept hence it interfered with the students" learning.

For instance, it was observed during the lesson that students tried to justify their answers or ideas by say "my former chemistry teacher explained it that way .... , and I also read it..." Again, the type of instructional method used, the way it is taught, revealed that students find it difficult in learning chemical bonding. Especially, it was indicated by students that lecture method does not cater for most of their learning differences in class. This was confirmed by the mean score differences between post-test score of control group and experimental group (mean difference= 6.650) which is shown in table 4 and as many as 13.3% of the total students scored below the average marks after they taught by TIA indicated Table 1 and Figure 3. When the students were interviewed several findings were also observed as follows;

Student interview

Male student; The male student is 23 years old and has been recognized as the best chemistry student two times at the Senior High School level in the school. He was also part of the experimental group. He believed that engaging with embodied of different modes of instruction that involved students' manipulation of symbols, video and verbal using technology were the keys to effective understanding or learning. And that physical learning instruction for chemical bonding learning should involve a range of instructional modes including 2D and 3D models as well as manipulative symbols and concrete example;

> *"I want the use of words, the use of drawings, the use of videos and computer animations, relating things learn to life situation, the use of experiment and drawings to teach a topic. Sometimes one area is not clear to me but the other will be"*

He thought using 2D and 3D models, symbol manipulation videos and verbal account to explore the concept should be involved in a chemical bonding. He also explained that engaging with different modes results in various dimensions of the concept being highlighted to him. He thought that diversity of instructional modes should be factored into the learning process, not only in chemical bonding.

I think of different modes to teach science gives me a physical representation and understanding of what it is. The concepts teacher wants to teach; I can physically see it, see how it works, hold it or feel it. Drawing and illustrations, symbols illustration computer videos are pictures way of looking at a number of concepts. Words should be used to explain the concept seen videos. Illustration by using symbols to help me understand what am learning and be able to use it or explain to other people.

She offered a more extended rational for the importance of teachers using multimodal instructions in learning process. He revealed that each mode of instruction provides a necessary contribution to the teaching and learning process in that engagement with each mode strengthened students' understanding of the underlying concept. From the following commentary, He seemed to value an integrated approach of instruction with the reason that it would require him to engage in an active translation across modes.

It gives me opportunity to interact with the concept in various ways, and I'm able to construct my own understanding. If am taught just one way, am able to explain the concept well, or when asked to say it in different way can do it. So, if am taught in multimodal ways, it will provide bases for me to understand in a way without weakness and my understanding will become strong.

While recognizing the general value of multimodal orientation to learning, he did not necessarily prefer a highly prescriptive sequence use of multimodal instructions. He claimed that the types of modes of instruction should not necessarily follow particular order to address students' aware learning styles. But believed that the teacher needed to be aware of the learning opportunities as they emerged in class and address them through different modal explanation. He argued that it was important to explore conceptual links from different point of views. He considered that this approach was achieved by making use of different modes of instructions to develop the concept and to address learners' differences;

> *"If the concept is "how electrons are transferred" then I would expect different modes of instruction such as videos or computer animations, diagram illustrations, verbal explanation etc. but not only lecturing. Its' not about doing the same activity time and time again, but its bringing together in different context"*

As the above abstract makes clear, He thinks that focus on multimodal choices should be connected to an integrated holistic approach to concepts. In terms of supportive and productive learning environment, He thinks that a multimodal instruction focus could be helpful according to know learning style in class.

> *I think that majority of us students differ in the way we learn things; some learn by visual than others; some by listening than others; some by performing experiment or manipulation of symbols only than others. But I think majority of us learn when those situations are combined and used together. Very few of us learn one particular way only. But some of my colleagues always have difficulties with whichever mode that teachers use.*

This account also suggested that he, while there is the need to expose the learners to a range of different instructional modes some of the students are more likely to react positively to particular modes of instructions.

Female student: This student offered chemistry as an Agriculture student in the Senior High School level. She is 20 years of age. She had one of the best grades among the female students in chemistry subject. She described her main problem of learning chemical bonding to be inquiring based, including 2D and 3D models and objects and also drawing, pictorial, experimental and physical modes of instruction. She did not see multimodal as a process that needed high structured procedures but rather a necessary aspect of a highly integrated approach of teaching. To her the importance and value at using different modes was to be able to develop in students deeper understanding of concept. She also agreed that there was the need for supportive and productive learning environment to teaching chemical bonding. She saw that multimodal instructions were way to cater for variety of learning style for better understanding. She claimed there was the need for a connection between informal and formal learning studied.

> *I think multimodal ways give me a variety of ways to understand where any lime or whenever way the questions are set, I can answer them with confidence. It also serves as a reminder in my mind; I see the concept clear in mind and how it works in my daily life. I agreed that students need opportunities to revisit ideas, but it shouldn't monotonous.*

She agreed that she needed opportunity to revisit ideas, but this repetition needed to be involved with small variation so that activities do not become monotonous. She saw the need for discussing the realia or visuals guided by the lifter or peer based. It think two things that were most effective; one I would say the practical activity Used and interacting with material and actually seeing what was happening in explaining concepts. The other thing was the way we were allowed to discuss what topic was showed to us both in videos and symbols." It was effective because we were able to actually explain ideas among ourselves and swapping ideas with each other"

She considered that she was different and varied considerably in the ability to interpret and construct concepts; hence the need to be instructed with different modes to address were learning benefits gained when she or the students' diversity. According to her there her colleagues are engaged with modal diversity;

> *Some of us in a class would have benefited from symbol manipulation and view animation of how bonds are formed or verbal way of teaching. But my colleagues may find it difficult to look at letters and number and interpret what they mean. Some too may be comfortable when a teacher use analogy to explain a concept. However, 1 think for many of us students, the most id effective way to get across their ideas is to see the actual video with verbal men, the performing experiment, and use symbol illustrations to depict explanation concepts as seen in books. So, 1 don't think students in general learn in ruction.*

This means that the type of modes that a teacher wants to use, the topic, experience and ability of the students and learning preferences should not totally dictate the modes used.

She also acknowledges that translation of main meaning of concepts across different modes was easier for most students;

> *If you want each student to tell you what they have learned, and they are not getting it when teacher changes the question to different ways, the student easily gets it. So, the way teachers need to teach content in different ways: Teacher can use maybe analogy to lecture their students but the uses of words only are not sufficient enough to explain concept.*

Research Question 2: What is the effect of multimodal instructional approaches on the students' performance on chemical bonding?

The researcher want find out the extent to which the MIA of teaching, the chemical bonding concept will help improve students' understanding of the concept. Table 2 and 3 present the frequencies and percentage distributions of the pre-test and post-test scores of the students in the experimental and control groups.

Table 2 and figure present the frequencies and percentage distributions of the pre-test and post-test scores of the students in the control groups.

