THE EFFECT OF USING MODELS ON STUDENTS' LEARNING OF CHEMICAL BONDING: The Case of Grade 11 Students of Preparatory Schools in West Wollega Zone, Oromia Regional State.

BY

TAKALE KEBEDE

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APPROVAL OF BOARD OF EXAMINERS

We, the undersigned, members of the Board of Examiners of the final open defense by Takale Kebede have read and evaluated his thesis entitled "**The Effect of Using Models on Students' Learning of Chemical Bonding: The Case of Grade 11 Students of Preparatory Schools in West Wollega Zone, Oromia Regional State**" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Master's in Chemistry.

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DECLARATIONS OF THE STUDENT

I hereby declare that this MSc. Thesis is my original work and has not been presented for a degree in any other university, and all sourc ial used for this thesis have been duly acknowledged.

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TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLE

LIST OF APPENDIX FIGURES

ABBREVIATIONS AND ACRONYMS

H1	Alternatives hypothesis
H0	Null hypothesis
EG	Experimental group
CG	Control group
CBPT1	Chemical bonding pre-test
CBPT2	Chemical bonding post-test
CBT	Chemical bonding test

ABSTRACT

The main purpose/objective/ of this study was to disprove uses of appropriate models have no effect on grade 11 students' learning of chemical bonding, after they were taught by using models on this selected chemical concept in eleventh grade. The data were obtained from 30 sample students participated on instructions based on using models (EG) and also 30 sample students participated in instructions based on traditional method(without using models)(CG). Chemical bonding pre-test was administered before the study in order to identify students' conception on chemical bonding concepts. Experimental group sample students scored on average below 50.8% of academic achievement and control group sample students scored on average below 50.3% of academic achievement on given test before the treatment. Chemical bonding post-test was administered after treatment was given for the experimental group by using models and for the control group sample students simply by traditional method of teaching. In the comparison of the post-test of the two groups, the experimental group students were scored on average above 86.7% of academic achievement, where as the control group students scored on average 66.8% of academic achievement on a given topic. Most experimental group students were very appreciated to learn about chemical bonding by using models prepared from simple materials found in their environment and in how they can prepare models easily. The result of the study showed that learning based on using models about chemical bonding was better than learning this topic without using models. Table 4.18 describes that there was significant difference between the two groups ($t=5.14$ at $p<0.05$). This confirms that the two groups were different in their academic achievement on chemical bonding after the treatment. Standing on this evidence alternate hypothesis was accepted and null hypothesis was rejected. Therefore, the researcher concluded that models have great effect on students' learning of chemical bonding. Based on the results obtained and conclusion made the researcher recommended that curriculum developers, authors and teachers should lay emphasis on the providing and using models with teaching chemical models.

CHAPTER ONE

1. INTRODUCTION

The research is experimental research which studied the effect of using models on students' learning of chemical bonding. In this thesis work there were experimental group sample students and control group sample students. The main objective of this study was to disprove the null hypothesis.

1.1 Background of the Study

Throughout the world, people are looking to education to pave the way for a more just social order on the grounds. Progress in education is taken to be essential for sustainable development, environmental protection, improvement in maternal and child health, participation in democratic, social and political issues. Education is also currently becoming the most important contributor to national economic growth. Empirical evidence suggests that educational investment has been one of the most important factors contributing to economic growth in both developed and developing countries (Haddad et al, 1990).

Learning is the process of making connections between the new knowledge and the existing ones. In learning process, students construct the new knowledge through cognitive frameworks, abilities, values and experiences (Nakhleh, 1992; Osborne and Freyberg, 1996). To learn, students must transfer information from working memory to long memory. Information is often withdrawn from memory just as it is wanted in. In learning, effective feed-back is often essential to acquire new knowledge and skills. Researchers take two broad approaches to account for difficulties in learning sciences, reflecting different conceptions of learning. Those who view science learning as conceptual change focus on learners domain-specific ideas how these change through interaction with internal and external stimuli, such as instruction, cognitive conflict and met cognition. Conceptual change text is one of the successful conceptual change strategies to facilitate conceptual understanding (Al Khawaldeh and Al Olaimat, 2010). In contrast, the theory of learning as strategy use focuses on the learners use and application of domain-specific ideas to solve problems, and their use of scientific processes to acquire scientific knowledge and hence encourages rote learning.

Chemistry is one type of science which studies about the properties, compositions and structure of substances. Substances are often understood in terms of aggregations of particles, and the nature of the bonding between those particles which are used to explain many of the chemical and the physical properties of the substance. It had been regarded as a difficult subject for students by many researchers, teachers and science educators (Nakhleh, 1992) because of the abstract nature of many chemical concepts, teaching styles applied in class, lack of teaching aids and the difficulty of the language of chemistry.All these cause students, from primary level to the university, to develop poor understanding and misunderstandings in chemistry. This is why Curriculum developers (experts) sequence the chemistry content knowledge that is to be taught with increasing difficulty to match the mental development of the students as their age increases. They also aim to support higher levels of content learning using previously learned content as prior knowledge. The selection of content and its organization/sequencing is based on the expertise of curriculum developers. When they are not aware of recent related science education research to guide the selection and sequencing the content, they rely heavily on the way they understand the content that is usually organized from the unknown to the known. Often, this sequencing fails to satisfy the learning needs of students especially those need described by psychological theories of learning (Abiola and Dhindsa 2002).

In this research work, chemical bonding is the concept chosen to conduct the study, since it is one of the most important topics taught in chemistry at upper secondary school level, and is also basic for other topics in chemistry (Nahum, Mamlok-Naaman and Hofstein, 2008). It is the physical process responsible for the interactions between atoms and molecules, and that which confers stability to bounded particles. The explanation of these interactions, which are basically electrical forces, is a complex area that is described by the laws of the quantum mechanics theory. Clearly, many of the concepts taught in chemistry in both secondary schools as well as in the colleges are highly based on understating the fundamental ideas related to this concept. There is no doubt that chemical bonding is one of the key concepts in chemistry and one of the most fundamental ones. In general, understanding the subject of chemical bonding is crucial for students' further learning because it underlies most of the advancing subjects in chemistry lessons. It is necessary for students to construct the meanings of chemical bonding concepts properly to understand other chemistry subjects such as chemical reactions, chemical reactivity, and structure of matter, change of state, physical and chemical change (Nicoll, Eshach and Garik, 2001).

The concepts associated with chemical bonding and structure, such as covalent bonds, molecules, ions, giant lattices, and hydrogen bonds are highly abstract and in order to fully understand these concepts, students must be familiar with mathematical and physical concepts and laws that are associated with the bonding concept, such as orbital, electro-negativity, electron repulsions, polarity, and Coulomb's law. In addition, learning about chemical bonding allows the learner to make predictions, and give explanations, about physical and chemical properties of substances. Sánchez ,Gómez and Martín (2003) have discussed how the most advanced models available to chemists for understanding the structure of matter, that is those that we might judge our best approximations to 'reality' given the current state of knowledge, derived from quantum chemistry.

It is also one of the areas in the physical sciences where understanding is developed through diverse models which are in turn built upon range of physical principles and when learners are expected to interpret a disparate range of symbolic representations standing for chemical bonds (Taber and Coll, 2002). This topic is dominated by the use of models (Taber and Coll, 2002), because we cannot see how atoms or other particles are held together (Coll and Treagust, 2003). One of the goals of the chemistry-teaching community is to develop more effective and scientifically aligned strategies to teach high-school students the key concept of chemical bonding. This attempt is motivated by many studies conducted worldwide that revealed the traditional approach of teaching bonding is problematic (Teichert and Stacy, 2002). More specifically, during the last two decades, researchers have found that students lack a deep conceptual understanding of the key concepts regarding the bonding concept and fail to integrate their mental models into a coherent conceptual framework when they learn by traditional approach (Bodner and Domin, 1998; Griffiths and Preston, 1992; Herron, 1996).

Researchers investigated that students have consistent problems with understanding chemical bonding (Dhindsa and Treagust, 2009) then learning of advanced chemistry content will be a serious problem (Coll andTreagust, 2001). Understanding chemical bonding is important to comprehend the nature of the chemical reactions, thermodynamics, molecular structure, chemical equilibrium and some physical properties such as boiling points. Also, reactivity, spectroscopy and organic chemistry concepts cannot be understood unless students understand the chemical bonding theories (Taber and Coll, 2002). In the studies of chemical bonding, learning and teaching, many researchers used instruments to assess students' difficulties. Henderleiter, Smart, Anderson, and Elian (2001) used interview to identify how organic chemistry students understood and applied knowledge of hydrogen bonding to the physical behavior of molecules.

Ethiopian students also face the same challenges on understanding the concept of chemistry in general and chemical bonding in specific (Derege,2013). Even though, there were such problems in Country, there was no study done in Beghi and Kondala Preparatory Schools. This was the main reason why the researcher directed his face to study on students conceptions on chemical bonding in those preparatory schools.

1.2. Statements of the Problem

Chemistry courses commonly cover a great number of abstract concepts because chemistry generally deals with the properties, characteristic and behavior of matter. As a consequence, it is complicate and difficult for students to construct the meanings of chemistry concepts easily. From the content of chemistry subject chemical bonding is the one that is very tough to the student because it consists of bulk of abstract concepts, which make it difficult to students. As the result of this problem, many of the present studies focuses on students' difficulties regarding the concepts of chemical structure and bonding, which are essential for understanding many concepts and topics in chemistry. For example according to Chwee and Ngoh (2001) Chemical bonding is a topic which many Preparatory School students find difficult to understand.

Levy (2004) research conducted around the world has clearly shown that the concepts associated with chemical structure and bonding, such as molecules, ions, hydrogen bonds, and giant lattices are abstract and are highly based on the sub-microscopic nature of chemistry.

According to Dhindsa(2014) investigation, the difficulty in learning chemical bonding concepts is associated with the sequence (ionic, covalent and polar covalent bonding) in which students are taught because this sequence receives little support from constructivist theories of learning.

Nimmermark, Martensson and Davidowitz (2016) examined using the sample of 700 Swedish and South African students from the upper secondary school and first-term Chemistry University and revealed as notable differences between the countries were found in textbooks and in the curriculum regarding the topics of ionic bonding, and bond energetic

As to Levy, Mamlok and Hofstein (2007) the traditional pedagogical approach for teaching chemical bonding is often overly simplistic and not aligned with the most up-to-date scientific models. As a result, high-school students around the world lack fundamental understanding of chemical bonding.

In our country Ethiopia also some researchers investigated on related topic in different areas. For example Derege (2013) was conducted an investigation on 167 grade 11 natural science students in two preparatory schools in Ethiopia. They were designed to predict the extent of variation in academic performance in some fundamental chemical concepts in the topics: Atomic structure and periodic table, and chemical bonding and structure from variations in Felder-Silverman's learning styles. The result confirmed us the influence of learning styles on academic performance is less likely to be the same across fundamental concepts in chemistry.

Melaku (2014) studied on what makes students believe Chemistry is difficult and what can be done to overcome these difficulties using approximately 100 samples of students in an introductory chemistry course and a second survey, which was given to approximately 93 students in another semester, distilled from the responses to the first survey. The findings show that student-related factors, such as scientific language literacy have the most influence on students' successes in chemistry.

1.3. Research Hypothesizes

H1. Uses of appropriate models have significant positive effect on grade 11 students' learning of chemical bonding.

H0. Uses of appropriate models have no effect on grade 11 students' learning of chemical bonding.

1.4. Objectives of the Study

1.4.1. General Objective

The general objective of study was:-

To investigate the effect of using models on students' learning of chemical bonding of grade 11 students of Preparatory Schools in Western Wollega Zone.

1.4.2. Specific Objectives

The specific objectives of the study were:-

1. To explore the difference in academic achievements of grade 11 students on chemical bonding concepts after using ball-and-stick chemical models and without using models in Beghi and Kondala Preparatory Schools, respectively.

2. To disprove the null hypothesis which says the uses of appropriate models have no effect on grade 11 students' learning of chemical bonding.

1.5. Significances of the Study

The study on the effect of using models on students' learning of chemical bonding may help the teachers how they can prepare and use models in teaching about chemical bonding. The forthcoming studies on students' conceptual change of chemical bonding by using models may provide important benefits for chemistry teachers, curriculum developers and textbook writers. This research may provide necessary information for school principals to provide chemical models. Finally, the findings of this study and its implication might provide some important direction for conducting further research in those areas.

1.6. Scope of the Study

West-Wollega Zone is the large zone which has 22 Woredas. In this Zone there are 22 governmental and 4 non-governmental Preparatory Schools and 77 governmental and 4 non-governmental High Schools. The researcher believed that it was better to conduct the study on the contributions of using models on students' conceptions of chemical bonding in this large scale. Due to the time constraint the study was confined to the two Woredas in West-Wollega Zone of grade eleven Preparatory School students.

