THE EFFECT OF COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE APPROACH ON STUDENTS' UNDERSTANDING OF CHEMICAL BONDING CONCEPTS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

GÜLÜZAR EYMUR

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
SECONDARY SCIENCE AND MATHEMATICS EDUCATION

JANUARY 2014

Approval of the thesis:

THE EFFECT OF COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE APPROACH ON STUDENTS' UNDERSTANDING OF CHEMICAL BONDING CONCEPTS

submitted by **GÜLÜZAR EYMUR** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Secondary Science and Mathematics Education Department, Middle East Technical University** by,

Prof. Dr. Canan Özgen _____
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Ömer Geban _______
Head of Department, **Secondary Science and Mathematics Edu.**

Prof. Dr. Ömer Geban ________
Head of Department, **Secondary Sci. and Math. Edu, METU**

Examining Committee Members:

Prof. Dr. Hamide Ertepınar
Preschool Teacher Education Dept.,İstanbul Aydın Univ. _______

Prof. Dr. Ömer Geban
Secondary Sci. and Math. Education Dept., METU _______

Prof. Dr. Ayhan Yılmaz _______
Secondary Sci. and Math. Education Dept., Hacettepe Uni.

Assoc.Prof. Dr. Yezdan Boz
Secondary Sci. and Math. Education Dept., METU _______

Assist. Prof. Dr. Ömer Faruk Özdemir
Secondary Sci. and Math. Education Dept., METU _______

Date:

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: GÜLÜZAR EYMUR

Signature:

ABSTRACT

THE EFFECT OF COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE APPROACH ON STUDENTS' UNDERSTANDING OF CHEMICAL BONDING CONCEPTS

EYMUR, Gülüzar

Ph.D., Department of Secondary Science and Mathematics Education

Supervisor: Prof. Dr. Ömer GEBAN

January 2014, 148 pages

The main purpose of this study was to investigate the effects of cooperative learning based on conceptual change approach on 9^{th} grade students' understanding in chemical bonding concepts and their attitudes toward chemistry as a school subject compared to traditionally designed chemistry instruction. Seventy-two ninth grade students from two intact classes of chemistry course taught by same teacher in a public high school in Ankara were participated. The study was applied in the spring semester of 2011-2012 academic years. The classes randomly assigned as experimental and control group. The control group was taught by traditionally designed chemistry instruction while the experimental group was taught cooperative learning based on conceptual change approach.

Chemical Bonding Concept Test (CBCT) and Attitude Scale toward Chemistry (ASTC) were used as pre- and post- tests. CBCT was used to define students' understanding of chemical bonding concepts. ASTC was used to identify the effect of treatment on students' attitude toward chemistry. Besides, Science Process Skills Test was used as pre-test to control students' intellectual abilities about science as covariate. After treatment, students' interviews were conducted to observe more information about their responses. Moreover, students from experimental groups were interviewed to obtain information about students' perceptions on cooperative work experiences.

Using Multivariate Analysis of Variance (MANOVA) and Two-Way Analysis of Variance (ANOVA) tested the hypotheses. The results showed that cooperative learning based on conceptual change approach lead to better acquisition of scientific conceptions related to chemical bonding concept than traditionally designed chemistry instruction. Furthermore, cooperative learning based on conceptual change approach instruction-developed students' attitudes toward chemistry positively. Also, gender differences were not affected in students' understanding of chemical bonding concept and their attitudes toward chemistry.

Keywords: Cooperative Learning Based on Conceptual Change Approach, Chemical Bonding Concept, Misconception, and Attitude toward Chemistry, Science Process Skill

ÖZ

KAVRAMSAL DEĞİŞİM YAKLAŞIMINA DAYALI İŞBİRLİKÇİ ÖĞRENMENİN ÖĞRENCİLERİN KİMYASAL BAĞLAR KONUSUNU ANLAMASINA ETKİSİ

EYMUR, Gülüzar

Doktora, Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü

Tez Yöneticisi: Prof. Dr. Ömer GEBAN

Ocak 2014, 148 sayfa

Bu çalışmanın ana amacı kavramsal değişim yaklaşımına dayalı işbirlikçi öğrenme yönteminin 9. sınıf öğrencilerinin kimyasal bağlar konusunu anlamalarına ve kimyaya karşı tutumlarına etkisini geleneksel kimya öğretim yöntemi ile karşılaştırarak incelemektir. Bu çalışmaya, Ankara'da genel bir lisede bulunan aynı öğretmen tarafından kimya öğretilen yetmiş iki dokuzuncu sınıf öğrencisi katılmıştır. Bu çalışma 2011-2012 öğretim yılının bahar döneminde uygulanmıştır. Sınıflar kontrol ve deney grubu olarak rasgele seçilmiştir. Kontrol grubunda bulunan öğrencilere geleneksel kimya öğretim yaklaşımı ile eğitim alırken, deney grubu öğrencilerine kavramsal değişim yaklaşımına dayalı işbirlikçi öğrenme yöntemi uygulanmıştır.

Kimyasal Bağlar Kavram Testi ve Kimyaya Karşı Tutum Ölçeği hem ön test hem de son test olarak uygulanmıştır. Kimyasal Bağlar Kavram Testi, öğrencilerin kimyasal bağlarla ilgili kavramları anlamalarını değerlendirmek için kullanılmıştır. Kimyaya Karşı Tutum Ölçeği kimyaya karşı tutumlarını değerlendirmek için Bilimsel İşlem Beceri Testi ise ön test olarak öğrencilerin bilimsel işlem becerilerini kontrol etmek için kullanılmıştır. Uygulamadan sonra, öğrencilerden cevapları hakkında daha çok bilgi almak için öğrencilerle yüzyüze görüşmeler yapılmıştır. Ayrıca, deney grubundaki öğrencilerle uygulama hakkında görüşlerini almak için görüşmeler yapılmıştır.

Araştırmanın hipotezleri Çoklu Varyans Analizi (MANOVA) ve İki Yönlü Varyans Analizi (ANOVA) kullanılarak test edilmiştir. Sonuçlar kavramsal değişim yaklaşımına dayalı işbirlikçi öğrenme yönteminin geleneksel kimya öğretimi ile kıyaslandığında kimyasal bağlar ile ilgili kavramların anlaşılmasında daha etkili olduğunu göstermiştir. Bunun yanında kavramsal değişim yaklaşımına dayalı işbirlikçi öğrenme yöntemi öğrencilerin kimyaya karşı tutumlarını da olumlu yönde geliştirmiştir. Ayrıca, cinsiyet farkının kimyasal bağlar ile ilgili kavramların anlaşılmasında ve kimyaya karşı tutumlarında bir etkisi olmadığı gözlenmiştir.