Table 2: Frequency distribution of pre-test score of students in the control group

Marks score	Frequency of Pre-test	Percentage (%)of Pre-test	Frequency of Post-test	Percentage (%)Post-test
0-7	28	46.7	8	13.3
8-14	30	53.3	47	78.4
15-20	-	-	5	8.3
Total	**60**	**100**	**60**	**100**

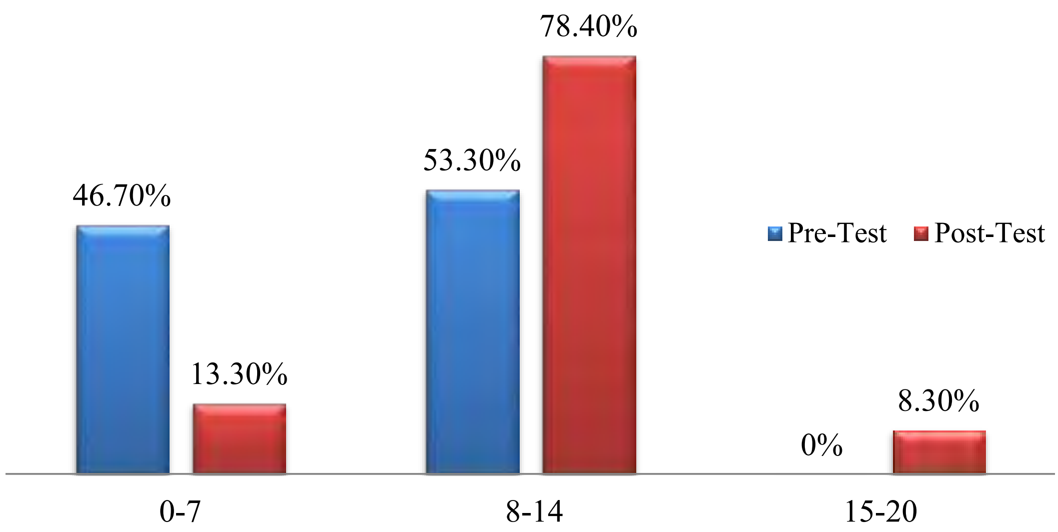

Figure 4: Frequency distribution of pre-test score of students in the control group

The result of Table 2 and Figure 4 showed that out of 60 students, 46.7% of the students scored marks within below average performance (0-7). Largely, 53.3% of the students scored marks within the average performance (8-14) in the pre-test. No student scored mark of the above average Performance in the pre-test. However, in the post-test after the student were taught by TIA, about 13.3% of the students still scored marks in the below performance level. Also, 78.4% students and 8.3% students scored marks in average performance and above performance ranges respectively, which indicates slight increase in sampled students perform. The increased in the percentages of average and above average, revealed that the TIA has positive effects on some learning of chemical bonding. Table 3 and figure 5 present the frequencies and percentage distributions of the pre-test and post-test scores of the students in the experimental groups.

Table 3: Frequency distribution of pre-test score and post-test of students in the experimental group

Marks score	Frequency of Pre-test	Percentage (%)of Pre test	Frequency of Post-test	Percentage (%) of Post-test
0-7	34	56.7	-	-
8-14	26	43.3	9	15
15-20	-	-	51	85
Total	**60**	**100**	**60**	**100**

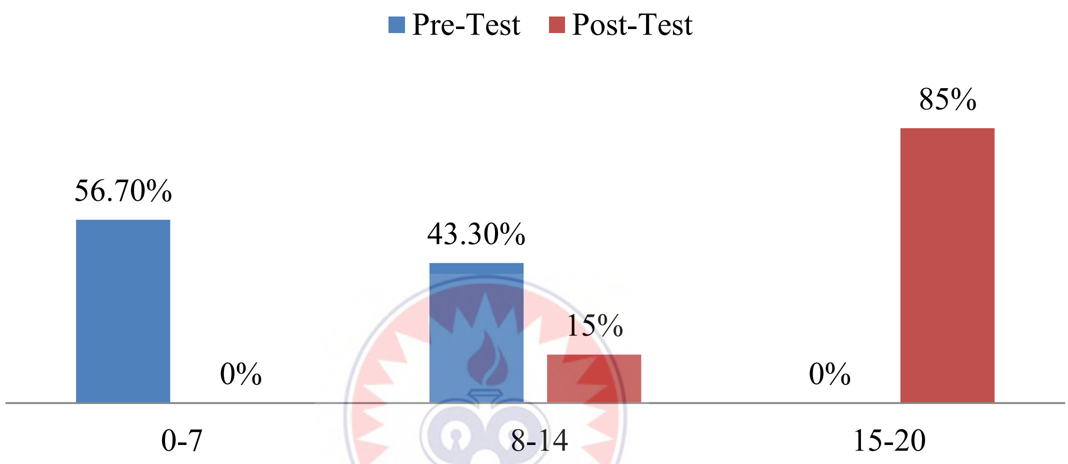

Figure 5: Frequency distribution of pre-test score of students in the experimental group

From the result of Table 3 and Figure 5, a higher number of students in the experimental group, about 56.7% scored within the below average marks in the pre-test. Also, 43.3% of the students scored mark in the average marks. No student scored marks above average performance in the pre-test.

However, after the experimental groups were taught by MIA and post-test, administered, no student scored marks within below average marks. 15% of the students scored marks within the average mark range. Highly, 85% of the students scored marks in the above average performance level. These higher marks scored at the above average level and no student scoring marks in the below average suggested that MIA of teaching have a higher positive effect on the students' understanding of chemical bonding. The Table 4 shows the results of the post-test marks scores, in percentage, of students in the experimental group and the control group. The scores were to determine the performance levels of the two groups.

Table four and figure six below present percentage distribution of post-test of both the experimental group and the control group

Table 4: Percentage distribution of post-test of students of the experimental group and the control group

Marks Score	Percentage (%) of Control Group	Percentage (%) of Experimental Group
0-7	13.3	-
8-14	78.4	15
15-20	8.3	85
Total	**100**	**100**

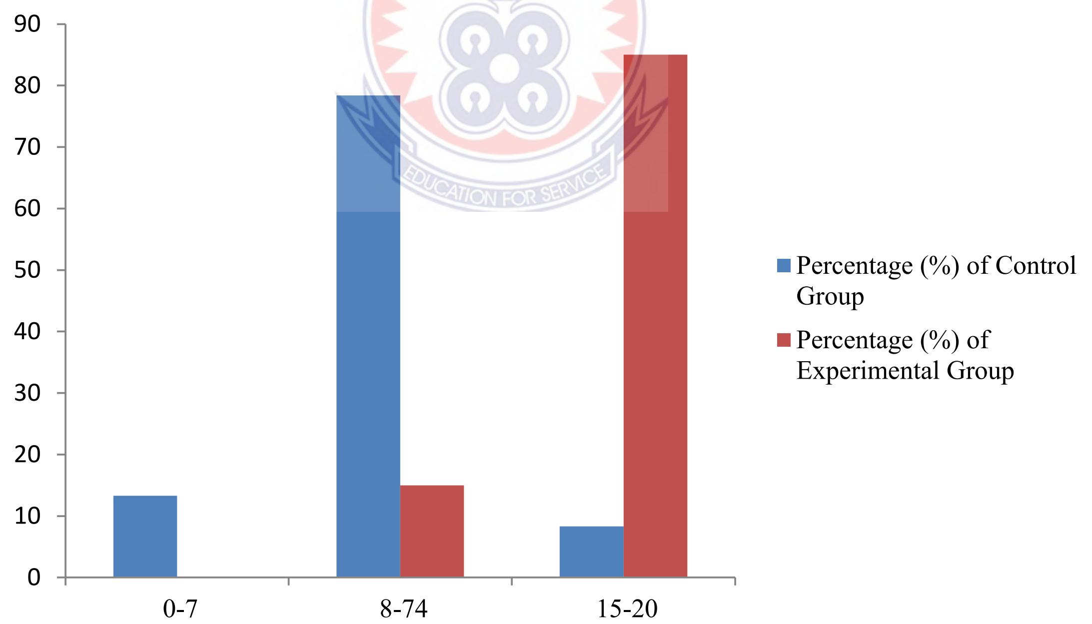

Figure 6: Percentage distribution of post-test of students of the experimental group and the control group

Considering the result in the Table 4 and Figure 6, whiles no student scored marks in the below average marks from the experimental group as many as 13.3% of the students scored marks in it from the control group. In the above average marks score, only 8.3% of the students from control group scored the marks while as high as 85% of the students from experimental group scored the marks. These results means that students learn better and understand the concepts of chemical bonding when they are taught by MIA than when they are taught by TIA.