1.7. Limitation of the Study

The researcher had limited resources to support the study with enough recent literature review.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Types of Chemical Bonding

Chemical bonds are the attractive forces that hold chemical species like atoms, ions and molecules together in chemical compounds (Erdik and Sarõkaya,2000), (Lagowski, 1997a, p.336), (Silberberg, 2003, p.59), (Lewis and Hawley, 2007). Chemical bonding is one of the most central topics taught in chemistry at upper secondary school level, and is also essential for other topics in chemistry (Nahum, Mamlok-Naaman and Holstein, 2008). Chemical reactions involve the breaking and forming of chemical bonds. Therefore, chemical bonding is a key concept in chemistry. Chemical bonds are classified as ionic, covalent and metallic bonds.

Ionic Bonding

Ionic bonding is defined as the result of electrostatic attraction between oppositely charged atoms or groups of atoms (Lagowski, 1997), or ions (Hopp and Henning, 1983). According to, Lewis (2007) ionic bonding is the result of electrostatic attraction between oppositely charged ions at one place, but refers to the transfer of electrons at another place. Metals become positively (+) charged by losing electrons, while, non metals gain electrons and become negatively (–) charged. The positive and negative charges formed in this way strongly attract each other which results in ionic bond formation. The oppositely charged ions are held rigidly in position throughout the ionic lattice by strong electrostatic attractions (Silberberg, 2003; Lagowski, 1997b; Hopp and Henning, 1983). This ionic lattice explains the properties of ionic solids: hard, rigid, brittle, and conduct electricity when melted or dissolved in water but not in the solid state (Silberberg; Lagowski).

Covalent Bonding

Covalent bond is formed by sharing an electron pair(s) between atoms. According to Silberberg (2003), covalent bonds occur when a shared pair(s) of valence electrons attracts the nuclei of two atoms and hold them together, filling each atom's outer shell.

This attraction draws the atoms closer, and repulsion between the atoms' nuclei and electrons also occur. The covalent bond results from the balance between these attractions and repulsion, where the system has its minimum energy (Silberberg, 2003).

Covalent bonding is also defined as a bond in which two electrons are shared by two atomic nuclei or a pair of atoms (Lewis, 2007), or as a bond where 'each atom of a bound pair contributes one electron to form a pair of electron' (Parker, 1997). According to Hopp and Henning (1983) in a covalent bond, two atoms are hold together as a result of the atoms meeting and their electrons enter the 'attractive region', the electric force field of the positively charged nucleus outside the atom, of the other. The bonding is caused by the electrons between the nuclei, the region where the forces of attraction by the two nuclei are greatest, and where the electrons preferentially go (Hopp and Henning, 1983). The bonding electrons are localized in the region of the nuclei which is also mentioned by Lewis (2007).

Polar and Non-Polar Covalent Bonding

Polar covalent bonding is described in terms of covalent bonding with unequally sharing of electrons. This unequally sharing of electrons between the atoms emerges when atoms with different electro negativities form a bond (Silberberg, 2003; Lagowski, 1997c) resulting in partially negative and positive poles of the bond (Silberberg), or that the electron density is shifted toward the more electronegative atom (Lagowski 1997). The unequal sharing is also described to occur when the electron pair is held more closely by one of the atoms (Parker, 1997) or the electrons lie nearer to one of the atoms in the bond, as a result of different attractive forces on the bonding electron pair (Hopp and Henning, 1983). Further reasons for the unequal sharing is that the electrons spend more time in the nearby region of one atom than the other, seen as a partial electron transfer or shift in electron density where the property electro negativity can be used to distinguish between non polar covalent bond and polar covalent bond (Chang, 2005).

Valence-shell electron-pair repulsion (VSEPR) theory is used to construct the molecular shape from Lewis structure. 'Each group of valence electrons around a central atom is located as far away as possible from the others in order to minimize repulsion' (Silberberg, 2003, p.370-371). A group is defined as any number of electrons that occupy a region around an atom, e.g. single, double or triple bond, a lone pair(s) or lone electron.

The three-dimensional arrangement of nuclei joined by the electron groups gives rise to the molecular shape (geometry).

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

Metallic Bonding

Metallic bonding is explained in terms of the electron-sea model (Silberberg, 2003; Parker, 1997). In this model, the metallic lattice is described to consist of the atomic cores, seen as cations, surrounded by the metal atoms' delocalized valence electrons that form an 'electron sea' (Silberberg), or immersed in a sea of delocalized electrons (Chang,2005). The electrons attract the metal cations together (Chang; Silberberg). There also exists models for metallic bonds in terms of electron-sea but without the term delocalized electrons and lack of the bond due to the attraction between cores and electrons. The metallic bond is then seen as the result of the sea of electrons free to move throughout the metallic lattice (Parker). Means, in metallic bonding the bonding-electrons are free to move through the three dimensional structure. These valence electrons, free to move between the atomic cores, are also said to form a so-called electron gas, that 'glue' the cations of the metallic lattice together, that is, the metallic bonding (Hopp and Henning, 1983). Some literature do not use the term electron-sea, but similar to (Silberberg), the metallic bonds are seen as the attraction between the atomic nuclei and the 'outer shell electrons' which are shared 'in a delocalized manner' (Lewis, 2007, p.172).

2.2. Uses of Models in Teaching Chemical Bonding

Chemistry as a discipline is dominated by the use of models. Models play an important and central role in science and science education in general as well as in chemistry and chemistry education. The development of models is essential when knowledge is produced, and models have a wide range of functions in science (Gilbert, 2008). Scientists develop theories to explain the observed natural phenomena, and models in science are linked to the theories with phenomena and are part of these theories. Models can be used to make abstractions visible, or to provide the basis for predictions about and explanation of phenomena (Gilbert, Boulter, and Rutherford, 1998). A model can not only be seen as a description and/or simplification of a complex phenomenon (Gilbert, 2007), but also described as a proposal for how concepts, of which the world is believed to consist of, physically and temporally correlate to each other in the material world (Gilbert, Boulter and Elmer, 2000). Gericke and Hagberg (2008) define a model as a representation of a phenomenon initially produced for a specific purpose.

In chemistry, chemical ideas are presumed to have been visually, mathematically, or verbally modeled since they were first produced (Justi and Gilbert, 2002b). Models play a key role in the development of chemical knowledge (Gilbert, 2007). This key role started with the first concrete model of the atoms by John Dalton at the beginning of the nineteenth century. He was followed by several leading chemists who increased the use of models in chemistry, and today, several models are used when chemical knowledge about phenomena is produced and communicated (Justi and Gilbert, 2002b). Chemistry deals with the properties and transformations of materials which are essentially abstract, and there is a need for representations or models at sub-microscopic level to understand macroscopic observations (Oversby, 2000).

Using models is important when developing scientific knowledge, and models play an important role when science is communicated. The central role of models in science consequently gives them equal importance in science education, and models in science attain a wide variation of epistemological states (Gilbert, 2007). For example, a mental model is a private and a personal representation, created by an individual regarding, for instance, natural phenomena (Gilbert, 2007; Van Driel and Verloop, 1999). When a mental model is placed in the public domain and expressed through speech or writing, it can be called an expressed model (Gilbert, 2007; Gilbert, Boulter and Rutherford, 1998).

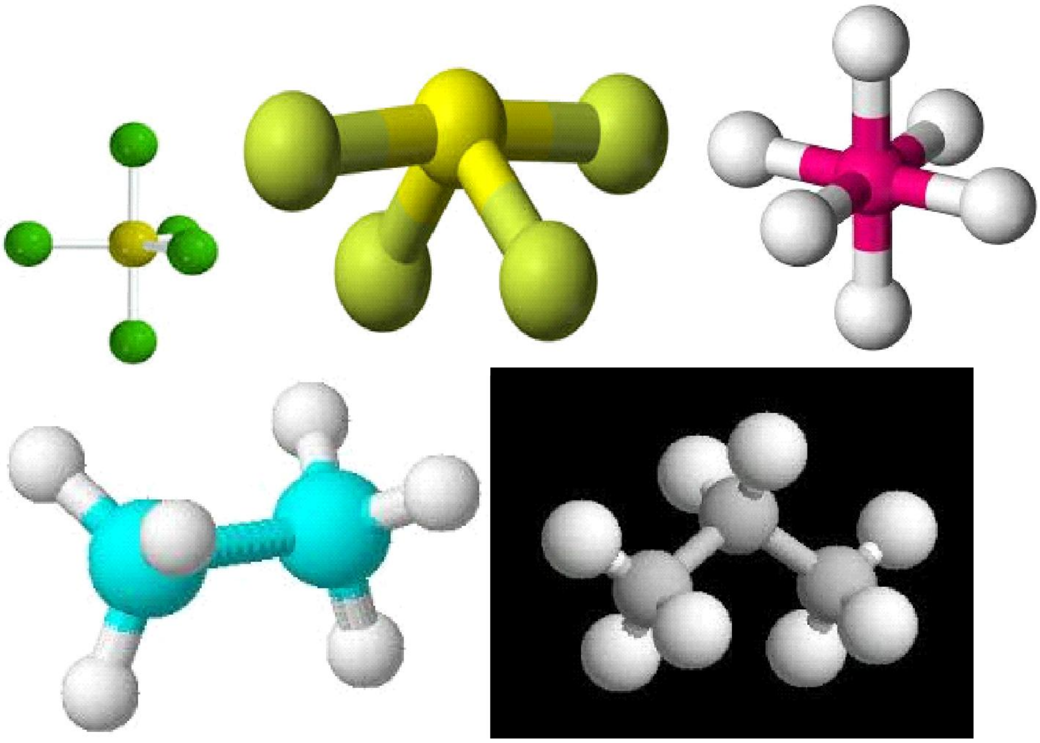
When scientists or researchers at the front line of science reach agreement about an expressed model, it can be termed a scientific model; it can be termed as a scientific model, for example, the Schrödinger model of the atom (Gilbert, 2007; Gilbert, Boulder and Rutherford, 1998).

2.3. Ball-and- Stick Chemical Models

The researcher used ball- and- stick models to do this experimental research from the chemical models present in chemistry. In chemistry, the ball-and-stick model is a molecular model of a chemical substance which is used to display both the three-dimensional position of the atoms and the bonds between them. The atoms are typically represented by spheres, connected by rods which represent the bonds. Double and triple bonds are usually represented by two or three curved rods, respectively. In a good model, the angles between the rods should be the same as the angles between the bonds, and the distances between the centers of the spheres should be proportional to the distances between the corresponding atomic nuclei. The chemical element of each atom is often indicated by the sphere's color.

In a ball-and-stick model, the radius of the spheres is usually much smaller than the rod lengths, in order to provide a clearer view of the atoms and bonds throughout the model. As a consequence, the model does not provide a clear insight about the space occupied by the model. In this aspect, ball-and-stick models are distinct from space-filling (Calotte) models, where the sphere radii are proportional to the atomic radii in the same scale as the atom distances, and therefore show the occupied space but not the bonds. In 1865, German chemist August Wilhelm von Hofmann was the first to make stick-and-ball molecular models. The concept of the chemical bond as a direct link between atoms can be modeled by linking balls (atoms) with sticks/rods (bonds). This has been extremely popular and is still widely used today **(**Pawel Zeidler, 2013**).**

Here are some examples of ball- and-stick chemical models.



Ball-and-Stick Models (Pawel Zeidler, 2013)

Model Based on Spheres (Space-Filling models) (Pawel Zeidler, 2013)

2.4. Problems Regarding Use of Models in Science Education

Models play an important role when scientific knowledge is developed and when science is communicated, but the use of models in science education is not unproblematic. Students' difficulties in understanding models in general have been reported in research, and research has also shown that the use of models in science education can cause students to have learning difficulties (Grosslight, Unger, Jay and Smith, 1991; Ingham and Gilbert, 1991; Justi and Gilbert 2002a). According to Taber and Coll (2002), a teaching model should be at an optimum level of simplification, which is being kept as simple as possible while still being scientifically correct. In such a case, a teaching model provides a ground for students to develop later on in their learning process. If a hybrid model is used as a teaching model, it is not a suitable ground for developing more complex models at a higher educational level, because they are formed by attributes from several scientific models (that also can be historical models) that they will be meeting in the next level. The limitations of the models and that several models can be used to explain will then be unclear. It is quite obvious that this might be confusing for the students. The merging of attribute is probably made in order to make a teaching model less simplified, but the result might be a model which instead is difficult for the students to learn. Teaching models in terms of simplified versions of scientific models developed for use in a teaching situation are frequently used in chemistry textbooks and by teachers. The need for simplifying the scientific models can be justified, but studies have shown that these teaching models failed both to support the students' understanding of a certain aspect of content and of the meaning of a model (Justi and Gilbert, 2002b). Moreover, the teaching models (hybrid models and/or simplified versions) can actually cause students to have learning difficulties, indicated by Gericke and Hagberg (2010b) in the context of genetics. They found that the models presented in textbooks were correlated to the alternative conceptions held by students.