Anahtar Sözcükler: Kavramsal Değişim Yaklaşımına Dayalı İşbirlikçi Öğretim, Kimyasal, Bağlar Kavramı, KavramYanılgısı, Kimyaya Karşı Tutum, Bilimsel İşlem Becerisi.

Serkan, Eslem and Eren

ACKNOWLEDGEMENTS

I am deeply indebted to my supervisor Prof.Dr. Ömer Geban for his valuable guidance, criticism and suggestions.

I would also like to thank Beyhan Boduroğlu who is a chemistry teacher of the participating students in this study and applied of the method of this study.

Finally, I wish to thank Serkan Eymur for his patience, support and encouragement.

TABLE OF CONTENTS

LIST OF FIGURES

FIGURES

LIST OF TABLES

TABLES

ABBREVIATIONS

CLCCA: Cooperative Learning Based on Conceptual Change Approach

TDCI: Traditionally Designed Chemistry Instruction

CBCT: Chemical Bonding Concept Test

ASTC: Attitude Scale Towards Chemistry as a School Subject

SPST: Science Process Skill Test

df: Degrees of freedom

SS: Sum of squares

MS: Mean square

X: Mean of the sample

P: Significance level

F: F statistic

CHAPTER 1

INTRODUCTION

In last decades, science educators mainly focus how students learn and which factors influence their learning. Common point of these studies is that learning takes place when students play an active role in learning. Unfortunately, some researches show that actually, there is not a definite method for students to be success.

The researches report that students often develop ideas those are different from those accepted by scientific community and intended by their teachers (BouJaoude, 1991; Ebenezer & Fraser, 2001; Peterson & Treagust, 1989; Treagust, 1988; Zoller, 1990). These different concepts generated by students are named "misconceptions", "alternative conceptions", and "alternative frameworks" (Ozmen, 2004). In addition, Bodner (1986) define the term *misconception "*as student conceptual and propositional knowledge that is inconsistent with or different from the commonly accepted scientific consensus and is unable to adequately explain observable scientific phenomena". Some researchers give great concern about misconceptions. Vosniadou (2001) reported that misconceptions identify learning in science and they are resistant to change. It is important to notice that student's misconceptions arise from their experiences and observations, in other worlds, from their understandings of the world (Sagner&Greenbowe, 1997). So, it is extremely difficult to change these misconceptions. Moreover; Sungur, Tekkaya, and Geban (2001) suggest that these misconceptions are stable and influence further learning.

There seems to be a common idea amongst researchers and teachers that much chemistry is difficult for many students (Nakhleh, 1992). Some researchers try to investigate the reason of this situation. They found that chemistry is a complex subject having many abstract and some counterintuitive concepts (Gabel, 1993). So, many students do not understand fundamental concepts correctly and also their scientifically inappropriate knowledge and misconceptions keep by the students and go unchanged from early schools to university. With these incorrect knowledge and misconceptions, many students face with some problems in advanced concepts.

There is no suspicion that chemical bonding is one of the vital and fundamental concepts in chemistry. Understanding of many concepts in chemistry is mainly relying on learning basic ideas associated with chemical bonding. However, students and even teachers feel that the concept is complicated and teaching of it causes many misconceptions. Students' misconceptions related to chemical bonding cause from students' misunderstanding of macroscopic level of matter (Gabel, 1996; Harrison& Treagust, 2000). They can't transfer their knowledge macroscopic level to submicroscopic levels. Accordingly, they generate misconceptions and scientifically inappropriate knowledge.

Many studies determine that students' misconceptions about science concepts proposed that traditional teaching methods cause the learners to be inactive in the classroom and passive in learning process (Morgil, Oskay, Yavuz, & Arda, 2003). As a result of that, the learners did not get meaningful learning. The students are passive listeners and the role of teachers is difficult and exhausting. So, the teachers only explain important parts of concepts. Students listen and answer teachers' questions (Muir-Herzig, 2004). It is suggested that science teaching by applying traditional methods lead students to understand the concepts at knowledge level that does not contain in depth understanding only memorizing ideas. Likely, such a traditional and teacher-centered strategies result in negative impressions on students and they believe that science is a boring and includes only certainty (Kiboss, 2002; Kiboss, Ndirangu, & Wekesa, 2004). On the contrary to traditional methods, many researches in literature reported that conceptual change approach in teaching cause remediation of students' misconceptions (Hynd & Alvermann, 1986; Smith, Blakeslee, & Anderson, 1993; Hynd, McWhorter, Phares & Suttles, 1994; Sungur, Tekkaya and Geban, 2001)

The one teaching strategy based on conceptual change is proposed by Posner, Strıke, Hewson, and Gertzog (1982). They reported that there are two proposal conceptual changes, which are "*assimilation*" and "*accommodation*." They call assimilation when the student use existing concepts to deal with new phenomena whereas when the students existing knowledge is inadequate to understand new concept successfully, this more radical form of conceptual change is called accomodation. They suggest four conditions to occur conceptual change: 1) There must be "*dissatisfaction*" with existing knowledge 2) A new conception must be "*intelligible*" 3) A new conception must appear initially "*plausible*" and 4) A new concept should be "*fruitful*" for new areas. Posner et al. claim that the above conditions are satisfied in a linear manner starting with dissatisfaction of the existing knowledge and going on with fruitfulness of the new concept. Therefore, dissatisfaction is the key to trigger conceptual change. So, the conceptual change model suggests that science teachers need to create dissatisfaction for conceptual change. In the case of creating dissatisfaction, science teachers also need to know students' existing knowledge about concepts.

Cooperative learning is not a new method in classrooms but until last decades some teachers apply it for restricted aims like group projects or homework. Nevertheless, in recent years, researches show that cooperative learning can be used properly in all subject areas from math to science.