The results of the analysis between pretest and post-test scores within the two groups indicated that there are significant differences of means for each group, $p < 0.05$. The extent to which there were differences in each groups pretest and post-test scores was determined. The result in table 4 revealed that the significant difference level between pretest and post-test mean score of experimental group students is three times higher than the significant difference of the pretest score and the post-test of score of the control group (X difference of experimental group= 9.967, X difference of control group = 2.983).

Research Question 3: What are the differential effects of using multimodal instructional approaches on the male and female students' performance on chemical bonding?

The additional research question in this study was to determine whether there was no significant mean difference between male and female students with respect to understanding chemical 8.6iiding concepts when they are taught by MIA. The findings indicated that there was-no significant difference of the mean between male and female students (P-value = 0.233, $p > 0.05$, showed in Table 5. The percentage distribution that showed the number of students of the male and female out of the total number of 60 was investigated as indicated in Table 5. The results from the analysis showed that the MIA of teaching was effective for both male and female students.

There was no significant difference between the male and female students' performance. Hence their understanding of chemical bonding was mostly the same.

Table 5 and Figure 7 below present percentage distribution of marks scored by male and female in the experimental group and the control group

Table 5: Percentage distribution of male and female in the experimental group

Marks score	Percentage(%) of Male in the Post-test	Percentage(%) of female in the Post-test
0-7	-	-
8-14	5	4
15-20	25	26

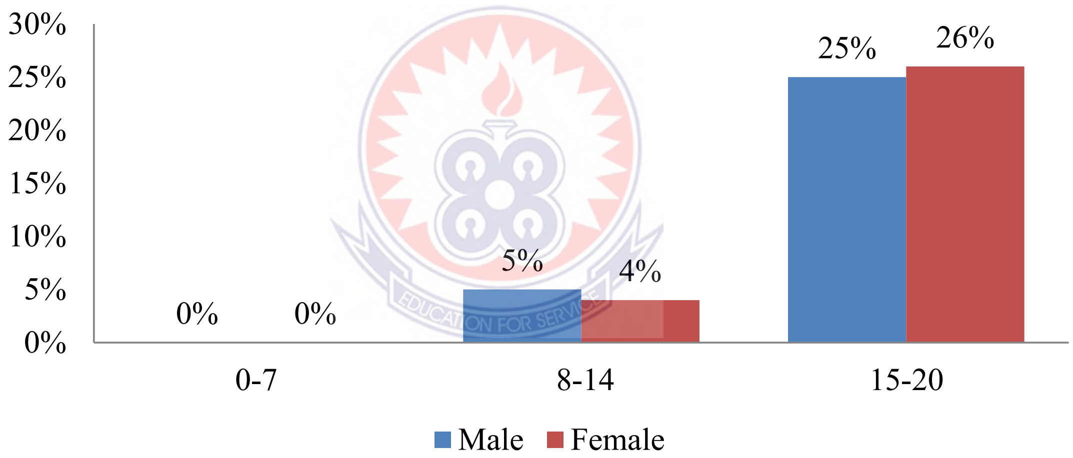

Figure 7: Percentage distribution of male and female in the experimental group

From Table 5 and Figure 7, none of the students from the male or the female side scored mark below average. When 5% male of experimental students scored marks in the average range, 4% of the female students also scored marks in the same range. In above average range, 25% males of the experimental students scored the marks while 26 females of the experimental students scored the marks in the range.

Research Question 4: What are the students' perceptions of the use of multimodal approaches to the learning of chernica1 bonding?

To answer the question posed that 'what are the perceptions of the students on the use of multimodal instructional approaches on the understanding of chemical bonding?' a five-point liken scale ranging from 'strongly Agree to Strongly Disagree was used. The responses of the students were analyzed by a descriptive statistics analysis such as frequency and percentage. All the responses of individual students in the experimental group about MIA on their understanding of chemical bonding were analyzed. The result of the number of students and the level of their views on each item in the questionnaire is presented in Table 6.

Table 6: Perceptions of students of about MIA

Count in percentages (%)	SA	A	NS	D	SD
MIA improve understanding of chemical bonding	58.3	33.3	8.3	-	-
MIA motivates learning of the concept	33.3	58.3	1.7	6.7	-
MIA makes me feel comfortable in class to the concept	70.0	25.0	5.00	-	-
Improves my ability to interpret and comprehend the concept	38.3	46.7	11.7	3.3	-
Learn better when taught only with verbal modal instruction	1.7	-	16.7	43.3	38.3
Learn better when MIA involves Visual, diagrams, charts, videos and PowerPoint animations	41.7	33.3	20.0	3.3	1.7
Five multimodal instructional approaches improve understanding and interest in learning chemical bonding	21.7	65.0	8.3	3.3	1.7

NB: SA=Strongly Agree, A=Agree, NS=Not sure, D=Disagree, SD=Strongly Disagree

As seen in the Table 6, sixty students used as experimental group had to give their responses about MIA to the questionnaire. In item 5, students were to respond to whether multimodal approach of teaching improves their understanding of concepts in bonding or not. According to the students' response, 58.3% of them strongly agreed that the approaches did improved their understanding of the concept; 58.3% strongly agreed, the 33.3% of the students agreed, 8.3% were not sure but none of them disagreed or strongly disagreed. In terms of whether MIA motivated students they to learn or not, it is observed that 33.3% strongly agreed that it did. 58.3% agreed, 1.7% of the students were not sure. But 6.7% students indicated that the instructional approach did not motivate them while no student strongly disagreed. From this statistical analysis it could be concluded that the MIA was confirmed to have motivated students to learn the concept. The next item was to find out whether the students were comfortable during the lesson when a concept was taught in different modes of instructions 70% of them strongly agreed that they were comfortable with that instructional approach, 25.0% of the students also agreed and 5.0 % students were not sure. No student disagreed and strongly disagreed. It therefore suggests students are more comfortable in learning chemical bonding concept when they are instructed by MIA for item 8, students were to respond to whether MIA had improved the ability to interpret and comprehend chemical bonding or not. The observation of result from the table showed that 38.3% students strongly agreed and 46.7% of them agreed which suggested that 85.0% of the students could now interpret and comprehend the concept without difficulties, 11.7% of them responded that they were not sure with only 3.3% of the respondents disagreeing. This meant that they could not interpret and comprehend the concept without difficulties.