There are further complications regarding models in science education. When the models are explained and expressed to the students, they can be expressed by the use of one or more of the five modes of representation, described as follows (Gilbert, 2007):

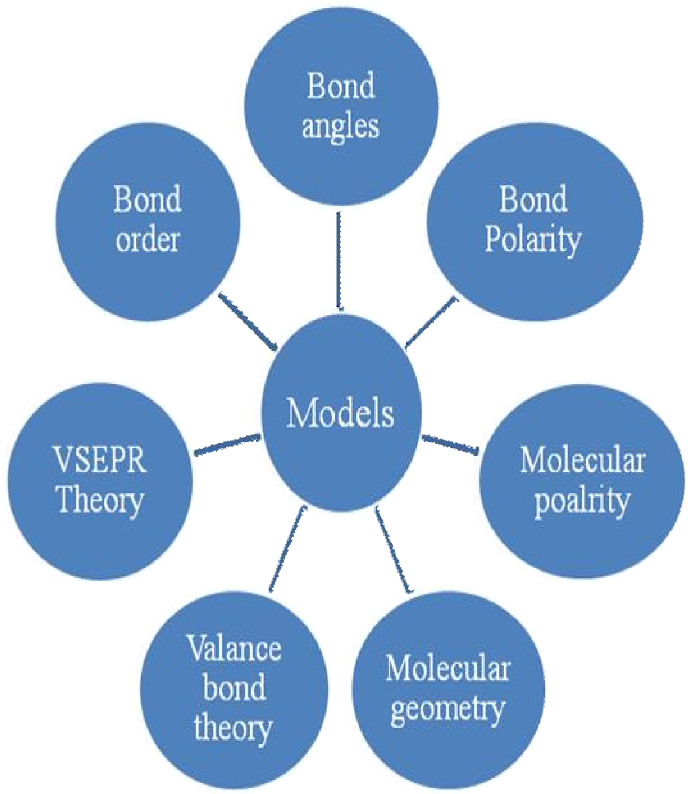
- The concrete model is three-dimensional and made of resistant material, for example*,* a plastic ball-and-stick model of an ionic lattice
- The verbal model can be either spoken or written, and can consist of 'a description of the entities and the relationship between them in a representation' (p.13), or an exploration of metaphors and analogies on which a model is based
- The symbolic model can 'consist of chemical symbols and formula, chemical equations, and mathematical expressions' (p.13)
- The visual model can be graphs, diagrams and animations, where two dimensional representations of chemical structures are common examples
- The gestural model consists of movements by the body or its parts.

But these circumstances are not the only problems. If the students have knowledge of different states of models and recognize their functions and limitations as well as the fact that a concept can be explained by several models, they gain a better understanding of scientific knowledge and nature of science (Boulter and Gilbert, 2000; Drechsler and Van Driel, 2008; Gericke and Hagberg, 2008). However, teachers and textbooks are not always explicit when using models (Gericke, Hagberg, Santos, Joaquim and El-Hani, 2012). Often the models are described as if the models themselves were the phenomena, and the models' nature and purpose are not discussed at all (Grosslight, 1991). Further, teachers might forget or they do not even know that they are communicating a model; instead, a model is presented as if it was a proven fact rather than a theory (Treagust and Coll, 2002).

The range and sophistication of the scientific models used by chemists to understand chemical bonding is one factor that contributes to students finding this topic difficult (Gilbert, 1998). Students are poorer at modeling than teachers expect, and younger secondary school students usually do not look further than a model's surface similarities. They think that models are toys or small incomplete copies of actual objects, and therefore they do not look for ideas or seek purposes in the model's form (Harrison and Treagust, 1998). From the results of their studies, Justi and Gilbert (2002) strongly recommend that students should learn about the nature of models and their use as thinking tools and learn about the scope and limitations of specific chemical models. Teachers should encourage the use of multiple models for a given phenomenon.

2.5. Conceptual Frameworks

This research is a true experimental research design applied on two different grade 11 chemistry students on chemistry concepts particularly on chemical bonding concepts by using ball-and-stick chemical models. The researcher used Ball-and-Stick models to do this paper because the models can explain bond orders, bond angles, bond polarity, geometry of the molecules, molecular polarity, VSEPR theory, Valence bond theory and net dipole moment of the molecules can be calculated by using ball-and-stick models.



CHAPTER THREE

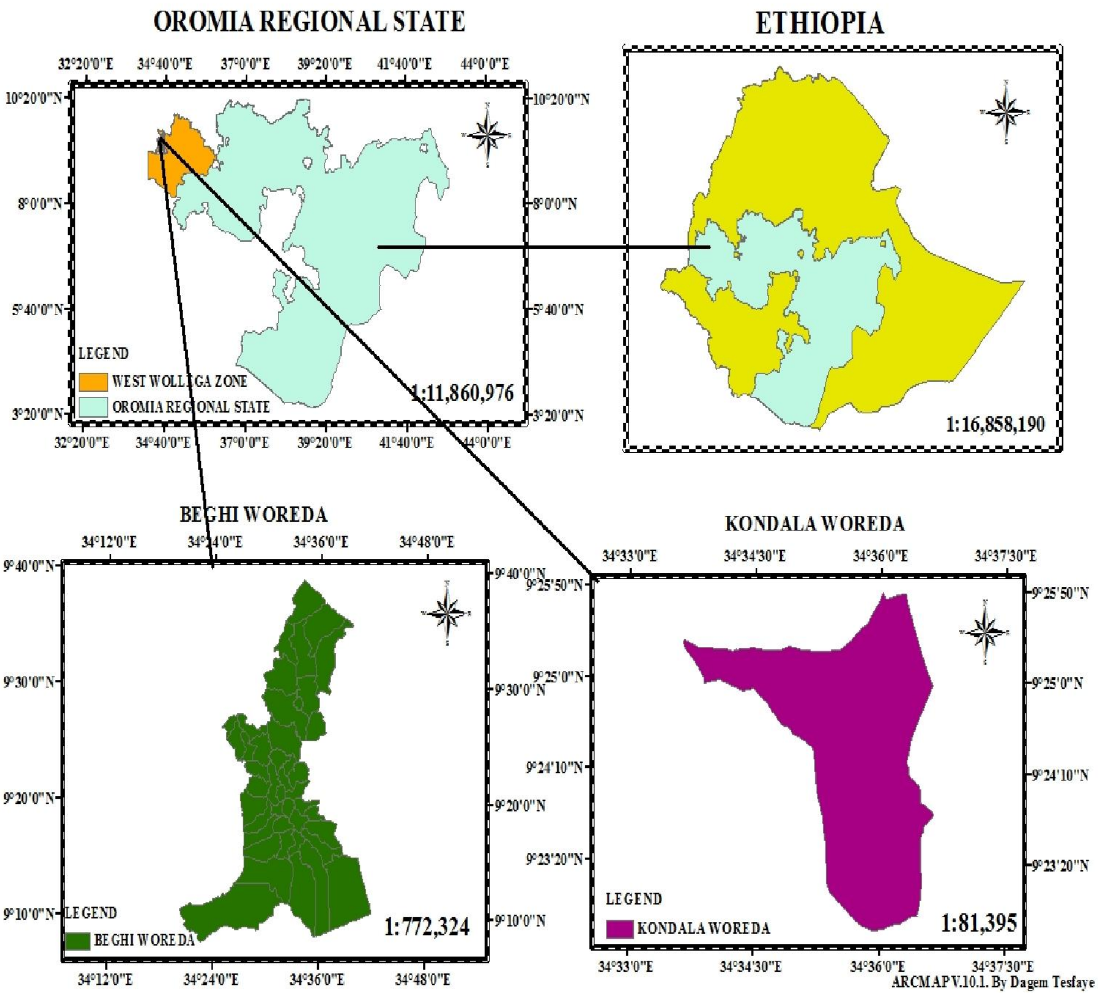
3. RESEARCH METHODOLOGY

3.1. Research Design

The research was a true experimental design type with control group and treatment group. The study was done in two different preparatory schools of different Woredas by taking grade eleven students as a reference. According to Robson (2002), an experimental design is employed where participants are assigned to different conditions. Beghi Preparatory School has seven classes and Qondala Preparatory School has four classes. To do this study, eight classes were selected purposefully to avoid extraneous variables. From eight sections of natural science students of a total 486 (289 male students and 197 female students), eighty students (62 male students and 18 students) were selected depending up on their academic achievements (top ten students). Top ten students were selected to have students having similar academic achievement in both experimental and control groups sample students. The research intended to identify students' conception on chemical bonding and investigating the effect of using models on teaching students about chemical bonding.

3.2. Study Area

The study was conducted in Beghi and Kondala Woredas in south-western Ethiopia which are located in the West-wollega zone of the Oromia region. Beghi and Gebadafino are towns of Beghi and Kondala Woredas, respectively. They are far by 664km and 654km from the capital city of the country Addis Ababa. The subjects for the study were grade eleven students of 2016/17 G.C at Beghi and Kondala Preparatory Schools found in Beghi and Gebadefino towns.



Source: Ethiopian Mapping Agency, 2017

3.3. Source of Data

To collect relevant information the researcher used primary sources of data. Primary sources are grade 11 natural science students, teachers and directors from both Preparatory Schools.

3.4. Samples and Sampling Techniques

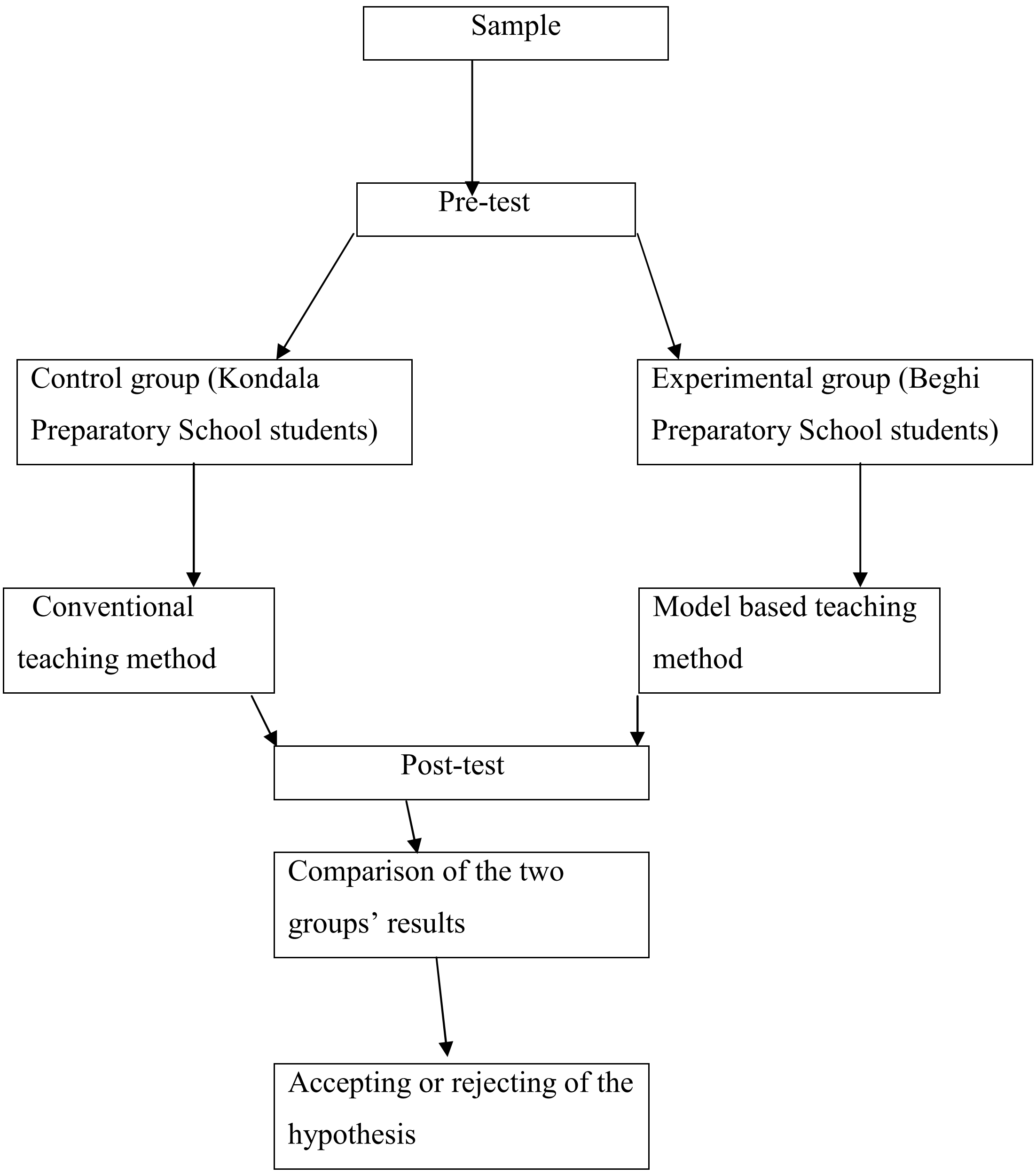
The total population, or the total number of grade 11 natural science students in both Preparatory Schools from the selected classes are 486. 241(142 males and 98 females) grade 11 students from Kondala Preparatory School and 245(147 males and 99 females) grade 11 students from Beghi Preparatory School. From this total population, the researcher had chosen eighty top ten students using purposive sampling technique for giving pretest. Purposive sampling technique was used to avoid extraneous variables. After the pretest, the total number of samples for the study was sixty in total by removing low scorer students (Table 4.1).