Correspondingly, there is increasing trend in usage of cooperative learning as a way of ordering classrooms for learning (Slavin, 1990). Cooperative learning means that students work in group and group members are responsible for their learning for each other (Slavin, 1984, 1990). Researches related with cooperative learning strategy claim that it has favorable effect on student achievement (Slavin, 1984). In addition, Johnson and Johnson (2000) found that cooperative learning provides further contribution than individual and competitive learning for student achievement. However, neither Slavin nor Johnson and Johnson make a research about conceptual change but many ideas in cooperative learning would seem to promote conceptual change. Fisher and Lipson (1985) claim that if conceptual change needs students to change their privilege knowledge, there should be free atmosphere for students to demonstrate their ideas. The lack of teacher hegemony in-group work supplies chance for students to show their misunderstandings and incorrect knowledge comfortably. In addition, while discussing their thoughts to those of their peers, students recognize different view than their own and to revise their ideas. The dissatisfaction that is the important and first step of conceptual change model can be achieved (Posner, Strike, Hewson & Gertzog, 1982).

Researchers found that student' attitudes toward science are affected by the kind of instruction model in science education (Chang, 2002). There is no doubt that students'attitude affect students' behavior toward science and also, it is crucial for student's science achievement. So, in this study, the effect of cooperative learning based on conceptual change on student's attitudes toward chemistry was considered.

Science process skill is crucial factor for students' understanding of science because it includes recognizing variables, thinking of solutions, and interpretation of graph, analyzing data and making inferences. Lazarowitz (2002) found that learning science needs high cognitive skills. In this study, the addition of students' science process skills to their comprehension of chemical bonding was also investigated.

1.1 Purpose of the study

There is still doubt related to the effectiveness and usage of cooperative learning based on conceptual change approach in chemistry. Although researches applied in high school level seem to demonstrate positive effects on learning, usefulness of cooperative learning based on conceptual change approach in chemistry as a teaching strategy has not been widely investigated. Cooperative learning based on conceptual change approach research especially on chemical bonding is still lacking. Therefore, the main purpose of this study was to investigate the effects of cooperative learning based on conceptual change approach on chemical bonding achievement and students' attitudes toward chemistry. Then, compare the effectiveness of this treatment on chemical bonding achievement and students' attitudes toward chemistry with traditional instruction model.

1.2 Significance of the study

In science education, researchers have been interested with the problems (1) changing students' prior knowledge which are incompatible with scientifically accepted conceptions (2) eliminating students' misconceptions (3) achieving meaningful learning which requires active student involvement in learning process. For these reasons, concern has been shifted in recent years on changing teaching strategies from traditional instruction to conceptual change instruction. Insistence on traditional instruction is one of the common features of misconceptions. Therefore, planning an instruction supports to eliminate students' misconceptions. In literature, there are many researches related with misconceptions and in these studies conceptual change instruction were used. However, cooperative learning based on conceptual change approach in chemistry has been used rarely. Also, at the present time, social and business lives need students to be prepared for group work. A lot of things have been said about cooperative learning in mathematics achievement. National mathematics organizations support cooperative learning as a teaching method for mathematics. But, there is a little study about cooperative learning in chemistry especially in chemical bonding. Due to space about cooperative learning with conceptual change approach in chemical bonding in literature, in this study cooperative learning based on conceptual change approach model was designed and applied. An elaborate explanation of the instruction was indicated and effectiveness of it was examined. Cooperative learning based on conceptual change approach model made better comprehension, achievement, and elimination of misconceptions than traditional model. Therefore, this teaching method might be used to increase understanding of chemical bonding and handle of students ' misconceptions by the teachers. In addition, students' attitude toward science was decided as an important factor in chemistry achievement.

This study is a proof for the favorable effect of cooperative learning based on conceptual change approach model on students' attitudes. Educators can use this model to increase students' attitudes toward chemistry.

1.3 Definitions of the Terms

Cooperative learning based on conceptual change approach: An instructional model in which students are trained according to constructivism presented by Posner (1982) et al. in groups including four members working together to achieve same goal.

Cooperative learning: Teaching method in which students work in small groups to achieve same goals by helping each other (Johnson, Johnson, & Holubec, 1994).

Traditional instruction: An instruction consists of lecturing and presentation of content area.

Chemical Bonding Achievement: Test scores from the pre- and post-chemical bonding tests that were prepared by the researcher.

Attitudes toward chemistry: Students' beliefs and feelings toward chemistry was evaluated and scored by Chemistry Attitude Survey instrument.

Misconception: Obstacles for students in learning and meaningful understanding of some concepts in science.

CHAPTER 2

LITERATURE REVIEW

Chemistry includes many abstract and complicated issues that are not feasible for daily lives. Although it is difficult and complex, it contains many important subjects in science (Stieff & Wilensky, 2003; Zoller, 1990). Students consider that chemistry is difficult to learn at each grade level. The major obstacle in chemistry instruction is the abstract nature of the chemistry concepts. In literature, many studies can be found that related to investigate the reasons of this issue. The majority of these studies' focuses can be collected in three main topics; studies that are deal with students' misconceptions in chemistry, studies that are related teaching methods and students' understanding of chemistry concepts in chemistry, and studies that are investigate the relationship between students' affective domains and students' chemistry achievement. On the other hand, the prior conceptions of the students' related science and chemistry are not necessarily taken into account in chemistry and science instruction settings. Ausubel (1968) emphasized the importance of prior knowledge by stating the differences in rote learning and meaningful learning. New knowledge and existing knowledge must be linked to reach meaningful learning. Ausubel (1968, p: 24) claimed that "the most important single factor influencing learning is what the learner already knows". In the process of learning, then, the important thing is to recognize students' existing knowledge in the acquisition and retention of subject matter knowledge.

It was stated that learning involves not only changing one's conceptions but also adding new knowledge to what's already there (Hewson, 1982). The outcomes in the learning depend on nature of interaction that occurs between new and existing conceptions. Changing existing conceptions with new conceptions is simply known conceptual change and there are plenty of researches that deal with investigating how to facilitate conceptual change in chemistry education. Researchers and teachers who are dealing with chemistry instruction and science instruction should facilitate and promote conceptual change to eliminate not only students' misconceptions in chemistry but also improve students' acquisition of chemistry concepts. Therefore, in this study, it is hope to investigate students pre-existing conceptions related to electrochemistry concepts, proposed an instruction method based on conceptual change approach to eliminate misconceptions, and having the students' better acquisition of electrochemistry concepts. In addition to these, the effect of this instruction on students' attitudes towards chemistry as a school subject is another issue that will be investigated.