However, when item 9 was sought to find out about using only verbal mode of instruction to teach, the trend changed from the other items; only 1% students strongly agreed that use of only verbal mode instruction help them to learn, 16.7% students were not sure, but 43.3% and 38.5% students disagreed and strongly disagreed respectively. This indicated that 81.8% of the students totally did not want the use of only verbal modal instructional approach to the concept. This statistical analysis suggests that verbal mode of instruction might be one of the causes of students" difficulties in learning chemical bonding.

In the case of item 10 which indicated that teachers used visual modes video, diagrams illustration, chart computer animations and PowerPoint presentations to teach, 25% of the students strongly agreed whiles 41.7% of them agreed that it should be embedded in the teaching and learning process of the concept. About 20.0% were not sure. However, 3.3% and 1.7% of the students disagreed and agreed respectively. According to the table, 21.7% of the student strongly agreed that five multimodal Instructional approaches made them comfortable in learning chemical bonding. 65.0% students agreed to the use of five modes of instruction, 8.3% of them responded that they were not sure, 3.3% and 1.7% of the students indicated that they disagreed and strongly disagreed respectively. The responses of students on the use of five multimodal instructional approaches revealed that the type of instructional approach was very important to students in learning chemical bonding concept. Generally, students felt that they should be instructed by MIA instead of the commonly use of the TIA for teaching the concept in the college of education. From the students' perceptions about the methods in terms of their understanding of the concept it is cleared and could be argued that the use of only one single modal instruction (verbal interaction) does not aid learning. This might cause difficulties in learning which can result to creation of several misconceptions in chemical bonding.

Also the difference in perception and attitudes of the male and female students, who were exposed to the MIA was analyzed using descriptive statistics. Table 6 shows the gender, difference on the students' perception after they were instructed by MIA. The table presented the results in frequency counts and percentages to exhibit each degree of both male and female perceptions about MIA. It was found out that higher number of male students more than female students strongly agree and agree had a positive perception towards the used of MIA to instruct chemical bonding.Table 7 presents the result of the perception of male and female students about MIA.

Table 7: Perception of male and female students about MIA

Count in percentages (%)		SA	A	NS	D	SD
MIA improve understanding of Male chemical bonding	Male	26.7	21.7	1.7	-	-
	Female	31.7	11.7	6.7	-	-
MIA motivates learning of the concept	Male	20.0	28.7	1.7	1.7	-
	Female	13.3	30.0	-	10.0	-
MIA makes me feel comfortable in class to the concept	Male	31.7	13.3	5.0	-	-
	Female	38.3	11.7		-	-
Improves my ability to interpret and comprehend the concept	Male	13.3	30.0	6.7	-	-
	Female	25.0	16.7	5.0	3.3	21.7
Learn better when taught only with verbal modal instruction	Male	1.7		5.0	21.7	21.7
	Female	-		11.7	21.7	16.7
Learn better when MIA involves Visual, diagrams, charts, videos and PowerPoint animations	Male	18.7	18.3	13.3	-	-
	Female	23.3	15.0	6.7	3.3	1.7
Five multimodal instructional approaches improve understanding and interest in learning chemical bonding.	Male	8.3	36.7	5.0	-	-
	Female	13.3	28.3	5.3	3.3	1.7

NB: SA=Strongly Agree, A=Agree, NS=Not sure, D=Disagree, SD=Strongly Disagree

From the perception of students by preference to MIA in teaching chemical bonding, a descriptive statistics crosstab was used to determine the frequency and percentage preference between male and female. 26.7% male students strongly agreed as against 31.7% of female students, 21.7% of males agreed as against 11.7% of female students.

But only 1.0% of the male students and 6.7% female students were not sure whereas none of the students disagreed or strongly disagreed. It was also observed from the table that 48.5% male students and 43.3% female students supported that multimodal instructions method helps to improve their understanding of the concept. No male student disagreed as 1.7% female said they disagreed. However, 1.7% and 10.0% of the male and female respectively strongly disagreed. It is also observed from the analysis that more of the females felt they were very comfortable with MIA method than their male colleagues (female=50.0%, male=45.0%). From the analysis, it can be concluded that many male students felt MIA improved their abilities to interpret and comprehend the concept and could communicate well in science community as compared to the female students (female=41.7%, male=45.0%). The inability of students to interpret and comprehend the concept in the literature has being the problem of many science students in the classroom. The result from the Table 6 indicated that only l .7% of the students, who are males, stated that instruction based on TIA only would help them learn the concept better. But the rest of the students stated that using only TIA to instruct the learning process of chemical bonding was inadequate to explain the concepts for them to understand it. They therefore disagreed that teacher should use TIA method only to instruct in the learning process. Finally, more male students than female students stated they want the used five multimodal instructional approaches to teach the concept. There was no male who disagreed or strongly disagreed with the usefulness of MIA as 3.3% and 1.7% of the female disagreed and strongly disagreed respectively with it.

4.3 Hypotheses Testing

The results in Table 8 indicated the data analysis between the control and experimental groups of the pre-test mean scores differences. The result revealed that there was no significant difference before the treatment between the experimental group and the control group in terms of students understanding of the bonding (

P=0.43, p>0.05), The control group had a mean score of 7.35 as compared to the experimental group.

However, the mean difference (0.333) between the two groups was not statistically significant. Table 8 shows the mean difference in performance between the control and the experimental group in the pre-test.

Table 8: Significant difference between control group and experimental group of the pre-test of students before treatment

Group Test	Means	t	df	P (2-tailed)	Mean Difference
Control Group	7.350	0.797	118	0.427	0.333
Experimental group	7.017				

$H_0$1: There is no significant difference between the mean score of students taught chemical bonding using multimodal instructional approaches and that of their colleagues taught with traditional instructional approaches.

In order to answer the question posed by hypothesis 1 stated, the student t-test data analysis was used. The analysis was based on the post-test score of both the experimental group and the control group.

Table nine presented t-test (2-tailed) mean score of the post-test scores of both the experimental and the control group.

Table 9: Two-sample t-test with equal variances of significant difference between control group and experimental group of the post-test score summary

Control group Means	Experimental group Means	t-test or Equality of Means			
		T	Df	p (2-tailed)	Mean Difference
10.333	16.983	-15.54	118	0.00	6.650

As a rule of thumb, the computed p-value should be less than the chosen significant level (0.05) for this study to reject the null hypothesis. Since the P-value. (0.00) in the result is less than 0.05, it could be concluded that there was a statistically significant difference between the experimental and control groups of the post-test. The students (experimental group) who were taught by MIA scored significantly high mean difference (6.65) than those taught by TIA ($X_{(MIA)}$ =16.983, $X_{(TDA)}$ =1.0.333).

Again, the researcher also analyzed the data to determine the mean scores differences between the pre-test and the post-test scores of the experimental group and that of the control group. The results of the analysis are indicated in the Table 10. Both results Showed that there are significant differences (p< 0•05, p=0•000) between the pretest mean score and the post-test mean score of the two groups. But the mean score difference of the experimental group was much higher (X difference 9.967) than the mean score x difference of the control group (X difference 2.983). This attested to the fact that MIA highly improved the understanding of students in learning chemical bonding.

Displayed in table ten is the summary of the mean difference score within both experimental and control groups.

Table 10: Summary of mean difference between pre-test and post-test within both experimental and control groups

	Pretest mean	Post-test mean	t-test for Equality of Means	
Experimental group	7.0167	16.983	0.000	9.967
Control group	7.3500	10.333	0.000	2.983

H_02: **There is no significant difference between the mean score of male and female students who are taught chemical bonding using multimodal instructional approaches**.