3.5. Data Collection Tools

Murali et al. (2004) defined data collection as the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. To obtain adequate information the researcher used self-made test and inter-views. The items of the questions were multiple choices for pre-test and post-test and open-ended for inter-views. The prepared questions were first analyzed by chemistry teachers before administered for the grade 11 Preparatory School sample students. Inter-view questions used the researcher to get the general views of the students on chemical bonding. Pretest and post test were used to see prior and posterior knowledge of the students selected for the sample.

3.6. Procedures

To get the relevant information about the concepts of sample students on chemical bonding the researcher first administered inter-view questions for four students, two teachers and two Schools' vice-directors by using open-ended questions one time in the School at working time. The researcher administered pre-test to correctly know the academic achievements of the students and take students having similar academic achievements from both Schools on concepts of chemical bonding. After pre-test was administered students were classified into experimental group (Beghi grade 11 Preparatory School students) and control group (Kondala grade 11 Preparatory School students) by using random technique. After this the researcher taught the concepts of chemical bonding the experimental group (EG) sample students by using ball-and-stick models prepared by him and the control group (CG) sample students by using traditional method of teaching. At the end of the treatment post-test was administered for both groups to see whether there is a significant differences between the two groups. In diagram



3.7. Method of Data Analysis

After collecting the necessary data, the data were analyzed by employing various statistical methods. Descriptive statistics (calculation of means) were used to describe the data in terms of mean scores and standard deviations. The paired samples t-test was used to determine whether the difference between two mean scores of the two groups (EG and CG) was significant or not. The t-test was calculated to compare the mean correct responses of each question and to that of the mean scores of experimental group and control group sample students scores.

3.8. Ethical Consideration

The research design is experimental, needs long time and patience of the participants (samples) of the study. Before the collection of data from the samples Beghi and Kondala Preparatory Schools principals, teachers and the sample grade 11 students were communicated the objectives of the study clearly and get consent from them.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

Chemical bonding and the properties of chemical bonding are abstract to students. Most students are not clear in defining chemical bonding, identifying the three types of chemical bonding, bond polarities, and molecular polarities and how to determine the bond angle and the shape of molecules. The present study has made attempts how using models in teaching about chemical bonding, avoid these difficulties and maximize students' conceptions of chemical bonding. Therefore, in this section the result of the experiment and the response of the students collected by the pre-test and pos-test were analyzed, interpreted and presented.

Table 4. 1 back ground information of the respondents

No	Group	Female	Male	Total
1	Experimental	4	26	30
2	Control	5	25	30
	Sub total	9	51	60

4.1. Analysis of Students' Conceptions of Chemical Bonding.

Under this sub unit the way of identification the effect using models on students' learning of chemical bonding was described. Before the treatment, formal interviews were conducted with four students, two teachers and two vice directors in order to identify the existence of students' problem on chemical bonding. The researcher also has the experience about Beghi preparatory school students because he taught that school since 2004E.C.Those interviewees indicated that their students have difficulty in understanding about chemical bonding. The teachers were not in a position to solve the problem. Pre-test questions were also given to the students to predict the outcome of students' academic achievement on chemical bonding.

4.2. Analysis of Interview Questions Prepared for Students, Teachers and Vice Directors.

I. Interview Questions Prepared for Preparatory Schools Vice Directors

1. Is there any chemical bonding models in your School these used by teachers to teach

students the concepts of chemical bonding?

This question is asked to analyze if there are any types of models used in their Schools. The interviewees answered as there are no any types of models in their Schools.

2. Is there ICT program in your School which is used to display the structures of chemical bonding?

There are computer based models those used in teaching chemical bonding and the researcher asked if there are such models in their Schools, but there no models based on.

II. Interview Questions Prepared for Grade 11 Beghi and Kondala Preparatory School Teachers

1. What is the academic achievement of your students toward learning of chemical bonding concepts?

Both interviewees said that, they have less motivation to learn chemical bonding concepts when compared with the motivations they have on other chapters.

2. What types of students' problems have you seen when you teach them the concepts of chemical bonding?

From the results obtained from both interviewees the students from both Schools have the problems of drawing Lewis structure, differentiating ionic bonding from covalent bonding, polar covalent bond from non-polar covalent bonding, determining bond angles and molecular geometry, using VSEPR Theory and Valence Bond Theory and determining polarity of molecules.

3. Do you use chemical bonding models while teaching the students the concepts of chemical bonding?

Both Beghi and Kondala Preparatory School teachers answered that there are no any types of chemical bonding models in their Schools that they use to teach their students the concepts of chemical bonding.

III. Interview Questions Prepared for Grade 11 Preparatory School Students

1. How you see chemical bonding concepts with other chemistry concepts?

   This question was asked the students to assess the concepts they have on chemical bonding with relative to other chemistry concepts. The results obtained from them showed that the bonding concepts are complex, abstract, difficult, similar with each other, confusing and need additional time like tutorial classes to understand very well when compared with other chemistry concepts.

2. What are your difficulties from the concepts of chemical bonding?

   The question was asked the students to explore which concepts are difficult to them. The following results were mentioned, determining bond angles, molecular polarity, molecular geometry, hybrid orbital, sigma and pi-bonds, how metallic bonding and coordinate covalent bonding are formed.

3. Have you used chemical bonding models in class or elsewhere?

   All the four students gave the same answer, No.

4.3. Results of the Administration of the Chemical Bonding Conception Pre-Test

With all the multiple choice questions scored individually, experimental sample students correct mean score of 10.2 out of 20 with standard deviation of 3.82.Similarirly the control group (sample) students correct mean score of 10.06 out of 20 with standard deviation of 3.37. This value indicates there is variation between the two groups, but it is not significant before the treatment. The scores of experimental sample students ranged from 1 to 18 and that of the control group sample students ranged from 1 to 18. From this one can understand that the two groups have similar background on chemical bonding.

Mean scores between the two groups was done by using paired samples t-test. From the result of the analysis, it was found out that there was no statistically significant difference between the mean scores of the two groups (t=0.13 at p> 0.05 levels of significance (Table 4.2) below.

Table 4. 2 Descriptive and t- test statistics for the pre-test

Group	N	Sum	Mean score	St.deviation	t_{cal}	t_{crit}	p-value	α-value
EG	30	305	10.2	3.82	0.13	1.672	0.89	0.05
CG	30	302	10.06	3.37				

4.4. Discussions and Interpretation of the Results.

The results of this study revealed, as the students responses suggested, the use of models is very important because significant differences were seen after the treatment. The forthcoming discussion deals with responses to individual pre-test question. Thus, each section below was begin with the question as it was asked on the test and proceeded by highlighting the main focus of the question, followed by analysis, interpretation and comparisons of responses. Analysis and interpretation is based on the response of sample students.

4.4.1. Results and Discussions of Chemical Bonding Pre-Test (CBPT1)

The following tables indicate the types of questions, the number of respondents and the percentage of the respondents those who answered both correct and incorrect answers from both experimental group sample students and control group sample students. Analysis and interpretations of students' responses depends on the following table

Table 4. 3 Percentage response of each question of chemical bonding pre-test

Qns	Choice	EG	CG	Total	100%	Qns	Choice	EG	CG	Total	100%
1	A	1	0	1	1.66	7	A	0	1	1	1.66
	B	1	1	2	3.33		B	16	18	34	56.67
	C	0	1	1	1.66		C	8	7	15	25
	D	28	28	56	93.33		D	7	3	10	16.67
2	A	1	17	18	30	8	A	8	5	13	21.67
	B	14	16	30	50		B	2	4	6	10
	C	0	4	4	6.67		C	18	16	34	56.67
	D	3	5	8	13.3		D	1	6	7	11.67
3	A	5	7	12	20	9	A	7	9	16	26.67
	B	5	5	10	16.67		B	4	7	11	18.3
	C	2	4	6	10		C	9	8	17	28.3
	D	18	14	32	53.3		D	10	6	16	26.67
	A	1	1	2	3.33	10	A	5	9	14	23.3
	B	0	2	2	3.33		B	15	15	30	50
	C	27	27	54	90		C	6	2	8	13.3
	D	2	0	2	3.33		D	3	5	8	13.3
5	A	1	3	4	6.67	11	A	9	10	19	31.66
	B	3	4	7	11.67		B	1	3	4	6.66
	C	11	10	21	35		C	10	9	19	31.66
	D	15	13	28	46.67		D	10	8	18	30
6	A	12	9	21	35	12	A	0	5	5	8.3
	B	1	1	2	3.33		B	12	6	18	30
	C	11	16	27	45		C	17	14	31	51.66
	D	6	4	10	16.67		D	1	5	6	10

Continued…..

Qns	Choice	EG	CG	Total	100%	Qns	Choice	EG	CG	Total	100%
13	A	8	5	13	21.66	17	A	11	8	19	31.66
	B	5	7	12	20		B	14	4	18	30
	C	12	6	18	30		C	2	7	9	15
	D	5	22	27	45		D	3	11	14	23.3
14	A	20	15	35	58.3	18	A	17	11	28	46.66
	B	4	10	14	23.		B	3	7	10	16.66
	C	0	2	2	3.33		C	4	6	10	16.66
	D	6	3	9	15		D	6	6	12	20
15	A	7	10	17	28.3	19	A	1	8	9	15
	B	19	13	32	53.3		B	5	4	9	15
	C	2	4	6	10		C	4	4	8	13.3
	D	2	3	5	8.3		D	18	14	32	53.33
16	A	4	4	8	13.3	20	A	2	3	5	8.33
	B	4	5	9	15		B	2	5	7	11.66
	C	17	15	32	53.3		C	13	16	29	48.33
	D	5	6	11	18.3		D	9	10	19	31.66

1. Which species has the longest F-A-F bond angle where A is the central atom?

A.BF_3 B. CF_4 C. NF_3 D. OF_2

This question deals with the concept of bond angle, when atoms form compounds or molecules there must be enough space between bonded atoms and the lone pairs present on the central atom in order to minimize the repulsive force between them. The purpose of this question is to know how far students understood those ideas and determine the bond angle of the molecules.

Analysis of the responses of this question indicates that only 20% of the grade 11 sample students responded the correct answer (A)(table 4.3), implies that since the molecule has trigonal planar shape and has no lone pair electrons on the central atom it has the longest bond angle. The most popular incorrect response was choice (D) that OF_2 molecule has the longest bond-angle (53.33%) which indicates that most sample students are not clear on the effect of lone pair electrons on bond angle of molecules.

Mean scores of the two groups was compared using descriptive statistics in order to know their conceptions on bond angle. From the results of the analysis the mean score of experimental group was 0.16 and that of control group was 0.2. From those results, it was found out that there was no statistically significant difference between the mean scores of the two groups (Table 4.4).

Table 4. 4 Descriptive statistics for pre-test#1

Question	Group	N	Mean	St.Dev
1	EG	30	0.16	0.37
	CG	30	0.2	0.43

2. Which of the following molecules is non polar?

A. CS_2 B. SO_2 C. $CHCl_3$ D. SF_4

This question deals with the polarity of molecules and how the polarity of the molecules can be determined. This question was asked the sample students to know if they cleared in polarity of molecules or not and what is the difference between polar bond and polar molecule.

Analysis of the responses of this question indicates that only26.67% of the grade 11 sample students answered the correct answerer (A), which indicates that since molecules having a linear shapes have zero net dipole moment value the above choice is the correct answer. The most popular incorrect response was choice (C), that $CHCl_3$ is the non-polar molecule (28%). 26.67% chosen (D) and 18.33% chosen (B).

Mean scores between the two groups was done using descriptive statistics. From the results of the analysis the mean score of experimental group were 0.23 and that of control group was 0.3. Based on this, it was found out that there was statistically significant difference between the mean scores of the two groups (Table 4.5)

Table 4. 5 Descriptive statistics for pre-test#2

Question	Groups	N	Mean	St.Dev
2	EG	30	0.23	0.43
	CG	30	0.3	0.46

3. How many atomic orbital are required for SP^3 hybridization?

A. 2 B. 6 C. 4 D.8

This question deals with what is hybridization, how atomic orbital are hybridized and what is the use of atomic orbital hybridization. Therefore, the question was asked to know if the students have this understanding or not.