2.1. Misconceptions

Some researches propose that students create some nonscientific concepts which they give the meaning about world. In literature, these nonscientific concepts have been explained and named in differently as "preconceptions", "misconceptions", "and alternative frameworks". In addition to these, Nakhleh (1992) preferred to define misconceptions as a concept that differs from the commonly accepted scientific understanding of the term and Driver and Oldham (1986) stated that misconceptions are related with the intuitive ideas and preconceptions that are gained before the school instruction. Subsequently, some researchers give great concern about misconceptions. Vosniadou (2001) reported that misconceptions identify learning in science and they are resistant to change. Novak (2002) stated that meaningful learning takes place replacing misconceptions with scientific ones and that misconceptions lead to distort new learning.

Özmen (2004) reported that misconceptions exist as an obstacle in obtaining the appropriate knowledge in his review on chemical bonding misconceptions. Taber (1995) showed that the students' misconceptions about charges performed as a wall to learning about chemical bonding. Some researchers propose that such hindrances to learning require removing before a new idea can advance (De Posada, 1997; Hewson&Thorley, 1989), and that such conceptual change needs reasonable attention on the part of the learner (Carey, 2000; Strike & Posner, 1992). In addition, some authors reported that the process of developing new concept is gradual that learner can have many ideas concurrently during process, and that unreasonable factors can affect learning process. (Duit & Treagust, 2003; Taber, 2006; Vosniadou & Ioannides, 1998). Moreover, some studies suggested that misconceptions could generate many difficulties for a new learning (Chi, Slotta, & deLeeuw, 1994).

2.2. Misconceptions in Chemical Bonding

Chemical bonding is one of the important and fundamental topics in chemistry. The concepts related with chemical bonding such as ionic bonds, covalent bonds or hydrogen bonds are highly abstract. Students are forced to shift from macroscopic level to microscopic level. To understand the chemical bonding, students should be acquainted with mathematical and physical concepts and laws which are related with the basic bonding concepts like orbital, electron repulsions, polarity. Therefore, students have many misconceptions associated with chemical bonding concept. Learning of chemical bonding gives opportunity for learners to have ideas and make explanations about chemical and physical characteristics of matters. Some concepts related with chemical bonding such as electronegativity, bonding, geometry or molecular structure are basics concepts of branch of chemistry from organic chemistry to analytical chemistry (Nicoll, 2001). However, in the literature bonding is considered by students, teachers, and chemists to be a very complex concept (Levy Nahum, 2007, Taber, 1998, 2001). In addition, Teichert and Stacy (2002) claimed that the traditional instruction for chemical bonding is problematic and comprehended incorrectly. Thus, new instruction method about chemical bonding should be developed to handle misconceptions and provide a deep understanding of concept.

Butts and Smith (1987) investigated 12^{th} grade chemistry students' understanding of the structure and properties of molecular and ionic compounds. They found that students misunderstood about covalent and ionic bonds. Some students considered that there was a covalent bond between sodium and chloride atoms.

Peterson and Treagust (1989) reported those grade 12 students' misconceptions of covalent bonding and structure. They demonstrated that the degree of weaknesses in student understanding of chemistry concepts in covalent bonding and structure. As shown by students' answers, 23% of students know that electron sharing in covalent bonds but they did not think the effect of electronegativity and the outcome unequal sharing of the electron pair on bond polarity. They determined eight major misconceptions related with incorrect answers which are divided into five categories such as bond polarity, shape of molecules, polarity of molecules, intermolecular forces and octet rule. These misconceptions were identified as follows:

Bond Polarity

- "Equal sharing of the electron pair occurs in all covalent bonds".

Shape of Molecules

- "The shape of molecules is due only to the repulsion between the bonding electron pairs."

- "The shape of molecules is due only to the repulsion between the nonbonding electron pairs."
- "Bond polarity determines the shape of a molecule".

Polarity of Molecules

- "Nonpolar molecules form when the atoms in the molecule have similar electronegativies."

Intermolecular Forces

- "Intermolecular forces are the forces within a molecule".
- "Strong intermolecular forces exist in a continuous covalent solid."

Octet Rule

- "Nitrogen atoms can share five electrons pairs in bonding".

Researches on the comprehension of intermolecular bonding revealed that students realize the relationship between intermolecular bonding and physical properties such as boiling point (Peterson&Treagust, 1989; Peterson, 1989; Taber, 1995, 1998). But, another research investigated by Goh (1993) exposed that students think that intermolecular bonding is stronger than intramolecular bonding that has consistent result with Peterson (1989).

Taber (1997) examined students' understanding of ionic bonding and identified their ideas about molecular framework. She reported that some students' understanding of ionic bonding: (i) stresses too much the process of electron transfer, (ii) clearly uses the concept of ion-pairs as molecules, (iii) is forced by a suitable consideration of valence (iv) gives careful attention to an irrelevant electron history (v) differentiates equivalent interactions between ions.

Students seem to have little understanding about the concept of electronegativity and causing a lot of misconceptions for chemical bonding; incapability of realize the correct polarity of polar covalent bonds, the idea that non-polar molecules are only composed between atoms of similar electronegativy and ionic charge decide molecular polarity (Peterson, 1989; Harrison& Treagust, 1998; Boo, 1998; Birk &Kurtz, 1999).

Boo (1998) examined the students' understanding of chemical bonds and energetic of chemical reactions. Many students considered that the chemical bond is a physical entity. This idea of a chemical bond as problem thus seem to be relation with everyday view that building any structure needs energy input and destruction releases energy to designate for the common misconception that bond making requires input of energy and bond breaking releases energy.

Peterson, Treagust, and Garnett (1989) developed diagnostic instrument to determine grade-11 and 12 students' misconceptions and comprehension of covalent bonding and structure. This instrument was applied grade-11 and grade-12 chemistry students in high schools in South Australia. The instrument was composed of 15 two-tier multiple choice questions in which the content knowledge was investigated in the first-tier and the understanding of information in six conceptual notions such as molecular shape, polarity of molecules, bond polarity, lattices, intermolecular forces and the octet rule. They claimed that students have a little appreciation of the position of the electron pair, effects of valence electrons and ionic charge. They reported some similar misconceptions with their previous research (Peterson, & Treagust, 1989) and some additional misconceptions were identified as follows:

- "The polarity of a bond is dependent on the number of valence electrons in each atom involved in the bond".