To answer the question posed by hypothesis 2 which stated that there is no significant difference in the performance of male and female students who have been exposed to the multimodal instructional approaches in their understanding of chemical bonding, analysis of student's t-test was run.

The summary of the results of the mean score difference between genders in both the control and experimental groups in the understanding of chemical bonding concept are shown in Table 11 below.

Table 11: Summary of mean difference between genders in the experimental group

	Male Mean	Female Mean	P(2-tailed)	Mean difference
Post-test scores	7.800	6.233	0.233	0.700
Pretest score	17.333	16.633	0.08	1.567

The findings of pretest mean scores between male and females indicated from the Table 11 that there was a significant mean different between them with regards to their understanding of chemical bonding concepts ($p=0.008$, $p< 0.05$). The mean pre-retest scores were 6.23 for females and 7.80 for males. The mean different of pretest mean scores was 1.567 indicating the extra performance of male students than female students. But the findings of post-test mean scores between both genders showed that there was no any significant mean difference between male and female students in terms of understanding chemical bonding concepts ($p=0.233$, $p >0.05$). The mean post-test scores were 17.33 for females and 16.63 for males. The results revealed the mean difference of 0.700 indicating the higher female students' performance more than male students.

4.4 Discussion

This study was designed to determine what caused students learning difficulties and to determine the effect of multimodal instructional approaches on the students" performance on chemical bonding.

The study revealed a wide variety of difficulties that students faced during teaching of chemical bonding. Several researches revealed that students had difficulty interpreting and understanding the concept, and how the concepts are taught. Chemical bonding which is a very abstract concept requires some knowledge from other areas like forces which students are not able to fully grasp. It was observed during the lesson with the students on learning chemical bonding that they could only memorize definition of terms rather than being able to interpret and comprehend the concepts (Bennett, 2011). This confirmed the possible reason why the two groups of students performed poorly in the pre-test items. From the analysis in Table 9 the mean of the experimental group is 7.017 and that of the control group was 7.350 out of the expected score mark of 20 from each group used for the study, the mean (y=7.1833) each group. Considering the totals, it indicated that overall performance was below average performance. This was because the test items were to test their level of ability to interpret, comprehend and construct the concept of chemical bonding. This suggested that the students had difficulties in interpreting and comprehending the abstract concepts (Ainsworth, 2006; Bennett, 2011). For instance, when the students were asked to discuss the meaning of chemical bonding in groups and report their ideas, the followings conceptions were observed: bonds were seen as linkage of elastic based on shapes interlocking; bonds are formed in terms of electrons attracting to one another; chemical bonding is only formed by charged ions; ions determine the polarity of bonds etc. Most of them thought that bonds are simple connections rather than force.

It was also observed that most of the students' misconceptions and even teachers' misconception on the concept cause learning difficulties for students. When teachers do not appropriately use analogy or story to explain ideas, it sometimes interfered with students learning of concepts. It makes new scientific knowledge which is being taught not easily connects to the already existing one for better understanding. This was observed caused difficulty for students to understand the concept. During the lesson, students tried to justify the answers or ideas by saying "my formal chemistry teacher explained it that way..." So, when teaching chemical bonding concepts, teachers should focus on these misconceptions and make the scientific concepts as practical as possible. They should also use the instructional modes for students to see for themselves how the concepts work.

From the interview, students suggested chemical bonding literatures should present the concepts in multiple modes of representation to cater for every learning style of learners. If not so, it would create learning difficulties for students who study the literatures;

> *"I think that majority of us differ in the way we learn things; some learn by visual than others; some by listening than others; some by performing experiment or manipulation of symbols only than others. But I think majority of us learn when those situations are combined and used together".*

Again, the difficulty the students face in learning chemical bonding was observed to be the type of instruction used; the way the topic was taught. It was confirmed that the use traditional instructions approach where the teacher transmits that facts to the students who are passive listeners, to teach caused a difficulty for students to understand the concept. In the control group where a lecture method was used, there was significant mean difference between the students' scores in the pre-test and their post-test scores ($p=0.00$, ie $p<0.05$) in Table 8 and with mean difference of 2.98. In Table 2, 13.3% of the students still performed below average. This is an indication that these students have not been helped by the method of teaching. The way the concept was explicitly explained during the lesson to the learners would have accounted for the improved result. However, when the students are instructed by multimodal instructions, they were able to learn better. As revealed in the statistical analysis, there was a significant difference of mean between post-test scores of the experimental group and the control group of students ($p<0.05$, mean difference= 6.650). It can be concluded that multimodal instructions effectively reduce the difficulties that most of the students were confronted with in learning chemical bonding (Tytler, Waldrip & Griffiths, 2004) while TIA could not. Also, students did not find it easy learning chemical bonding when they were instructed by the traditionally instructional approach for the course. There was a very high statistical difference in percentages between those students who have difficulties in learning concepts when they are instructed with only lecture method (verbal modal) and those students who do not (1.7% strongly agree and agree whiles 81.6% students disagreed and strongly disagree showed in Table 6). The report from interviewing the students showed that they valued an integrated approach because it challenges them to engage in an active translation across modes and concepts;

> *"It gives me opportunity to interact with the concept in various ways and I' m able to construct my own understanding. If am taught just one way, I' m able to explain the concept well... So, if am taught in multimodal ways, it will provide bases for me to understand in a way without weakness...."*

This suggests that the type of method use to teach, students' misconceptions and content representation cause difficulties. These should be critically looked at by educators in teaching chemical bonding. In learning, difficulty might not be because of the abstract nature of the concept only.

The extent to which multimodal instructional approaches improve the students' understanding of chemical bonding was determined by comparing the percentage difference, the mean differences and the significant level of the performance of the experimental and control groups in the post-test. Based on the statistical analyses results displayed in Tables 4 and also in 9, it can be concluded that the instruction by using the MIA caused a significantly better acquisition of scientific con conceptions related to chemical bonding and improved learners' interest in the concept than TIA. In the Table 4, only 8.3% of the students from control group scored perform marks which indicated that their performance in chemical bonding is above average. But 85% of the students who were taught by MIA had performed above marks. These findings revealed that students who are taught using MIA are able to interpret, comprehend and construct chemical bonding concepts with devoid of misconception than using TIA to teach the concept. These results mean that students learn better and understand the concepts of chemical bonding when they are taught using MIA than when they are taught by TIA.

From the hypotheses analyses, mean scores of both experimental and control groups of students in the post-test scores indicated there was a higher score for experimental group in Tables 9 and 10. That is, there was a significant difference between the post-test mean scores (the performance) of the students instructed using multimodal instructional approach and traditional instructional approach, revealing the tendency for students to have higher test scores when they are instructed using MIA, ($p= 0.00$, $p < 0.05$). The mean difference (X difference 6.65) indicated the extent to which or how the students instructed using MIA understood chemical bonding better than those instructed by traditional approach. It was also clear from the mean difference that the levels of understanding of chemical bonding between students instructed by multimodal instruction and the traditional instruction that multimodal instructional approaches improve students' literacy in chemical bonding better. The relatively high performance of students' scores when they were instructed by MIA was due to the complacency, interest and the positive attitude towards the instructional approaches.