Analysis of the responses of this question indicated that only 31.66% (Table 4.3) of the grade 11 sample students chosen the correct answer (C), which indicates that, there are one s and three p orbital totally four hybrid orbital. The most popular incorrect answer selected by the respondents was choice (31.66%) (Table 4.3.2), here they simply understood type of orbital mixed together. From (Table 4.3), 30% of the respondents chosen choice (D) and only 6.66% selected choice (B).

Mean scores between the two groups was done using descriptive statistics. From the results of the analysis the mean score of experimental group were 0.53 and that of control group was 0.53. Bases on this, it was found out that there was no statistically significant difference between the mean scores of the two groups (Table 4.6)

Table 4. 6 Descriptive statistics for pre-test#3

Question	Group	N	Mean	St.Dev.
3	EG	30	0.53	0.5
	CG	30	0.53	0.46

4. Which one of the following molecules does not have a tetrahedral central atom?

A. SF_4 B. AlH_4^- C. BF_4^- D. $SiCL_4$

This question deals with the shapes or molecular geometry and structures of the molecules. This question asked the students to know the conception of the students on the geometry of the molecules. Valence Shell Electron Pair Repulsion Theory helps the students to determine the shape of the molecules.

Analysis of the responses of this question indicates that only 21.66% of the grade 11 sample students responded (A), the correct answer of this question, SF_4 molecule does not have tetrahedral shape. The most popular incorrect response which was responded by the respondents is choice (D).From (Table 4.3), one can easily understood that 20% responded (B) and 30% responded (C).

Mean scores between the two groups was done by using descriptive statistics. From the results of the analysis the mean score of experimental group were 0.23 and that of control group was 0.2. From the result of analysis, it was found out that there was no statistically significant difference between the mean scores of the two groups (Table 4.7).

Table 4. 7 Descriptive statistics for pre-test#4

Question	Group	N	Mean	St.Dev
4	EG	30	0.23	0.43
	CG	30	0.20	0.43

5. Which one of the following molecules has both single and triple bonds?

A.HCN B. N_2 C. CO_2 D.BF_3

This question deals with the number of bonds and from this question students also learn bond strength, which means that students can learn as bond strength increases as bond number increases. The purpose of this question was to predict students' conception on this idea.

Analysis of the responses of this question indicates that only 58% of the grade 11 sample students responded the correct answer (A) (Table 4.3.1),implying that HCN has both single and triple bonds..The most popular incorrect answer chosen by students was choice (B), which is regarded as N_2 has both single and triple bonds (23.33%) refer the same table.

Mean scores of the two groups was done by using descriptive statistics. The mean score of experimental group was 0.56 and that of control group was 0.6. From the result of the analysis, it was found out that there was no statistically significant difference between the mean scores of the two groups (Table 4.8).

Table 4. 8 Descriptive statistics for pre-test#5

Question	Group	N	Mean	Std.dev
5	EG	30	0.56	0.5
	CG	30	0.6	0.49

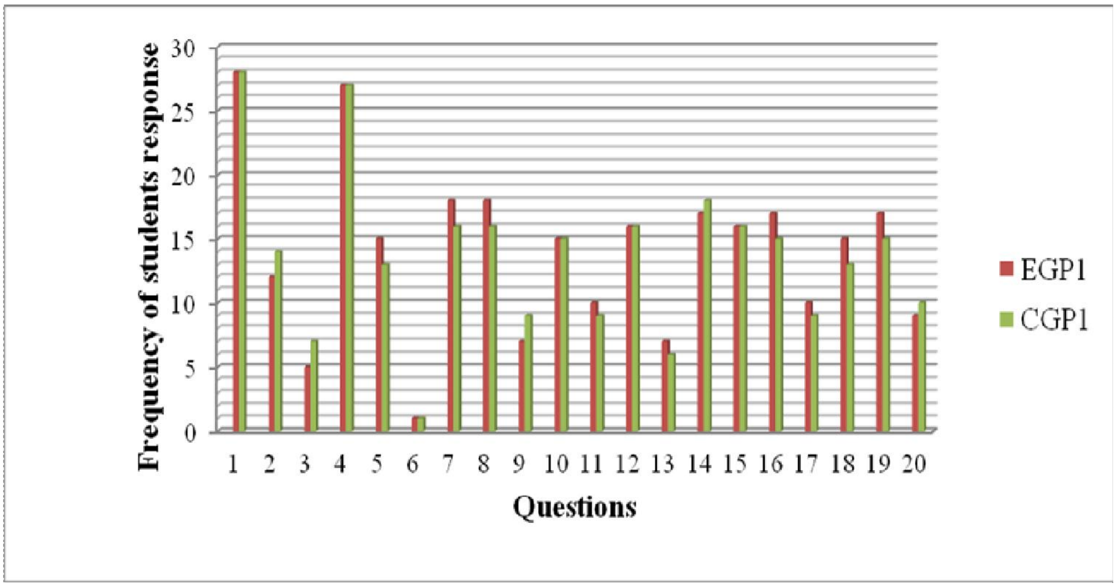


Figure 1. The frequency distribution of correct responds of the experimental and control group before the treatment

EGP1 =Pre-test score of students of the experimental group

CGP1=Pre-test score of the control group

Figure 1; show that the sample students chosen as the experimental group and those chosen as the control group were found almost on the same academic achievement before any treatment was given for the by researcher on the 20 multiple choice questions given for them. The frequency of the respondents for each question was given in above tables. But, the above figure, figure1 summarize the above tables together and give the same information regarding the frequency of the response.

4.4.2. Results and Discussions of Chemical Bonding Post-Test (CBPT2)

The following tables indicate the types of questions, the number of respondents and the percentage of the respondents those who answered both correct and incorrect answers from both experimental group sample students and control group sample students after treatment was given for both of them by using ball-and-stick chemical models and traditional method of teaching, respectively. Analysis and interpretations of students' responses depends on the following tables.

Table 4. 9 Percentage response of each question of chemical bonding post-test

Qns	Choice	EG	%	CG	%	Qns	Choice	EG	%	CG	%
1	A	0	0	2	6.7	7	A	27	90	19	63.3
	B	0	0	4	13.3		B	3	10	11	36.66
	C	0	0	0	0		C	0	0	0	0
	D	30	100	24	80		D	0	0	0	0
2	A	1	3.3	2	6.7	8	A	30	100	21	70
	B	0	0	2	6.7		B	0	0	4	13.3
	C	0	0	0	0		C	0	0	4	13.3
	D	29	96.7	26	86.7		D	0	0	1	3.3
3	A	30	100	18	60	9	A	5	16.7	4	13.3
	B	0	0	6	20		B	24	80	15	50
	C	0	0	5	16.7		C	1	3.3	5	16.6
	D	0	0	1	3.3		D	0	0	6	20
4	A	27	90	20	66.6	10	A	4	13.3	6	20
	B	2	6.7	2	6.7		B	23	76.7	17	56.6
	C	1	3.3	4	13.3		C	0	0	3	10
	D	0	0	4	13.3		D	3	10	4	13.3
5	A	2	6.7	4	13.3	11	A	1	3.3	4	13.3
	B	4	13.3	4	13.3		B	0	0	5	16 7
	C	22	73.3	18	60		C	1	3.3	3	10
	D	2	6.7	4	13.3		D	28	93.3	18	60
6	A	0	0	0	0	12	A	0	0	3	10
	B	0	0	1	3.33		B	0	0	4	13.3
	C	4	13.3	7	23.3		C	17	56.7	11	36.7
	D	26	86.7	22	73.3		D	13	43.3	12	40

Qn. No	Choice	EG	%	CG	%	Qn. No	Choice	EG	%	CG	%
13	A	0	0	8	26.7	17	A	0	0	2	6.7
	B	29	96.7	14	46.7		B	0	0	3	10
	C	1	3.3	5	16.7		C	28	93	19	63.3
	D	0	0	3	10		D	2	6.7	6	20
14	A	21	70	12	40	18	A	4	13	7	23.3
	B	9	30	8	26.7		B	9	30	9	30
	C	0	0	5	16.7		C	0	0	4	13.3
	D	0	0	3	10		D	17	56.7	10	33.3
15	A	1	3.3	4	13.3	19	A	26	86.7	17	56.6
	B	5	16.7	2	6.6		B	0	0	2	6.7
	C	24	80	18	60		C	1	3.3	8	26.7
	D	0	0	6	20		D	3	10	3	10
16	A	0	0	4	13.3	20	A	0	0	2	6.7
	B	0	0	5	16.7		B	0	0	5	16.7
	C	29	96.7	20	66.6		C	0	0	0	0
	D	1	3.3	1	3.3		D	30	100	23	76.6

1. Which species has the longest F-A-F bond angle where A is the central atom?

    A. BCl_3 B. CCl_4 C. PF_3 D. OF_2

The response analysis of this question showed that 100% of the experimental group grade 11 sample students and 60% of the control group grade 11sample students replied correctly choice (A), which was the correct answer of the question asked.

Mean scores between the two groups was done by using descriptive statistics. The mean score of experimental group was 1 and that of control group was 0.6. From the result of the analysis, it was found out that there was statistically significant difference between the mean scores of the two groups (Table 4.10).

Table 4. 10 Descriptive statistics for post-test#1

Question	**Group**	**N**	**Mean**	**St.Dev.**
1	EG	30	1	0.00
	CG	30	0.6	0.49

2. Which one of the following molecules has a polar covalent bond but not polar molecule?

    A. H_2O B. H_2S C. PH_3 D. CF_4

From the analysis of the responses of the respondents, it was observed out that 93.3% of the experimental group grade 11 of sample students and 60% of the control group students replied correctly choice (D), which was the correct answer of this question.

Mean scores of the two groups was done by using descriptive statistics. The mean score of experimental group was 0.93 and that of control group was 0.63. From the result of the analysis, it was found out that there was significant difference between the mean scores of the two groups (Table 4.11)

Table 4. 11 Descriptive statistics for post-test#2

Question	Group	N	Mean	St.Dev.
2	EG	30	0.93	0.25
	CG	30	0.63	0.49

3. How many atomic orbital are required for sp3d hybridization?

A. 2 B. 4. C. 5. D. 8

From t he analysis of the responses of the respondents, it was obtained that 56.7% of the experimental group sample students and 36.7% of the control group sample students replied the correct answer of the question.

Mean scores of the two groups was compared by using descriptive statistics. The mean score of experimental group was 0.57 and that of control group was 0.37. From the result of the analysis, it was found out that there was statistically significant difference between the mean scores of the two groups at (Table 4.12).

Table 4. 12 Descriptive statistics for post-test#3

Question	Group	N	Mean	St.Dev.
3	EG	30	0.57	0.50
	CG	30	0.37	0.49

4. Which one of the following molecules does not have a tetrahedral central atom?

A. AlH_4^- B. SCl_4 C. BF_4^- D. $SiCl_4$

From the analysis of the responses of the respondents, it was obtained that 96.7% of the experimental group sample students and 46.66% of the control group sample students replied correctly the correct answer of the question choice (B).

Mean scores of the two groups was compared by using descriptive statistics. The mean score of experimental group was 0.97 and that of control group was 0.47. From the result of the analysis, it was found out that there was statistically significant difference between the mean scores of the two groups (Table 4.13).

Table 4. 13 Descriptive statistics for post-test#4

Question	Group	N	Mean	St.Dev.
4	EG	30	0.97	0.18
	CG	30	0.47	0.50

5. Which one of the following molecules has both single and triple bonds?

A. CHCH B. N_2 C. BF_3 D. C_2H_4

The analysis of the responses of the respondents showed that 70% of the experimental group students and 40% of the control group students replied correctly the correct answer of the question which was choice (A).