- “Ionic charge determines the polarity of the bond”.
- “The shape of the molecule is due to equal repulsion between the bonds”.
- “The V-shape in a molecule of the type SCl_2 is due to repulsion between the non-bonding electron pairs”.
- “Covalent bonds are broken when a substance changes shape”.
- “High viscosity of some molecular solids is due to strong bonds in the continuous covalent lattice”.

A highly common misconception for chemical bonding is that students were confused about ionic bonding as a molecular framework (Tan &Treagust, 1999; Birk&Kurtz, 1999). Tan and Treagust (1999) found that a high percentage of students believed that sodium chloride exists as molecules. They also developed instrument for evaluating 14-16 year olds students' misconceptions about chemical bonding. They reported some common misconceptions as below:

- “Metals and non-metals form molecules”.
- “Metals and non-metals combine to form molecules consisting of oppositely charged ions”.
- “Ionic compounds exist as molecules formed by covalent bonding”.
- “Metals and non-metals form strong covalent bonds”.
- “The strength of intermolecular forces is determined by the strength of the covalent bonds present in the molecules”.
- “There are strong intermolecular forces in a macromolecule”.
- “Covalent bonds are broken when a substance changes state”.

Birk and Kurtz (1999) examined students' misconceptions with different grade level from high school to chemistry faculty and determined effect of experience on retention and elimination of misconceptions about bonding. They used diagnostic instrument developed by Peterson, Treagust, and Garnett. They reported that students seem to comprehend that the shape of molecule was not decided by bond polarity. The other important misconception was that ionic charge decided the polarity of the bond. Another common misconception about bond polarity was found that equal sharing of the electron pair forms in all covalent bonds. This misconception is explained in Taber's interview study and Taber (1998) reported that when polar bonds was learnt, students had tendency about thinking them according to their existence design of covalent (sharing between two atoms of non-metallic elements) or ionic bonding (electron transfer between metal and non-metallic elements). Although students learnt degrees of electronegativity, they did not adapted polar bonding. They commonly consider that polar bonds as examples of covalent bonds in which sharing was unequal.

Much of studies showed that students generally tend to confuse inter- and intra- molecular bonding concepts. Taber (1998) reported that students thought intermolecular bonding namely Van der Waals' forces "not a real chemical bonding" just a forces. Also, students considered that hydrogen bonding was not "an actual bond" and it is a weaker than "proper" bonds.

Henderleiter, Smart, Anderson, and Elian (2001) conducted a study about understanding of hydrogen bonding in organic chemistry students. They found similar results with Taber (1998) and reported that students confused hydrogen bonding with a covalent bond or they thought of "intermolecular hydrogen bonding resulting in formation of new covalent bonds". Levy Nahum (2007) also found similar results in Israel and he reported that students confused inter- and intra- molecular bonding.

Another students' common misconception is about metallic bonding. Taber (2003) found that high school students generally inadequate knowledge of metallic bonding in England. He considered that learning about chemical bonding mainly stress on covalent bonding and ionic bonding but little importance was given to metallic bonding. He reported that students learnt metallic bonding as a "sea of electrons" but this was only a rote memorization and "slogan" with lack of comprehension. Students considered that metallic bonding was not a "proper" bond but "just force".

Acar and Tarhan (2008) conducted a comparative study of learning metallic bonding in two classes in Turkey. To determination of effectiveness of two instructional strategies, one of the classes was selected an experimental group who were taught with cooperative learning approach and the other class was selected control group who were taught with traditional approach. They found that as mentioned Taber (2003) many students confused metallic bonding and ionic bonding. Almost half of students thought that interactions between metals were "weak forces" and there was an electron sharing like covalent bonding. Acar and Tarhan reported that ionic and covalent bonding was taught before metallic bonding. In this sense, Taber (2003) claimed that students categorized metallic bonding in terms of previously learnt bonding such as covalent or ionic.

Coll and Treagust (2001) investigated undergraduate and postgraduate Australian students' mental models of chemical bonding. They found that students generally preferred simple models and they forced to used their models for explain physical properties of substances. Coll and Taylor (2001) examined another study with secondary, undergraduate, and postgraduate students' misconceptions about chemical bonding. The researchers started to study with in-depth analysis of the learning materials such as lesson plans, textbooks, and lecture notes.

Observed data synthesized into eight mental models which were the sea of electrons model, band theory for metals, electron transfer model, the model for calculation of electrostatic charges for ionic substances, the molecular orbital theory, the octet rule, the valence bond theory and ligand field theory for covalent substances. Then, students' conceptions were evoked by semi-structured interviews. The student models exposed in interviews were compared with the models observed in the learning materials and this determined the below misconceptions:

- "Metallic bonding is weak bonding".
- "Intramolecular covalent bonding is weak bonding".
- "Ionic bonding is weak bonding".
- "Continuous metallic or ionic lattices are molecular in nature".
- "The bonding in metals and ionic compounds involves intermolecular bonding".
- "Ionic bonding comprises sharing of electrons".

The findings of study showed that even postgraduate students have some misconceptions and struggled to remember details of models and concepts. They believed that source of these misconceptions were overload curriculum material, confusion and careless use of terminology and abstract concepts. Besides, secondary school, undergraduate and graduate students' mental models of ionic bonding was investigated by Coll and Treagust (2003). They found that secondary school students' mental models were shaped by the idea that ionic bonding includes attraction of opposite charges. Model understanding was inadequate and there were some misconceptions about basic concepts such as ionic size and shape. The most common misconception was related to "molecularity of lattice". The undergraduate students' considered that attraction of opposite charges species was driving force for ionic bonding. This consideration was different than secondary school students' view that main driving force was octet rule. The undergraduate students' misconceptions again related with ionic size and shape. The graduate students thought that continuous nature of lattices as an important factor for ionic bonding. The findings of this study showed that students struggle to shift from macroscopic level to microscopic level. They suggested that teachers should stress link between macroscopic level and microscopic level. Also, this study implied that students used their simple mental model to explain bonding and properties of ionic substances. So, they suggested that teachers should provide more persuading confirmation for the use of sophisticated mental models.