In the experimental group, the instructional-students interaction from the multimodal approaches was emphasized for learning. The teacher encouraged the students to ask questions, work together, explain what they saw and thought during the learning process. They used their current ideas about the concept and became ready to change with the scientifically correct explanations. The multiple modes of instructions provided the development of reflective thinking and metacognitive awareness. But students in the control group were not aware of their conceptions which were not scientific. In the group also, there was a slight interaction between the teacher and the students; students listened to their teacher, studied their literature materials and compiled their own notes. The reason why the students in the control group were not so successful as compared to those in the experimental group might be attributed to the fact that they were not given the opportunity to think about the concepts, ask questions to clear their doubts. For that matter, they continued to hold wrong conceptions which were not scientific on chemical bond.

Meaningful learning occurs if students are challenged by instructions to think about the concept and ask question for a situation for better understanding. The high result of the mean difference from the Table 9 and 10 confirmed the fact that using MIA creates learning environment that allows learners to easily learn concepts to better improve their chemical bonding literacy especially for lower-achieving students (Fadel, 2008; Mayer, 2003). This is also confirmed from the students' interview that the use of MIA would engage students in an active translation across modes of representation address their learning differences and make them able to interpret and construct the concept according to the scientific principles. The study therefore supports the argument that multimodal instructions improve students' competency in chemical bonding concepts. It could be concluded that students instructed through instruction based on the use of multimodal approaches had more positive attitudes toward chemical bonding than students taught by traditional designed instruction. Most students taught said chemical bonding was a difficult concept to learn and did not want to study it. In the MIA, students were actively involved in the learning process. This might have caused students in the experimental group to have more positive attitudes.

The third research question in this study was to investigate whether there was a significant mean difference between male and female students with respect to understanding chemical bonding concepts. When the students were instructed using MIA the results indicated in the Table 11 that there was no significant difference of the mean between male and female students (P-value = 0.233, $p > 0.05$).

Again, it was established that there was no significant interaction between gender difference and treatment in terms of understanding chemical bonding concepts. This meant that, there was no significant difference in performance of understanding the concept between male and female students who were instructed by multimodal instructional approaches and participated in the post-test items. The reason why no significant difference was found in this study might be due to the fact that the multimodal instructions approach used to instruct concept had catered for the learning differences of both male and female students in the classroom. This situation might also have positive effect on their attitudes toward chemical bonding. The fact that there was a significant mean difference between male and female students from the finding in Table 11 in the pretest scores, has informed the teaching technique used as treatment to examine the effect of it in catering for gender abilities to learn chemical bonding (P -value = 0.008, $p < 0.05$). The significant difference arose from the fact that male students' mean scores was 7.800 whiles female students' mean scores is 6.233, indicating that male students relatively understood chemical bonding more than female at initial stage. However, since there was no significant difference in their mean scores after treatment, but with female having higher post-test mean score (mean score for female= 17.333 whiles mean score for male = 16.633) then it can be concluded that females were at the better side in the understanding of chemical bonding. The females are therefore more evenly distributed across multimodal learning techniques.

Another purpose of the present study was to determine the perception of students learning chemical bonding through the use of multimodal instructional approaches. The findings indicated that almost all the students who participated in the experimental class learnt and understood chemical bonding concept. Catering for differences in students' learning experiences and outcomes for better understanding, developing motivation for positive attitude towards the concept, creating challenging and comfortable learning environment, ability to interpret and comprehend, use of traditional approaches where students are passive listeners, and use of up to five multimodal instructional approaches were areas that were investigated to determine effect of the approach of teaching. However, the data collected from the questionnaire (see Appendix D) and confirmed that students' learning styles in class, ability to understand chemical bonding as well as to interpret and comprehend and being motivated to learn the concept among others were made possible by the MIA.

The data in table 6 revealed that 91.6% of the students understood the concept through the use of multimodal instructional techniques. With regard to gender, more male students (48.4%) said they understood the concept as against 43.4% female students. This therefore confirmed the results of the mean scores of male and female students (male =17.33, female = 16.63) in terms of performance in the CBCT. For understanding, the learning outcome would be better instructed by MIA in the learning face of students because it caters for their learning styles (Sankey, Birch, & Gardiner, 2010).

Also, it was observed that students were motivated when they were instructed using MIA to learn chemical bonding. The result on motivation revealed that 91.6% students also think they were motivated to learn the concept while only 6.7% of students did not by disagreeing to that. It is clear from the result more female students (5.0%) were not colleagues' score in the CBCT from table 5.3. Nevertheless, 95.0% of the students said they were more comfortable in the class when the concept was instructed in different modes. This supports the report that using different modes of instructions in an integrated form creates learning environments that cater for learning styles of students making then feel comfortable and perform better (Omrod, 2008). It also confirmed the qualitative analysis in the interview of students. Multimodal learning environments allow for active participation in a lesson and critical thinking development.

Furthermore, the study also sought to determine whether students have positive or negative perception towards the use of verbal modal instruction to teach concepts. The result from their responses showed that only 1.7% of the students (mainly male students) indicated that they understand the concepts while as much as 81.3% of the students (43.4% of the male, 38.4% of the female) thought they did not if the verbal modal instruction only is used to teach them. The result indicated that no female student preferred the use of a single mode of instruction such as verbal mode. This confirms the findings of Wehrwein, Lujan, and Di Carlo, (2007) that, among others, female students learn better from learning instructions that involve touch, hearing, smell, taste, and sight. From the interview findings, it also indicated that the students see the traditionally instructional approach of teaching which is characterized by verbal modal instruction as monotonous that does not fully explain the concept to them. They argued that concept should be taught with integrated modes of different instructional approaches to enable them do away with their misconceptions which are not scientific.

Also, the questionnaire sought to determine views of the students on the use of five different multimodal instructions in the teaching and learning of chemical bonding. The results showed that 85.7% of the students were very comfortable and understood better the concept when they are instructed by multimodal instructions while 4.7% of the students disagreed. It could be concluded that students who were instructed through multimodal instructions preferred that they were taught chemistry concepts especially chemical bonding by using the multimodal instructional approaches. Some of the reasons that were given by the student during the interview are that; it catered for learners learning style, it made concept not easily forgotten, it increased the interest of learning chemical bonding concepts, it demystified the perception that the concept is difficult to learn and it helped to do away with misconceptions about the concept. Generally, most students saw chemical bonding as a difficult area in chemistry to learn and do not want to study or choose to answer questions on it when they are not compelled. The multimodal instructional approaches focused on practically explaining the concepts and students' ideas, encourage student to think about situations and ask questions, and share their ideas. These students were actively and passionately involved in the teaching and learning process. These factors would have made the students of the experimental group to have high positive attitudes and high performance in the Chemical bonding test.

In conclusion, this study revealed that students had difficulty in understanding chemical bonding concepts. The use of multimodal instructional approaches results in deeper conceptual understanding of chemical bonding.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the findings, implication of the findings for teaching science, and conclusions. It also includes recommendations and suggestions for further studies.

5.1 Summary of the Major Findings

The major findings of the study is summarized under the following headings; the causes of student inability to understanding chemical bonding as expected and the extent to which multimodal instructional approaches improved their understanding of the concept. The headings also include differences in the performance between students taught using MIA and TIA, performance differences between male and female who were taught using MIA, and students' perception about the teaching methods.