Mean scores of the two groups was done by using descriptive statistics. The mean score of experimental group was 0.7 and that of control group was 0.4. From the result of the analysis, it was found out that there was statistically significant difference between the mean scores of the two groups (Table 4.14)

Table 4. 14 Descriptive statistics for post-test#5

Question	Group	N	Mean	St.Dev.
5	EG	30	0.7	0.46
	CG	30	0.4	0.49

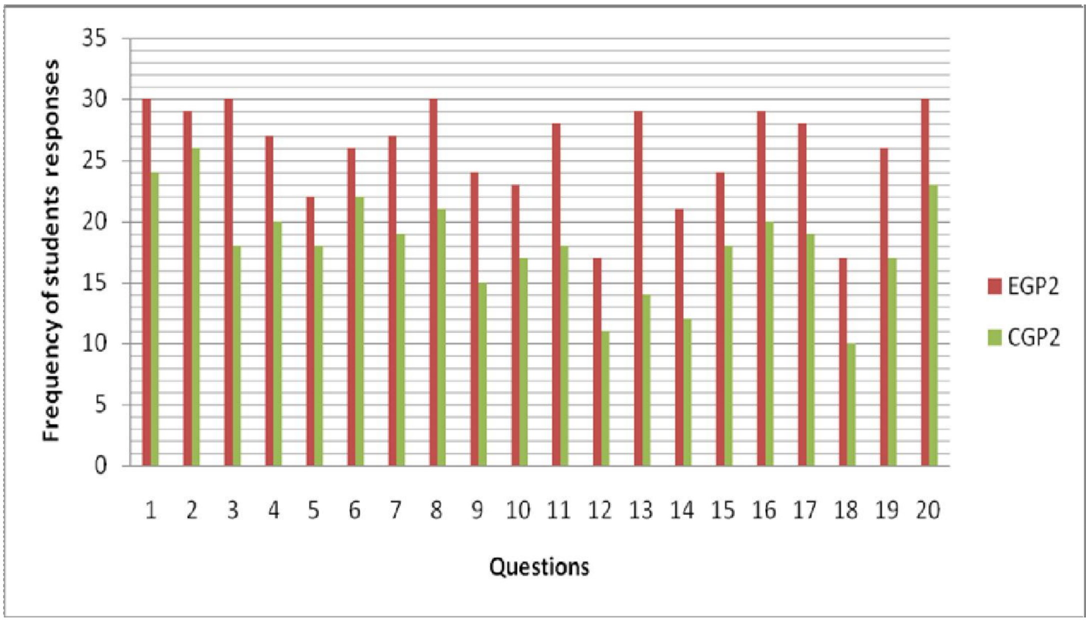


Figure 2 The frequency distribution responds of the experimental and control group after the treatment.

EGP2=Post-test score of the experimental group

CGP2=Post-test score of the control group

Figure.2. Shows that the experimental group students, those instructed by using models about chemical bonding performed better than the control group students, those instructed simply by traditional method

4.5. The Effect of Conceptual Change Models Oriented Instruction on Students' Conception on Chemical Bonding

In this section the data obtained with the help of pre-test and post-test which were measured as the percent mean scores and the percent mean gains of the sample students and the effect conceptual change model oriented on students conception on chemical bonding were interpreted and analyzed.

Table 4. 15 The pre-test percentage mean results of sample students in grade 11

Description	Experimental Group	Control Group
Total scores	305	302
Mean scores	10.2	10.06
Percentage mean scores	50.8	50.3

As shown on the table 4.15, the pre-test percent mean result of students in the experimental group was 10.2 and that of control group was 10.06 out of 20.Therefore, from this result it is possible to conclude that insignificant differences observed between the mean value of the students scores in the experimental group and control group.

Table 4. 16 One tail paired samples t-test result of the pre-test of the respondents

Pair	Pair Difference		df	t_{cal}	t_{crit}	p-value	α-value
	Mean	Std.Deviation	58	0.13	1.672	0.89	0.05
EG-CG	0.14	0.45					

Additionally, the statistical comparison for the percentage mean scores of the pre-test of the experimental and control groups of the mean as shown in the table 4.15 and table 4.16 describes that there was no significant difference between the two groups (t=0.13 at p>0.05). This confirms the fact that the two groups were essentially similar in their academic back ground on chemical bonding. The students in those schools; however scored on average below 50.8% on academic achievement and 49.2% of them have no the conception of chemical bonding.

Table 4. 17: The post-test percentage mean results of sample students in grade 11

Description	Experimental Group	Control Group
Total scores	520	401
Mean scores	17.3	13.3
Percentage Mean scores	86.7	66.8

As shown on the table 4.17, the post-test present mean result of students in the experimental group is 17.3 and that of control group was 13.3 out of 20. Therefore, from this result it is possible to conclude that significant differences observed between the mean value of students scores in the experimental group and control group (see figure 2)

Table 4. 18 One tail paired samples t-test result of the post-test of the respondents

Pair	**Pair Difference**		**df**	t_{cal}	t_{crit}	**p-value**	α**-value**
	Mean	Std.Deviation	58	5.14	1.672	0.000	0.05
EG-CG	3.96	4.2					

Furthermore the statistical comparison for percentage mean scores of the post-test of the experimental and control groups of the mean as shown in the table 4.17 and 4.18 describes that there was significant difference between the two groups (t=5.14 at p<0.05). This confirms the fact that the two groups were different in their academic achievement on chemical bonding when they are taught by using models and without using models.

Table 4. 19 The mean gains and percent mean gains academic scores of experimental and control groups of the respondents.

Description	Experimental group		Control group	
	20	100	20	100
Mean of pre-test	10.2	50.8	10.06	50.3
Mean of post-test	17.3	86.7	13.3	66.8
Mean gain	7.1	35.9	3.24	16.5

Table 4.19, explains that the mean gains of the students in academic score of the two groups. It can be understood that the percentage mean gain by the experimental group was 35.9% and that of control group was 16.5%. Consequently, the mean gains were suggestive of the fact that there was significant difference between experimental group and control group.

Table 4. 20 Gain of one tailed paired samples t-test result of the respondents

Pair	Paired Difference		t	p
	Mean	Std.Dev	5.01	0.00
Experimental-Control	3.82	3.75		

A statistical comparison for the paired sample in table 4.20 students in experimental group better performed than students in control group ($t=5.01$ at $p<0.05$). This obviously implies that the students have acquired significant gain on chemical bonding after they have learned by using ball-and-stick chemical models for about four weeks (figure 2).

Results of the study indicated that the proportion of the students those have the academic achievements of chemical bonding in experimental group was higher than those of control group students when compared. Moreover, proportion of the correct responses given to these items by experimental group students was higher than the proportion of the correct answer given by the control group students. Therefore, it can be concluded that instruction based on using models while teaching about chemical bonding was more effective on students achievements about chemical bonding than the instruction based on traditional methods(without using any models). Therefore, the researcher concluded that models have great significant contributions on students' conceptions of chemical bonding. Standing on this evidence null hypothesis was rejected and alternative hypothesis was accepted.

Intended for above reason, the difference between the percentage mean gains of the experimental and control group proved that students in the experimental group performed better because of the effectiveness of the conceptual change models oriented instruction.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

The main purpose of the present study was to identify students' conceptions and compare the effectiveness of conceptual change occurred on models oriented instruction over traditional instruction about chemical bonding in case of grade eleventh students. In this study chemical bonding test (CBT) was given before the study in order to determine students' conceptions and additional CBT was administered after instruction was given by using chemical models those prepared from the materials found in the environment. It was observed that there was no significant difference between two groups regarding their conceptions on chemical bonding before the treatment. After treatment was given by using the prepared models significant difference was observed between the two groups.

5.1. Summary and Conclusion

The formal interview was done between the researcher, two vice directors, two teachers and four students. The result of the interview indicated that many students have a problem of understanding chemical bonding "defining chemical bonding, identifying chemical bonding, determining polar bond and polar molecules, drawing Lewis structure, determining shapes of molecules, bond angles, and hybrid orbital." During the treatment, experimental group students received instruction based on models, while those control group students received without using models. The results showed that the eight weeks instructions based on models caused a significantly better understanding of chemical bonding than the instruction based without using models. The difference may result from the fact that the models based instruction helped the students to realize that some of their prior knowledge is inconsistent with that of scientific view and helped the students to understand about chemical bonding which was abstract to them simply learning by tradition method. Results also showed that it is very difficult to bring students' conceptual change on chemical bonding which is the main abstract subject in chemistry by using traditional method of teaching rather it is better to use models and make tangible this abstract concepts.

Literature review indicated that most of High School, Preparatory School and even university students have difficulties in understanding of chemistry especially about chemical bonding (Chwee and Ngoh, 2001). However, there are not many studies related to using models in teaching about chemical bonding. Therefore, the taxonomy of the effect of using models on students' learning of chemical bonding presented in this study gains importance. The result of this study support the previous studies in chemistry literature which indicated that students have difficult on variety of chemistry concepts. Therefore, teachers should be aware of students' prior knowledge about chemical bonding since they construct knowledge by the help of already existing conceptions. Moreover, teachers should understand the importance of models and how models can be prepared so that they can plan future activities in a way that instruction promotes meaningful learning. In addition, they should realize that it is difficult to teach about chemical bonding which is abstract without using models since it is not enough to simply present the important concepts because research studies presented that the contribution of models in teaching about chemical bonding is very important (Teichert and Stacy, 2002; Bodner and Domin, 1998). Therefore, teachers should be encouraged to use models in teaching chemistry concepts especially chemical bonding. Researchers and curriculum developers should focus on students' prior knowledge, how models can be prepared from simple materials found in their environment by teachers and students and how they can use to make most chemistry concepts which are abstract to make meaningful or tangible.

The goal of teaching about chemical bonding by using models (ball-and-stick models) in this thesis is to make tangible the concepts of chemical bonding into students' mind which is abstract to them and helped them to try at their studying place while they are studying about chemical bonding and they can expand this into other sciences.

5.2. Recommendation

Most of the time the instruction taking place in country is traditional based, because both teachers and students believed that practical learning is only taking place in laboratory by using chemicals and models (science supporting things) which are expensive to get. But, it is possible to prepare models from things found in our environment and use in class to make abstract ideas in science tangible. Therefore, if we want our students to become literate citizens in the science and technology field, it is very important to orient the scholar education towards a truly meaningful, valid in the scientific and technological domain. This cannot be achieved without changing science into practice, it is mean that converting ideas to tangible things.

The result of this study have great implications on teaching and learning chemistry, not only chemical bonding. Based on the results obtained and the conclusion made, the following are the researcher's recommendations.

- Curriculum planners, authors and teachers should lay emphasis on the processes of science rather than the content of science. This will make the discipline more understandable and promote transfer of learning.
- Teachers should use models while teaching chemistry concepts which are abstracts like chemical bonding because they are not easily understandable by students. Students should also practice this by themselves.
- Experienced teachers should be assigned to teach science subjects in preparatory schools because science at this level is abstract and difficult to understand easily.
- Students should practice preparing models from materials found in their environment and using in the class as well as at their studying place.
- Teachers and students should get more time in the classroom of the government schools so that they can discuss the learning materials in depth and thereby develop different skills such as interaction skills.
- Curriculum developers should provide models with the science because most contents in science are abstract and difficult to understand.
- Additionally, large scale study to assess the contribution of using models on students' conceptions about chemical bonding must be encouraged.

REFERENCES

Abiola, O.O. and Dhindsa, H.S. (2012). Improving classroom practices using our knowledge of brain how the works. International Journal of Environmental and Science Education, 1(7), 71-81.

Al Khawaldeh, S.A., and Al Olaimat, A.M. (2010). The contribution of conceptual change texts accompanied by concept mapping to eleventh-grade students understanding of cellular respiration concepts. Journal of Science Education and Technology, 19, 115-125

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

Bodner, G.and Domin,D. (1998).Mental models: The role of representations in problem solving in chemistry. Paper presented at International Council for Association in Science Education, Summer Symposium, and Proceedings.

Boulter, C., and Gilbert, J. K. (2000). Challenges and opportunities of developing models in science education. In J. K. Gilbert, and C. Boulter (Eds.), *Developing models in science education* (pp. 343-362). Dordrecht: Kluwer Academic Publishers.

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

Chwee, D. Ngoh, K.(2001). Alternative Conceptions of Chemical Bonding, National Institute of Education, Nanyang Technological University Singapore.

Coll, R. K., and Treagust, D. F. (2003). Investigation of secondary school, undergraduate, and graduate learners' mental models of ionic bonding. *Journal of Research in Science Teaching, 40*(5), 464-86.

Coll, R.and Treagust, D. F. (2001). Learners' mental models of chemical bonding. Research in Science Education, 31, 357-382.

Dhindsa, H.S. and Treagust, D.F. (2009). Conceptual understanding of Bruneian tertiary students: Chemical bonding and structure. Brunei International Journal of Science and Mathematics Education, 1(1), 33-51.

Dereje, A. .(2013) Do Learning Styles Influence Students’ Understanding of Chemistry Concepts and Academic Performance in Chemistry? ISSN 2239-978X Journal of Educational and Social Research Vol. 3 (5) August 2013

Dhindsa, H.S. (2014). Prospective Pedagogy For Teaching Chemical Bonding For Smart And Sustainable Learning: chemistry education research and practice.

Drechsler, M., and Van Driel, J. (2008). Experienced teachers' pedagogical content knowledge of teaching acid-base chemistry. *Research in Science Education, 38*(5), 611-631. *Education*, 69 (3), 191-196.

Erdik E., and Sarõkaya Y., (2000). *Temel Üniversite Kimyasõ*, Gazi Kitap evi, Ankara.