Nicoll (2001) examined undergraduate students' misconceptions about chemical bonding and they were interviewed about concepts of electrons, bonding, electronegativity, and structure. He divided students' misconceptions into five sub-group such as polarity, bond confuse, general bonding, wrong bond and micro bonding. Students tried to define polarity without usage of electronegativity. They may know about polarity, but they did not link between polarity and electronegativity. That is, misconceptions in this polarity sub-group consist of wrong explanations of polarity. Students' misconception about confusion the explanations of ionic and covalent bonding was categorized in bond confuse. For example, one of the students was asked to account for what covalent bonding was: "I just think of it as attractions, um, between the negative and positive ends, um, of an atom". General bonding group included misconceptions related to process of bonding. Students gave wrong explanations about why bonding takes place and bonding concept. Another group was wrong bond and in this misconception group students such as Bill asked to account for what a chemical bond was ordered hydrogen bonding along with ionic and covalent bonding. Micro bonding group was for students who had misconceptions about microscopic content of bonding. One of the students Casey asked to explain what she would see while looking at one water molecule, she answered "if you saw the electrons, they would be touching". He categorized this as microscopic misconception of bonding because the electrons could not be touching.

Othman, Treagust and Chandrasegaran (2008) investigated the relationship between students' conceptions of the particulate nature of matter and their understanding of chemical bonding. The study was applied to grade-9 and grade-10 students in Singapore. The most common misconception was found about the structure of sodium chloride that it occurs as molecules. Many students could recognize the presence of sodium and chloride ion but they still considered that one sodium ion and one chloride ion form "ion-pair molecule". They also identified misconceptions about intermolecular and intramolecular forces. The one of the misconceptions was that intramolecular forces were broken with boiling and melting. The other misconception was that the covalent bond was weak. The last misconception was that the strength of the intermolecular forces is determined by the strength of the covalent bonds present within the molecules. The results of study demonstrated that students' inadequate comprehension of particulate nature of matter affected their understanding of chemical bonding.

Rompayom, Tambunchong, Wongyounoi, and Dechsri (2011) used open-ended questions to diagnose students' understanding of inter- and intramolecular forces. Applying open-ended questions after ending normal instruction on chemical bonding concept evoked sixty-four students. They reported that students had difficulty in understanding of inter- and intramolecular forces. It is found that students considered that "when the substance changes its state, covalent bonds are broken". They could not differentiate intermolecular and intramolecular forces and how they associate with changing state of substances.

2.3. Conceptual Change Approach

Hewson (1991) stated that the word "change" could be defined in three different aspects. First, in some cases, since there is only one entity before and a different one after the change, change means extinction. Second, in some cases, there is no extinction; change means an exchange of one entity for another. Third, in some cases, change means extension. When describing conceptual change with respect to these definitions, extinction does not seem to be appropriate. In literature, there is a common agreement that the process of the student exchanging one idea for another is conceptual change. But, for some, it is believed that students learn things they did not know by making connections to what they already know. From this perspective conceptual change includes both exchange and extension (Hewson, 1991).

Smith, Blakeslee, and Anderson (1993) reported that conceptual change is a process that includes meaningful learning by rearranging, restructuring, or reconstituting current ideas to adapt new concepts. Hydn**,** Alvermann, and Qian (1997) stated that altering or reorganizing of existing schemata to account new learning is conceptual change.

Posner (1982) developed a theory that describe how people rearranging or reorganizing their ideas with new ones. They described two kinds of conceptual change, assimilation, and accommodation. The assimilation takes places when students apply their current ideas to handle with new event. The accommodation takes place when students should restructure or rearrange their main ideas. They have mainly studied on accommodation and explained four steps that must be accomplish to take place modification:

1. The "*dissatisfaction"* must occur with current ideas. The person must recognize that the current ideas produce obstacles or do not apply a new situation. The abnormality is the main reason of dissatisfaction. An abnormality happens when individual is not capable to assimilate something.

2. A new idea must be "*intelligible"*. The person must capable of understand how events can be arranged with new idea adequately. Intelligibility also needs structuring or recognizing a compatible figuration of what the new concepts explaining.
3. A new idea must be "*plausible"*. It means that students should consider that the new idea is correct and logical with current ideas.
4. A new idea must be "*fruitful*." It means that students should find an answer to new problems by using new idea.

Hynd (1997) stated that conceptual change's difficulty comes from its epistemological, cognitive, affective reasons. With respect to epistemological view, students generally believe that their observations about the world are accurate and correct. Conceptual change can only be acquired when people realize that their previous observations and scientific beliefs about the world are not consistent. According to cognitive view, when students are confronted with conflicting data, students generally prefer ignore or memorize it rather than preferring conceptual change. In affective view, conceptual change has also been linked to attitudes and motivation. Strike and Postner (1990, p.10) stated "A wider range of factors needs to be taken into account in attempting to describe a learners' conceptual ecology. Motives and goals and the institutional and social sources of them need to be considered".

Cognitive conflict should be created in students' cognitive structure to accomplish conceptual change. Cognitive conflict is the one of the major tool to reach conceptual change. Students should be exposed to different events from their everyday relevant conceptions to create cognitive conflict (Scott, Asoko, and Driver, 1991). And, also before the new conception accepted, the new concept should be fruitful and more helpful for the students understanding and interpreting the phenomena in their world (Posner et al., 1982). The new conception has to be seen challenging old beliefs. Then students can change their conceptions accordingly.

In literature, there are lots of studies that were used conceptual change strategies and having better acquisition of related understanding when compare with methods that were not use conceptual change strategies. Some of these researches are also support the notion that conceptual change oriented instruction have potential to eliminate students' misconceptions in related subjects. The details of these studies especially their effects were given below.

Niaz (2002) was conducted a study to construct a teaching strategy, which was based on conceptual change approach and facilitate conceptual change in freshman students' understanding of electrochemistry. There were two groups in this study that were control and experimental group. The experimental group consisted of 28 students whereas control group consisted of 29 students. Students in experimental group were instructed with respect to teaching experiments, which were based conceptual change approach; whereas those in control group were instructed with respect to solve problems without experimental format. Results showed that the difference in performance of the experimental and control groups on posttests was statistically significant. It was concluded that teaching experiments which were based on conceptual change approach facilitating students understanding of electrochemistry. In this study, the internal validity issues such as subject characteristics, implementation, testing were discussed. However, the effect size, power and practical significant issues were not specified. In addition to this, the small sample size of this study can be stated as limitation of this study.