5.1.1 The causes of students' difficulty in understanding chemical bonding

From the interviews conducted, every student mentioned that the chemical bonding is a difficult concept to study. The factors such as the abstract nature of the concept, the verbal teaching technique, the use of some analogies to explain the concept and the use of inappropriate symbolic representations of concepts were identified to have caused learning difficulties. The researcher observed during the treatment that students have the misconception that force of attraction is only occurs in ionic bond but not in covalent and metallic bonds. It was also found out that the teacher‟s inability to explain the concept well contributes to students‟ inability to grasp the concepts correctly. The students could only memorized definitions of terms rather than able to interpret and comprehend the actual meaning of the concepts.

5.1.2 The extent to which multimodal instructional approaches improved the of students' understanding of the concept

The statistical analysis of the experimental group's pre-test and post-test results (Tables 3, 4 and 10) indicated that there was statistically significant difference in the performance before and after the treatment. The analysis also indicated a very high (85.0%) improvement in the performance of experimental group after teaching the group using the multimodal instructional approaches.

5.1.3 Performance of students taught using MIA and T1A

The statistical analysis of the pre-test of both the experimental and the control groups showed that there was no statistically significant difference in the performance between the two groups at the beginning of the study as shown in Table 8. The results revealed that the performance of the experimental and the control groups were comparable on their initial understanding of the chemical bonding concepts. But the statistical analysis of the post-test of the experimental and control groups in Tables 4 and 9 indicated clearly that there was statistically significant difference in the performance between the experimental group and the control group. The experimental group performed far better than the control group in the post-test (8.5%). There was significant improvement in the performance of students in the experimental group over the control group after the treatment. This means that students who were taught using MIA could interpret and comprehend more of the scientific chemical bonding concepts in the study than those who were taught using TIA.

5.1.4 Performance between male and female students who were taught using MIA

The findings of pretest mean scores between male and females indicated from the Table 11 that there was a significant mean different between them with regards to their understanding of chemical bonding concepts. The female performed better than their male counterparts before the treatment. However, the performance of the post-test mean score between both genders showed that there was no significant difference between male and female students mean scores in terms of understanding of chemical bonding concepts. The mean post-test scores were 17.33 for female and 16.63 for males. The mean difference of 0.700 indicated the higher female students' performance than male students.

5.1.5 Students' perception of the teaching methods.

The effect of MIA was also confirmed from students' perception about the approach of teaching. Their perceptions of learning through multimodal instructional approaches indicated that the treatment improved their abilities and confidents to interpret and comprehend chemical bonding, cater for different learning styles and motivated them to learn the concept. Considering the results, it means that students have positive attitudes towards the use of multimodal instructional approaches to teach chemical bonding. It was also noticed that it does not necessary means that integrating different modes of instructions should followed a particular order. Contrary, the results indicated that students do not like to be instructed by verbal mode of instruction.

5.2 Conclusion

Multimodal instructional approaches which integrating different pedagogy instructions (Vaughan & Bruce, 2008) as means of improving learning outcomes in a classroom is widely acknowledged in journals and other educational research work (Dolin, 2001; Russell & McGuigan; 2001). The introduction of the multimodal instructional approaches produced a significant improvement in students' learning and understanding of concepts in the chemical bonding as compared to the commonly instructional technique, traditionally instructional approach. Students' abilities to interpret and comprehend the concept were hugged when they were taught using multimodal instructional approaches. However, it was revealed that traditional instructional approach which was characterized by verbal instructional approach was noticed to be the cause of the difficulty students faced in learning chemical bonding. It can be concluded that multimodal instructional approaches which is guided by child-centered approach greatly improved the understanding of chemical bonding. It helps approach students properly interpret and comprehend concepts and caters for learning difference in classroom. It also motivates activate mental challenge and critical thinking, make students feel comfortable and develop their interest to learn and understand chemical students bonding.

5.3 Implications for Classroom Teaching

Primarily, teachers' instructional approaches have direct effects on the learners' understanding during lessons. This correlates with students' achievement (Tatto, 2001). The findings of the study indicated that multimodal instructional approaches had a direct impact for improving methods of teaching and learning and students' academic performance. There was a strong link between the students' content knowledge and the pedagogy that researcher used to teach the experimental group.

This approach is also likely to improve the students' understanding in other concepts in science courses. Each five modes of instructional approaches could be used to cater for students learning style for them to feel comfortable in the classroom. The method of instruction used in the study would also motivates and challenge students to critically think about the concept in the learning process. The study therefore suggests that students should be taught by using MIA in the learning of concepts in chemistry. The method of instructions has a strong link with performance in learning chemical bonding especially detail learning for examination and application of concept in the daily life.

Also, since the ultimate aim of a teacher in class is to teach a concept to the understanding of every student in the class, multimodal instructional approaches can be used to solve this problem due to its ability to cater for students learning differences. This would help motivate students to actively participate in learning process for educational goals to be achieved.

Further, in the cases of limited resources for science lessons, teachers can use some innovative teaching methods such as multimodal instructional approaches to empower the students to learn science concepts better and also develop positive attitudes towards the subject. Curriculum designers should include multimodal instructional approaches in the activities. The textbooks or literature should make use the instructional approaches to provide opportunities for different learning differences. This would make interacting with educational materials more convenient to learners. In conclusion, chemistry concepts which are abstract in nature could be taught by MIA to improve the students' abilities to interpret and comprehend concepts. It also creates conducive and friendly environment for all students with different learning style in the classroom.

5.4 Recommendations

Based on the findings of the study, it is recommended that:

1. The governing councils and academic boards of Offinso and Berekum Colleges of Education should make adjustments in their academic calendars to organise capacity building workshops for science tutors in their colleges on the use of multimodal approaches in teaching since the method has proved to be effective.
2. Berekum and Offinso Colleges of Education should focus on learner‟s alternative knowledge (misconceptions) because it was observed that the students' conceptions which are not scientific do cause learning difficulties.
3. Ministry of Education, Curriculum Research Development Division, University of Cape Coast, University of Education, Winneba and other agencies should make some structural changes in the discipline of science education in schools that will encourage the use of multimodal instructional approaches in the training of science teachers.
4. The Ghana Education Service and Ghana Association of Science Teachers and other interested agencies should regularly and periodically organize in-service training for science teachers on modes of instructions and students' alternative concepts in chemical bonding.
5. Institutions or authors or books interested in getting relevant pedagogy for particular concepts should include MIA as teaching method for chemical bonding.

6. Science tutors should take steps to correct misconceptions in science because it leads to students" inability to grasp chemical bonding concepts.

5.5 Suggestion for the Further Studies

The research focused on use of MIA to teach selected students in selected colleges of education in Ghana to determine the effect of the method on their academic performance and their perceptions towards chemical bonding. Based on this study, the following suggestions are made:

1. This study indicated the need for further research in the construction of concept representation; and the design of professional learning programs to support teacher understanding of how to maximize learning opportunities and students learning styles.
2. Similar study can be carried out for different levels of education in Offinso and Berekum municipalities in different science topics to investigate the effectiveness of multimodal instructional approaches on
3. Further study is encouraged on integrating less or more modal instructional approaches to determine its impact on academic performance and understanding of concepts
4. A larger sample size could be used to conduct and replicate this study in different schools to provide a generalization of its effect for pedagogy development.
5. Further research may be carried out to investigate the understanding and the perceptions of science tutors in Offinso and Berekum Colleges of Education on the use of multimodal teaching techniques.