Gericke, N. M., and Hag berg, M. (2010b). Conceptual variation in the depiction of gene function in upper secondary school textbooks. *Science & Education, 19*(10), 963-994.

Gericke, N. M., and Hagberg, M. (2010a). Conceptual incoherence as a result of the use of multiple historical models in school textbooks. *Research in Science Education, 40*(4), 605-623.

Gericke, N. M., Hagberg, M., Santos, V. C., Joaquim, L. M., and El-Hani, C. N. (2012). Conceptual variation or incoherence? Textbook discourse on genes in six countries. *Science and Education.* Advance online publication.

Gilbert, J. (1997). Models in science and science education. In J. Gilbert (ed.), *Exploring models and modeling in science and technology education: Contributions from the MISTRE Group*, pp. 5-19. Reading: The University of Reading, Faculty of Education and Community Studies.

Gilbert, J. (1998). Explaining with models. In M. Ratcliffe (ed.), *ASE Guide to Secondary Science Education,* London: Stanley Thornes

Gilbert, J. K. (2007). Visualization: A metacognitive skill in science and science education. In J. K. Gilbert (Ed.), *Visualization in science education* (pp. 9-27). Dordrecht: Springer.

Gilbert, J. K., Boulter, C., and Rutherford, M. (1998). Models in explanations, part 1: Horses for courses? *International Journal of Science Education, 20*(1), 83-97.

Gilbert, J., Boulter, C., and Elmer, R. (2000). Positioning models in science education and in design and technology education. *Developing models in science education* (pp. 3-18). Dordrecht: Kluwer Academic Publishers.

Gilbert, J. (1991).Model building and a definition of science. *Journal of Research in Sciene Teaching*, *28*, 73-79.

Grosslight, L., Unger, C., Jay, E., and Smith, C. L. (1991). Understanding models and their use in science: Conceptions of middle and high school students and experts. *Journal of Research in Science Teaching, 28*(9), 799-822.

Haddad, W. D. et al. (1990). *Education and Development: Evidence for New Priorities*. World Bank Discussion Papers 95, Washington, D. C.: The World Bank.

Harrison, A. G. and Treagust, D. F. (1998). Modeling in science lessons: Are there better ways to learn with models? *School Science and Mathematics*, *98*, 420-429.

Harrison, A. G., and Treagust, D. F. (2000). Learning about atoms, molecules, and chemical bonds: A case study of multiple-model use in grade 11 chemistry. *Science Education*, *84*, 352-381

Henderleiter, J., Smart, R., Anderson, J., and Elian, O. (2001). How do organic chemistry students understand and apply hydrogen bonding? Journal of Chemical Education, 78(8), 1126-1130.

Hopp, V., and Hennig, I. (1983). *Handbook of applied chemistry: Facts for engineers, scientists, technicians, and technical managers*. Washington, DC: Hemisphere Pub.

Ingham, A., and Gilbert, J. K. (1991). The use of analog models by students of chemistry at higher education level. *International Journal of Science Education, 13*(2), 193-202.

Justi, R. S., and Gilbert, J. K. (2002a). Modeling, teachers' views on the nature of modeling, and implications for the education of modelers. *International Journal of Science Education, 24*(4), 369-87.

Justi, R. S., and Gilbert, J. K. (2002b). Models and modeling in chemical education. In J. Gilbert, O. De Jong, R. Justi, D. Treagust and J. Van Driel (Eds.), *Chemical education: Towards research-based practice* (pp. 213- 234). Dordrecht: Kluwer.

Justi, R., and Gilbert, J. (2000). History and philosophy of science through models: Some challenges in the case of "the atom". *International Journal of Science Education, 22*(9), 993-1009.

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

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

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

Levy, N, Mamlok-N, Hofstein, A.(2007). Developing a New Teaching Approach for the Chemical Bonding Concept Aligned with Current Scientific and Pedagogical Knowledge: DOI 10.1002/sce.20201 published online 30 January 2007 in Wiley Inter-Science (www.interscience.wiley.com).

Levy, N., Hofstein, A. Mamlok,N., And Bar-Dov, Z.(2004). Can Final Examinations

Amplify Students' Misconceptions In Chemistry? Chemistry Education: Research and Practice 2004, Vol. 5, No. 3, Pp. 301-325

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

McMillan, J. & Schumacher, S. 2010. Research in Education. Evidence base Inquiry. 7th Edition, International Edition Boston: Pearson Education Inc.

Melaku. M.,(2014).What makes chemistry difficult? AJCE, 2014, 4(2), Special Issue (Part I) ISSN 2227-5835

Murali,*et al*. (2004) Responsible conduct in data management. Faculty development and instructional design centre. Northern Illinois University, DeKalb, IL 60115, USA.

Nahum, T. L., Mamlok-Naaman, R., and Hofstein, A. (2008). A new "bottom-up" framework for teaching chemical bonding. *Journal of Chemical Education, 85*(12), 1680-1685.

Nakhleh, M.B. (1992). Why some students don't learn chemistry. *Journal of Chemical*

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

Nimmermark, A., Mårtensson, J. and Davidowitz, B.(2016). Teaching of chemical bonding: a study of Swedish and South African students' conceptions of bonding: Chem. Educ. Res. Pract., 2016, 17, 985.

Osborne, R. and Freyberg, P. (1996). *Learning in science: The implications of children's science*. Hong Kong: Heinemann Education.

Oversby, J. (2000). Models in explanations of chemistry: The case of acidity. In J. K. Gilbert, and C. J. Boulter (Eds.), *Developing models in science education* (pp. 227-251). Dordrecht: Kluwer Academic

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

Robson, S. (2002) Real world research: A resource for social scientists and Practitioner-Researcher. Second Edition Malden MA. Blackwall Publishing

Sanchez Gomez, P. J., and Martín, F. (2003). Quantum versus 'classical chemistry in university chemistry education: A case study of the role of history in thinking the curriculum. *Chemistry Education: Research & Practice, 4*(2), 131-148

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

Taber, K. S., and Coll, R. (2002). Bonding. In J. Gilbert, O. De Jong, R. Justi, D. Treagust and J. Van Driel (Eds.), *Chemical education: Towards research-based practice* (pp. 213-234). Dordrecht: Kluwer Academic Publishers.

Teichert, M., and Stacy, A. (2002). Promoting understanding of chemical bonding and spontaneity through student explanation and integration of ideas, Journal of Research in Science Teaching, 39(6), 464 – 496. Treagust, and J. H. Van Driel (Eds.), Chemical education: Towards research-based practice (pp. 213 – 234). Dordrecht: Kluwer.

Van Driel, J. H. (1998, April). Teachers' knowledge about the nature of models and modeling in science. Paper presented at the annual meeting of the *National Association for Research in Science Education*, San Diego.

Van Driel, J. H., and Verloop, N. (1999). Teachers' knowledge of models and modeling in science. *International Journal of Science Education, 21*(11), 1141-1153.

APPENDICES

Appendix I

Appendix Table 1 Distribution responses of students for each question of the CBPT1 and CBPT2.

Question#	Pre-test EG	Pre-test CG	Question#	Post-test EG	Post-test CG
1	28	28	1	30	24
2	12	14	2	29	26
3	5	7	3	30	18
4	27	27	4	27	20
5	15	13	5	22	18
6	1	1	6	26	22
7	18	16	7	27	19
8	18	16	8	30	21
9	7	9	9	24	15
10	15	15	10	23	17
11	10	9	11	28	18
12	16	16	12	17	11
13	7	6	13	29	14
14	17	18	14	21	12
15	16	15	15	24	18
16	17	15	16	29	20
17	10	9	17	28	19
18	15	13	18	17	10
19	17	15	19	26	17
20	9	10	20	30	23
Total	280	273	**Total**	517	362
Average	14	13.65	**Average**	25.85	18.1

Appendix Table 2 Percentage distribution responses of the two groups based on their results.

	Experimental Group			**Control Group**	
Question#	CBPT1 100%	CBPT2 100%	**Question#**	CBPT1 100%	CBPT2 100%
1	93.3	100	1	93.3	80
2	40	96.6	2	46.6	86.6
3	16.6	100	3	23.3	60
4	90	90	4	90	66.6
5	50	73.3	5	43.3	60
6	3.3	86.6	6	3.3	73.3
7	60	90	7	53.3	63.3
8	60	100	8	53.3	70
9	23.3	80.	9	30	50
10	50	76.6	10	50	56.6
11	33.3	93.3	11	30	60
12	53.3	56.6	12	53.3	36.6
13	23.3	96.6	13	20	46.6
14	56.6	70	14	60	40
15	53.3	80	15	53.3	60
16	56.6	96.6	16	50	66.6
17	33.3	93.3	17	30	63.3
18	50	56.6	18	43.3	33.3
19	56.6	86.6	19	50	56.6
20	30	100	20	33.3	76.66
Average	46.64	86.10	Average	45.48	60.1

CBT1=pre-test CBT2= Post-test

Appendix Table 3 Descriptive statistics of respondents for each question on both pre-test and post-test are summarized in appendix table 3.

Pre-test				Post-test			
		EG	CG			EG	CG
Question	N	Mean	Mean	Question	N	Mean	Mean
1	30	0.93	0.92	1	30	1	0.8
2	30	0.4	0.46	2	30	0.97	0.7
3	30	0.9	0.9	3	30	0.9	0.66
4	30	0.5	0.43	4	30	0.73	0.6
5	30	0.03	0.03	5	30	0.87	0.7
6	30	0.6	0.5	6	30	0.9	0.6
7	30	0.6	0.5	7	30	1	0.7
8	30	0.33	0.3	8	30	0.77	0.56
9	30	0.53	0.53	9	30	0.8	0.6
10	30	0.56	0.5	10	30	0.97	0.6
11	30	0.3	0.33	11	30	0.57	0.66
12	30	0.56	0.5	12	30	0.57	0.6
13	30	0.56	0.5	13	30	0.87	0.4
14	30	0.3	0.33	14	30	1	0.56
15	30	0.23	0.3	15	30	0.7	0.76

Appendix Table 4 Descriptive and t-test statistics for each question of pre-test

Group	**Mean**	**Std.Deviation**	**Df**	t_{cal}	t_{crti}	**p-value**	α**-value**
EG	14	6.66	38	1.099	1.686	0.286	0.05
CG	13.65	6.37					

Appendix Table 5 Descriptive and t-test statistics result of students for pre-test out of 20

N	Group	Mean	St. deviation	df	t_{cal}	t_{crti}	p-value	α-value
30	**EG**	10.2	3.82	58	0.13	1.672	0.89	0.05
30	**CG**	10.06	3.37					

Appendix Table 6 Descriptive and t-test statistics for each question of post-test

Group	Mean	St. Deviation	df	t_{cal}	t_{crti}	p-value	α-value
EG	26.85	4.10	38	12.3	1.686	0.00	0.05
CG	18.1	4.2					

Appendix Table 7 Descriptive and t-test statistics result of students for post-test out of 20

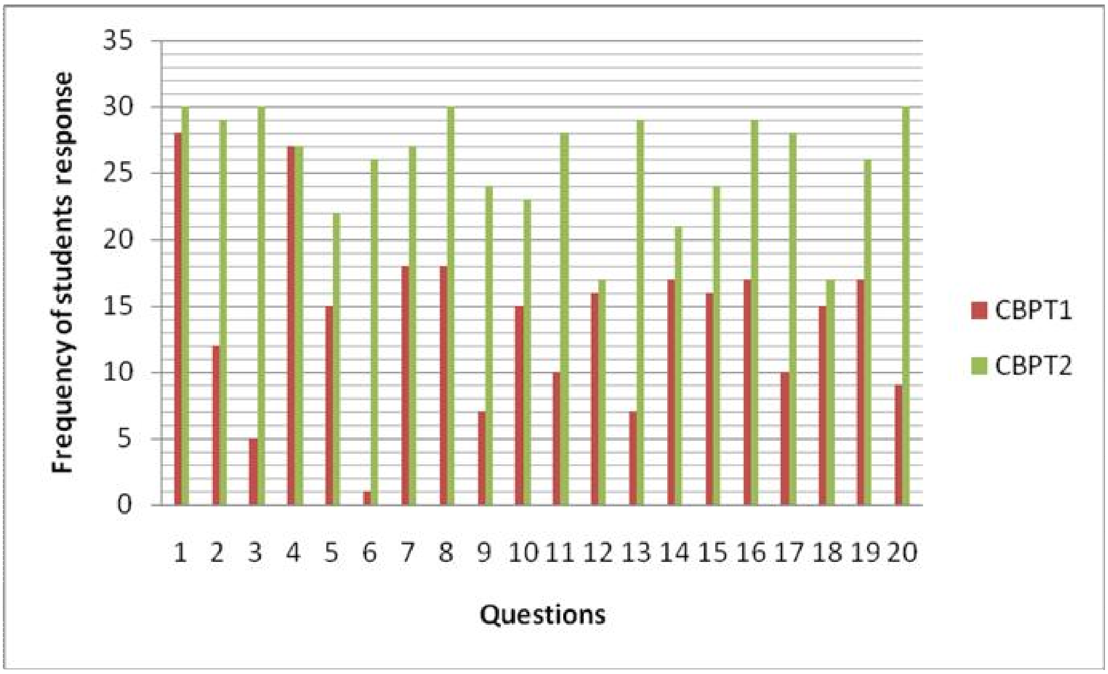
N	Group	Mean	St. Deviation	df	t_{cal}	t_{crti}	p-value	α-value
30	EG	17.3	2.45	58	5.136	1.672	0.00	0.05
30	CG	13.3	5.32					