Başer and Geban (2007) carried out a study to investigate the effectiveness of a teaching strategy based on conceptual change approach to dispel students' misconceptions about static electricity concepts. In this study, 60 tenth grade students from two classes of a physic course taught by the same teacher were enrolled. There were two groups of students: Experimental group and control group. Experimental group was instructed by conceptual change texts through teacher lecture. Control group received traditionally designed physic instruction. At the end of the treatment, all students were administered the Static Electricity Concepts Test which was developed by researchers. Results showed that the conceptual change oriented instruction caused a significantly better acquisition of scientific conceptions and elimination of misconceptions than the traditionally designed physic instruction. The internal validity issues were not specified in this study. In addition to this, power, effect size and practical issues were not specified.

Ceylan and Geban (2009) investigated effectiveness of conceptual change instruction understanding of the state of matter and solubility. The sample was 119 tenth grade students in Ankara. They assigned experimental group that was taught by conceptual change instruction and control group that was taught by traditional instruction. In experimental group, misconceptions were considered and instruction was prepared based on active participation of students in learning process. The lessons were designed based on 5E learning cycle model in the experimental group. In control group, instruction was only designed based on teacher's explanation and textbooks. The misconceptions were not taken into consideration in the control group. The teacher was trained about 5E learning cycle model before the study. They used State of Matter and Solubility Concept Test as pre-and post-tests to measure students' achievement on this concept. The results showed that conceptual change instruction caused greater achievement compared to traditional instruction in the state of matter and solubility concepts.

Özkaya, Üce, Sarıçayır, and Şahin (2006) examined the effectiveness of conceptual change teaching strategy to improve students' understanding of galvanic cells. The study consisted of 74 first-year university students. These students were divided into two groups such as experimental and control group in which teacher used conceptual change instruction and traditional instruction, respectively. In the experimental group, students were acquainted with their misconceptions about galvanic cells while the students in control group were not. To compare students' understanding of galvanic cell, they developed 18-item test that included multiple-choice and true-false questions. They also prepared 9-item multiple-choice problem-solving tests to determine students' capacities on solving quantitative problems. These two tests were applied for the experimental and control groups at the end of the treatment. They reported that students' achievement on galvanic cells in experimental group was higher than control group based on achievement test.

Ebenezer (2010) studied on the effects of the Common Knowledge Construction Model (CKCM) lesson sequence a subset of conceptual change approach. The effect on seventh grade students' science achievement was investigated. The study contained sixty-eight seventh grade students in English medium private school in Pune, India. They assigned as experimental group and control group. The study conducted four weeks and lessons were done three times each week. A unit on excretion instructed two groups. Common Knowledge Construction Model instructed the experimental group while the control group was instructed by traditional method. They developed "Excretion Unit Achievement Test (EUAT)" which consisted four questions with three parts to question one. It included draw and label, matching, and open-ended questions. The results showed that the students taught by CKCM learned excretion unit better than the students taught by traditional instruction. They reported that conceptual change approach increase students' achievement in science. In addition, qualitative results showed that conceptual change approach caused the replacement and change of students' conceptions with scientifically accepted ones.

Franke and Bogner (2011) investigated achievement of conceptual change when students face with their misconceptions in gene technology lessons. 294 secondary school students in eleventh grade participated to study. They used quasi-experimental method and divided students into two instructional groups. Two groups were taught by same instructional strategy. Also, experimental group students faced with their misconceptions based on conceptual change instruction. They used multiple-choice questions to determine students' conceptions and their learned knowledge. This questionnaire contained eight questions based on processes of gene technology. The choices of questions included one correct answer and three wrong distracters that present students' misconceptions. The results showed that conceptual change was achieved in the experimental group and students change their misconceptions about concepts and processes of gene technology.

Cooper (2012) tried to increase teaching and learning of matter and its properties by using conceptual change approach in sixth grade. They developed instructional unit based on conceptual change that provide students to be actively involved in learning process. The study was conducted in Thailand and curriculum of Thailand related to matter and its properties was considered. The instructional unit contained five topics such as changes in the state of matter, solution processes, properties of states, chemical change and separation of mixtures. Conceptual change was tried to achieve by using particle models, role play, and experiments. In this study, multiple data sources were used like student concept surveys, classroom observations, and student and teacher interviews. The results showed that the instruction according to conceptual change lead teachers to increase their ability, interest and attitude toward learning and teaching science. With regard to students learning, the conceptual change instruction support learning process of students by enhancing student-student and student-teacher interactions. The teaching methods such as using particle models, role-play, and experiments used in conceptual change instruction were successful strategies in teaching.

Çetingül and Geban (2011) investigated the effect of conceptual change instruction on students' understanding of acids and bases concepts compared to traditional instruction. 50 tenth grade students were contained in this study. Two classes were randomly assigned as control and experimental groups that were taught by the same teacher. The conceptual change text was developed based on national curriculum. This text contained meaning, strength, concentration, reactions, and properties of acids and bases, pH concept, neutralization and indicators topics in ten pages. "Acid-Base Conceptions Test" was prepared by the researchers to identify students' understanding. This test included 21 multiple-choice questions that contained one correct and three distracters with misconceptions. The study was applied four weeks. The control group was instructed by traditional method while experimental group was instructed by conceptual change instruction. The experimental group students were given conceptual change text based on analogies during instruction. The findings showed that conceptual change text based on analogies lead to significantly better understanding of the acid-bases concepts. The success of students in experimental group arouse from instructional strategy and materials used in class. The activities based on conceptual change approach provide students to modify their knowledge and remediate their misconceptions.

In the light of literature, conceptual change approach has been successful instruction method to increase students' understanding and help students remediate their misconceptions. Especially, conceptual change instruction has been used many abstract and difficult concepts in chemistry education like chemical bonding concept and conceptual change seems to be satisfactory to increase students' achievement. Therefore, further research is requiring for developing conceptual change instruction with other learning strategies. For this reason, in this study, cooperative learning based on conceptual change approach was used to increase students' achievement and remediate their misconceptions about chemical bonding.

2.4. Cooperative Learning

Cooperative learning is not a new approach in education, but until 90's it has only been applied for particular purposes by some teachers. However, researches have described cooperative learning methods that are suitable to use at every grade level for teaching every type of concepts from math to science during 90's (Slavin, 1995). Cooperative learning is a teaching method where students work together in small groups to help each other learn concepts. In cooperative groups, students are assumed to help and discuss each other, to evaluate each other's information and increase each other's understanding (Slavin, 1989). There are many causes that cooperative learning can be used effectively in classrooms. The most important cause is that cooperative learning enhances student achievement likewise other effects such as improving students' relations and enhancing self-esteem (Slavin, 1995).