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APPENDICES

APPENDIX A

Items on Chemical Bonding

Time: 50 minutes

Index Number .... Sex ....

Answer all questions. The questions below have four options. On question paper circle one answer that you think is correct for each question.

1. When NaC1 dissolves in water, there is no bond still occurs between sodium and chlorine ions in solution because....
   A) NaCI is still occurring as molecular in water
   B) NaCl exists as isolated pairs of Na + and Cl^-
   C) Ionic bonds is broken during the dissolving process.
   D) Positive charges on sodium ions must be neutralized by gaining of electrons from I chloride ions in the solution.
2. In chemical bonding, electrostatic force of attraction exists between only when atoms gain and loses electrons. (1) True or (2) False because ......
   A) the force of exist between shared pair electrons and the positive nuclei in covalent bonding
   B) some atoms can only share electrons to form bonds
   C) it exists between the shared paired electrons involved in bonding
   D) it is when atoms gain or loses electron that electrostatic force of attraction can exist
3. In HF, the bond between hydrogen and fluorine is a/ an
   A) ionic

B) covalent

C) metallic

D) Hydrogen

4. A triple bond consists of two atoms which share

A) two electrons

B) four electrons

C) six electrons

D) eight electrons

5. Calcium chloride, $CaCl_2$, is a/an

A) ionic compound

B) covalent compound

C) hydrogen bond compound

D) metallic compound

6. Element X (electronic configuration 2, 8, 2) and element Y (electronic configuration 2, 7) react to form an ionic compound, XY2 because

A) An atom of X will share one pair of electrons with each atom of Y to form a covalent molecule, XY2.

B) Covalently bonded atoms of X and Y form a network covalent compound.

C) X will transfer two electrons to two Y to form an ionic compound XY2.

D) X will transfer one electron to Y to form an ionic compound XY.

7. The two types of bonds found in ammonium ion are

A) covalent and ionic

B) covalent and coordinate

C) metallic and ionic

D) polar covalent and. ionic

8. The bond between sulphur and chlorine would be

    A) ionic

    B) polar covalent

    C) nonpolar covalent

    D) no bond formed

9. The electrostatic force of attraction in covalent bonding is between...

    A) shared electrons and core electrons in atoms involved in bonding

    B) shared electrons and positive nuclei of the two atoms

    C) nucleus of one atom and shared pair electrons

    D) lone pair electrons and shared pair electrons

10. Which of the following indicates a double bond?

    A) H_2O

    B) NH_3

    C) CO_2

    D) N_2

11. A bond formed between two atoms in which one atom alone donates the pair of electrons to be shared between the two is known as..

    A) polar covalent bond

    B) dative covalent bond

    C) hydrogen bond

    D) electrostatic bond

12. Solid Cu conducts electricity because

    A) it contains mobile electrons.

    B) it contains covalent bond.

    C) it contains ionic bonds.

D) it exists as a molecule

13. Which of the following substance is a polar covalent molecule?

A) Hydrogen

B) Oxygen

C) Sodium chloride

D) Water

14. Which one of these statements represents the true characteristics of chemical bonds?

A) They are material connections.

B) They are only formed between atoms that donate/accept electrons.

C) They are either fully ionic or covalent.

D) They are electrostatic forces.

15. Which one of the'f011owing statement is correct for potassium bromide, KBr?

A) It does not conduct electricity when it dissolves in water.

B) It contains nonpolar bonds.

C) It contains intramolecular bonds formed as a result of sharing electrons.

D) It contains intramolecular bonds formed as a result of electron transfer.

16. Which one of the following statements is correct for ionic bonding?

A) Metals and nonmetals form ionic bond.

B) Compounds containing ionic bond conduct electricity when they are solid.

C) Ionic compounds are gases at room temperature.

D) Ionic compounds exist as molecules formed by covalent bonding.

17. Which one of the following statements is correct for covalent bonds?

A) Atoms of a metal and nonmetal share electrons to form molecules

B) B)It forms substance which is soluble in water

C) Metals and nonmetals form strong covalent bonds

D) Covalent bond occurs due to sharing of electrons.

18. Which of the following statements is a property of ionic compound?

A) It has low melting point

B) It does not conduct electricity in the solid stage

C) It is soluble in organic solvent like petrol

D) It consists of molecules

19. If chemical bonding in metal A is weaker than metal B, then metal A has a

A) lower melting point

B) lower brittleness

C) lower electrical conductivity

D) lower thermal expansion coefficient

20. An atom X has the following electronic configuration 2, 8, 2. Which of the following statements is true about the atom?

I it is a non-metal s

II it is a metal s

III it can form an anion easily

IV it can form a cation easily

A) I, II

B) I, IV

C) II, III

D) II, IV

APPENDIX B

Marking Scheme of CBCT

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

APPENDIX C

Instructional Objective

By the end of the lesson the pupil will be able to:

2. Define chemical bonding
3. Explain how chemical bonding occurs
4. Describe types of chemical bonds.
5. Distinguished between intermolecular and intermolecular bonds.
6. Explain ionic, metallic and covalent bonds.
7. Differentiate between covalent and ionic bonding.
8. Identify polarity
9. Distinguished between polarity and non-polarity
10. Give examples of ionic, metallic and covalent bonding.
11. Explain the structures of ionic and covalent compounds.
12. Explain the properties of ionic and covalent compounds
13. Mention examples for ionic and covalent compounds.

APPENDIX D

Research Questionnaire for BEd Primary Education Students in Colleges of Education

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

This questionnaire seeks information about the effect of multimodal instructional approach on learning chemical bonding. All information given is purely for academic and research purposes and therefore remains confidential. Kindly respond to all questions as accurate as possible to you.

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

Section One: Demographic Data

Index Number ....

1 .Course offered at SHS; Science student [ ] Arts student [ ] Agricultural Science [ ] Business student [ ]Language student [ ] Vocational(especially arts and culture) Student [ ]

2.Age: 30years and above[ ] 25-30 years [ ] 20-24years[15-19years 3.Sex: Male[I Female [ ]

QUESTION ITEMS	RESPONSES				
	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
5. Multirnodal teaching ' improved my understanding of conceits in bonding					
6. Multimodal teaching approaches ' motivated me in learn chemical bonding					
7. I felt comfortable when a teacher taught by the same concept in different modes instruction					
8. Multimodal teaching approaches improved my ability to interpret and comprehend chemical bonding.					
9. I learn concept better when teachers teach by using only verbal modal instruction such as lecture method.					
10. I learn better when my science teacher teach with graphic and visual modes such as computer simulations, video, diagrams tables, charts and power point presentations					
11. I like to be instructed by pent-multimodal instruction approaches in the learning of chemical bonding					

APPENDIX E

Student Interview Protocol, Semi-structured

Students' perception on Multimodal Instructional Approach

1. Do you think engaging with different methods instructions results to effective learning of topics in class? Why?
2. Which of the multimodal instructions approaches, that is verbal, symbolic, analogy, realia or visual instructions do you

a) engage best with

b) learn best with

3. What is your judgment about the effectiveness of these instructional modes in terms of learning style, interest and how it promotes active learning?