Appendix Table 8 Descriptive and t-test statistics result of experimental group students out of 20

N	Test	Mean	St.Deviation	df	t_{cal}	t_{crti}	p-value	α-value
30	CBT2	17.3	2.45	58	13.53	1.672	0.00	0.05
30	CBT1	10.2	3.82					

Appendix Table 9 Descriptive and t-test statistics result of control group students out of 20

N	Test	Mean	St. Deviation	df	t_{cal}	t_{crti}	p-value	α-value
30	**CBT2**	13.26	5.32	58	5.018	1.672	0.00	0.05
30	**CBT1**	10.06	3.37					

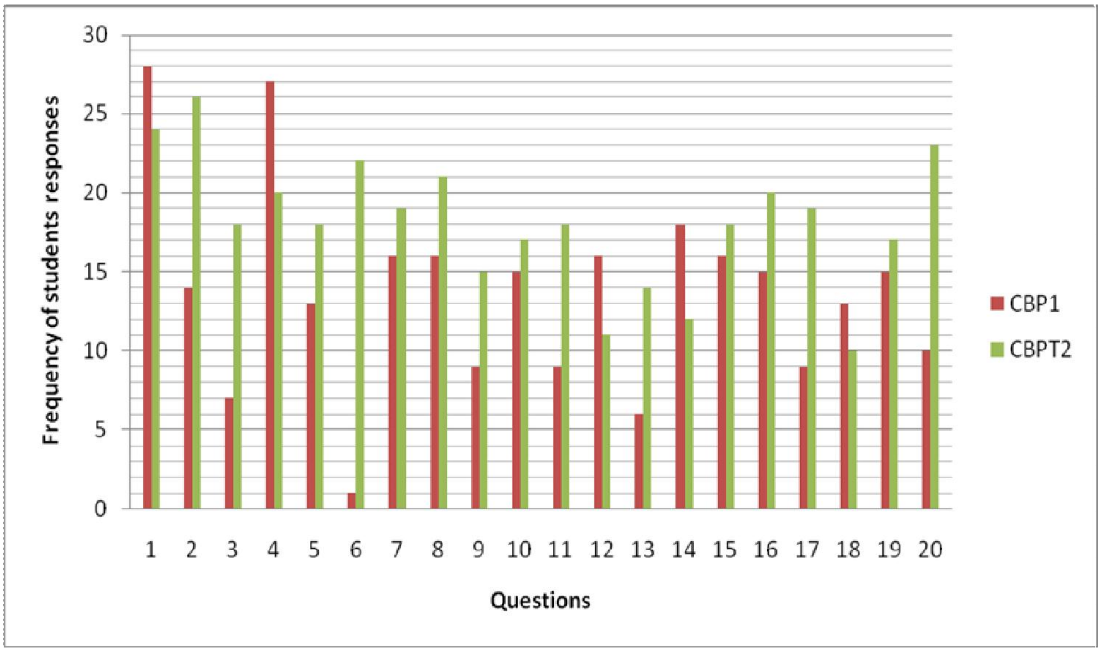


Appendix Figure 1 The frequency distribution of students' correct answers respond of the experimental group before and after the treatment.

CBPT1= Chemical Bonding Pre-test for Experimental group

CBPT2= Chemical Bonding Post-Test for Experimental group

As observed from the above appendix figure one there was a significant difference between the scores of the experimental group sample students before and after the treatment by using chemical models (ball-and-stick chemical models) when compared with control group sample students.



Appendix Figure 2 The frequency distribution of the students' correct answers respond of the control group before and after the treatment.

CBPT1= Chemical Bonding Pre-test for Control group

CBPT2= Chemical Bonding Post-Test for Control group

As seen from above appendix figure two, there was a difference between the pre-test and post-test scores of the control group sample students before the treatment and after the treatment given by traditional method, but the difference was not significant when compared with that of experimental sample group students.

Appendix II

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Natural Science

Program of chemistry

Post Graduate Studies

Chemical Bonding Inter-view Questions

I would kindly request you to had information in chemistry especially in the area of chemical bonding to get students' conception on chemical bonding. No information will ever be released that can be connected to you in any way. The data will be handled secretly throughout

I be thankful for your help to this study

I. Interview Questions Prepared for Preparatory Schools Vice Directors1

1. Is there any chemical bonding models in your School these used by teachers to teach students the concepts of chemical bonding?
2. Is there any chemical bonding models in your School used by teachers to teach students the concepts of chemical bonding?

II. Interview Questions Prepared for Grade 11 Preparatory School Teachers

1. What is the attitude of your students toward learning of chemical bonding concepts?
2. What types of students' problems have you seen when you teach them the concepts of chemical bonding?
3. Do you use chemical bonding models while teaching the students the concepts of chemical bonding?

III. Interview Questions Prepared for Grade 11 Preparatory School Students

1. How you see chemical bonding concepts with other chemistry concepts?
2. What are your difficulties from the concepts of chemical bonding?
3. Have you used chemical bonding models in class or elsewhere?

Appendix III

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Natural Science

Program of chemistry

Post Graduate Studies

Chemical Bonding Pre-Test (CBPT1)

I kindly request you to complete this pre- test to had information in chemistry especially in the area of chemical bonding to get students' conception on chemical bonding. No results will ever be released that can be connected to you in any way. The data will be handled secretly throughout.

I be thankful for your help to this study

Name_________________ School name___________________________

Section_______________ Date__________________________

Instruction: This test consists of 20 multiple choice type questions. Read each question carefully and choose the best answer from the given alternatives. The time allowed for the test is 1:30 hour.

1. Which one of the following is not a form of chemical bonding?

A. Covalent bonding B. Metallic bonding C. Ionic bonding D. Hydrogen bonding

2. How many bonding pairs and lone pairs are, respectively does the ICl_4^- ion has?

A. 3,2 B. 4,2 C. 5,1 D. 4,1

3. Which species has the longest F-A-F bond angle where A is the central atom?

A. BF_3 B. CF_4 C. NF_3 D. OF_2

4. Which one of the following compounds contains both ionic and covalent bonds?

A. CO_2 B. Cl_2O C. Na_2CO_3 D. OF_2

5. Which of the following molecules has a coordinate covalent bond?

A. CO_3^{2-} B. CO C. HNO_3 D. All

6. The most important reason for the bond formation is:

A. To has noble gas electronic structure C. Electron pair sharing

B. Lowering of energy D. Electro static force

7. Which of the following compounds contains ionic and dative bond?

A. HCl B. NH_4Cl C. NaCl D. CH_4

8. How many ionic bonds result from the formation of $MgCl_2$?

A. One B. Three C. Two D. Four

9. Which of the following molecules is non polar?

A. CS_2 B. SO_2 C. $CHCl_3$ D. SF_4

10. Which of the following is not true about metallic bonding?

A. Formed when valence electrons of metal and metal ions attract each other.

B. Formed when the valence electrons are shared between metal atoms.

C. Affected by the number of valence electrons.

D. Affected by the size of metal ions

11. Which one of the following molecules has a polar covalent bond but not polar molecule?

A. H_2O B. H_2S C. CCl_4 D. NH_3

12. How many atomic orbital are required for SP^3 hybridization?

A. 2 B. 6 C. 4 D. 8

13. Which one of the following molecules does not have a tetrahedral central atom?

A. SF_4 B. AlH_4^- C. BF_4^- D. $SiCL_4$

14. Which one of the following molecules has both single and triple bonds?

A.HCN B. N_2 C. CO_2 D.BF_3

15. The carbon atoms in ethane (C_2H_6), ethylene (C_2H_4) and ethylene (C_2H_2) provide, respectively, examples of the three types of hybridization corresponding to:

A. sp, sp2, sp3 B.sp3, sp2,sp C. sp, sp3, sp2 D. sp3,sp,s

16. In which of the following compounds would inter-molecular hydrogen bonding occur?

A. HCHO B. PH_3 C. CH_3OH D. $COCl_2$

17. Which set contains only covalently bonded molecules?

A.BCl_3,$SiCl_4$, PCl_4 B. NH_4Br, N_2H_4 C. I_2,H_2S,NaI D.Al_2O_3,AS_2O_5,Cl_2

18. Which molecule has Lewis structure that does not obey the octet rule?

A.NO B. CS_2 C. PF_3 HCN

19. Which of the following molecules is not AX_3E type molecule?

A. NH_3 B.H_3O^+ C. PH_3 D.H_2O

20. Which molecule listed below has two sigma and two pi bonds?

A. N_2 B. C_2H_4 C. N_2F_2 D. HCN

Appendix IV

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Natural Science

Program of chemistry

Post Graduate Studies

Chemical Bonding Post-test ($CBPT_2$)

I kindly request you to complete this pre- test to had information in chemistry especially in the area of chemical bonding to get students' conception on chemical bonding. No results will ever be released that can be connected to you in any way. The data will be handled secretly throughout.

I be thankful for your help to this study

Name__________________ School name_____________________________

Section________________ Date____________________________

Instruction: This test consists of 20 multiple choice type questions. Read each question carefully and choose the best answer from the given alternatives. The time allowed for the test is 1:30 hour.

1. Which one of the following is not a form of chemical bonding?
   A. Metallic bonding C. Ionic bonding
   B. Covalent bonding D. Dipole-dipole force
2. How many bonding pairs and lone pairs, respectively does the ion IF_4^- has?
   A.3, 2 B. 5,1 C. 4,1 D. 4,2
3. Which species has the longest F-A-F bond angle where A is the central atom?
   A. BCl_3 B. CCl_4 C. PF_3 D. OF_2
4. Which one of the following compound contains both ionic and covalent bonds?
   A. K_2CO_3 B. Al_2O_3 C. CO_2 D. OF_2

5. From the following molecules which does not obey the octet rule?

A. OF_2 B. PF_3 C.BCl_3 D. NH_3

6. Which one is the most important reason for bond formation?

A. To has noble gas electronic structure C. Electron pair sharing

B. To increase the internal energy D. To be stable

7. Which of the following compounds contains both ionic and dative bonds?

A. NH_4F B. HF C. HI D. CF_4

8. How many ionic bonds result from the formation of Li_3N?

A. 3 B.2 C.4 D. 6

9. Which of the following molecules is non polar?

A.$CHCl_3$ B. BCl_3 C. NH_3 D. HBF_2

10. Which of the following is/ are true about metallic bond formation?

A. Formed when the valence electrons are shared between metal atoms.

B. Affected by the number of valence electrons of the metals.

C. Not affected by the size of metal ions

D. Formed when valence electrons of metals and metal ions repel each other.

11. Which one of the molecules has a polar covalent bond but not polar molecule?

A. H_2O B. H_2S C. PH_3 D. CF_4

12. How many atomic orbital are required for sp3d hybridization?

A. 2 B. 4. C. 5. D. 8

13. Which one of the following molecules does not have a tetrahedral central atom?

A. AlH_4^- B. SCl_4 C. BF_4^- D. $SiCl_4$

14. Which one of the following molecules has both single and triple bonds?

A. CHCH B. N_2 C. BF_3 D. C_2H_4

15. What type of hybridization is used by carbon in C_2H_2 (acetylene)?

A. sp2 B. sp3 C. sp D. sp3d

16. In which of the following compounds would inter-molecular hydrogen bonding does not-occur?

A. HF B. NH_3 C. H_2S D. CH_3CH_2OH

17. Which set contains only covalently bonded molecules?

A.Al_2O_3, As_2O_5, Cl_2 C. PCl_3, BCl_3, $GeCl_4$

B. I_2, H_2S, NaI, D. NH_4Br, N_2H_4, HBr_4

18. Which molecule has Lewis structure that does not obey the octet rule?

A. H_2O B. NH_3 C. PF_3 D. AlF_3

19. Which one of the following molecules is an AX_2E_2 type molecule?

A. H_2O B. NH_3 C. H_3O^+ D. NH_4^+

20. Which molecule listed below has three sigma and two pi bonds?

A. N_2 B. C_2H_4 C. HCN D. C_2H_2