Cooperative learning is efficient when students have in common goals in group work with the guidance of positive structure (Johnson & Johnson, 1999). There are three types of cooperative learning such as formal cooperative learning, informal cooperative learning, and cooperative base groups. Formal cooperative learning applies from one lesson time to a few weeks. It can be used for academic assignment and course projects and it is the heart of cooperative learning. Informal cooperative learning applies from a few minutes to one class time and also known ad hoc groups. It can be used for direct teaching such as lectures, videos, and slides shows. Cooperative base groups are heterogeneous long-term groups with permanent members that apply at least one year (Johnson & Johnson, 1999). In cooperative learning, teachers have particular roles in classrooms including of: (1) previous instructional adjustments (2) explaining the objective and cooperative structure (3) monitoring and intervening, and (4) evaluation and processing. The teacher is in guidance role in cooperative learning.

Not all grouping is cooperative. The pseudo-learning group and the traditional classroom learning group are not the cooperative learning group (Johnson, D., Johnson, R. & Holubec, E., 1998). In pseudo-learning group, students are structured to work in group but entering into rivalry with, are not interested and are not trust each other. Students are assigned to work little together; the hiding information takes place from each other, they consider their assessment will be individual not as a group and they may not want to work together in the traditional classroom learning group. Therefore, this portrays what a cooperative group is and is not.

There are five important components of cooperative learning which include positive interdependence, individual accountability, face-to-face interaction among students, the suitable use of interpersonal and group skill, and group processing (Johnson & Johnson, 1999). The most essential component is positive interdependence where students notice, "we are mutually dependent, sink or swim". Individual accountability means that every member is responsible for both reaching group' goals and helps each other. Other component is face-to-face interaction that includes sharing knowledge, teaching each other, and explanation of solutions. Interpersonal and group skills include intellectual and partnership skills. The last component is group processing which consist of considering teamwork achievement and discussing group work whether it is successful or it would be changed.

Slavin (1989) investigates cooperative learning methods and he found that team rewards and individual accountability are important for achievement. Three concepts are essential for all cooperative learning methods that are team rewards, individual accountability, and equal opportunities for success. There are three general cooperative learning methods usable for many subjects and grades: Students Teams-Achievement Divisions (STAD), Teams-Games-Tournaments (TGT) and Jigsaw II.

Student Teams-Achievement Divisions (STAD): STAD is a general and the most successful method which is developed by Slavin(1986). STAD uses the idea that students work together to learn and responsible for their teammates' learning as well as their own. STAD includes four main steps: class presentation (teaching), team study, testing and team recognition. (i) Class presentation: is a teaching of materials and it is most often direct instruction or a lecture discussion achieved by teacher. (ii) Team study: Teams are consisted of four students which are in harmony according to academic performance, gender, and ethnicity. Each team is composed of high, low and two average achievers. The main aim of team is to provide learning for all team members and adjust their members to do well in testing. The team is the most essential component of STAD. After teaching, the team study together with worksheet. This study includes discussions about problems, helping each other for understanding, correcting any misunderstanding. Team has some rules in STAD:

- Students have responsibility about their teammates learning
- Team study is not finished until all students have understand the concept
- Firstly ask your teammates for help before teacher
- Students should discuss and talk with teammates gently

During team study, teacher may walk around and encourage students to join teamwork or ask questions for guidance. (iii) Testing: Students are tested by individually and not allowed to help each other after team study is finished. The aim of individual testing is to give each a achievement goal that can be achieved if he works harder. (iv)Team recognition: Teams deserve some rewards, certificates or some appreciative words based on their average scores. By considering most successful method, STAD was also used as cooperative learning method in this study.

Teams- Games-Tournaments (TGT): Teams- Games-Tournaments is originally originated by David DeVries and Keith Edwards in Johns Hopkins. As in STAD, it is composed of class presentation and teamwork, but replaces testing with tournaments where students play academic games with other team members to add scores to their team points. During playing games, low achievers play with other low achievers and high achievers play with other high achievers to provide equal opportunities for success. As in STAD, teammates help each other prepare for games while studying worksheets and account for concept but when they are playing, they cannot help each other to provide individual accountability. After tournaments, high achiever team deserves team rewards.

Jigsaw II: Jigsaw II is developed by Elliot Aronson's (1978). It has also four- member groups as in STAD and TGT. The first step of Jigsaw II is that chapters, short books, or other materials are divided into parts according to number of team members. Each team member is selected to become an expert about his or her responsible part. Experts of each team meet to discuss their common parts after they read assigned part. After meeting, they return their team and teach their parts to their teammates. Lastly, testing is applied as other methods. Team recognition is same as STAD.

2.5. Applications in Cooperative Learning

In literature, there are many studies related to the cooperative learning with students' attitudes, achievement and learning outcomes.

Slavin and Karweit (1982) evaluated the effects of mastery learning and student team learning on students' mathematics achievement. The study was applied to 1.487 ninth grade general mathematics students in the Philadelphia. The Comprehensive Test of Basic Skills mathematics part was used as an instrument. It is found that the team learning classes have greater achievement than non-team learning classes on the Comprehensive Test of Basic Skills. In addition, the mastery learning showed no increase in achievement comparison with non-mastery classes. They mainly emphasized that mastery learning and the student team learning could be used for many lower class and urban classes.

Edwards and DeVries (1972) investigated the effects of student teams and learning games on students' attitudes and achievement in mathematics. They used Team Games as a cooperative learning method in seventh grade students. The study went on four weeks in four seventh grade mathematics classes. They compared ability (high, middle and low), team versus individual and game versus tests. The results revealed that the high ability student teams' scores lower than the low and middle ability student. Also, the games groups got higher scored than the no games teams, the individual no games group and the individual games group. The reason of this finding was explained that the low ability students were in a condition to achieve the most and least to lose in teams and opposite is valid for high ability students.

Edwards and DeVries (1974) conducted a study that analyzes the effects of Teams-Games-Tournament, student attitudes, achievement, and classroom processes with 128 seventh grade students in mathematics and social studies classes. The four groups were assigned randomly with 128 students. They reported that the Teams-Games-Tournament affected on student attitudes, achievement, and classroom processes in mathematics classes. As compared to the traditional classes, the Teams-Games-Tournament show no effect on student attitudes, achievement and classroom processes in social studies classes. The students observed that the Teams-Games-Tournament classes were more adhesive. This study of cooperative learning showed that performing of different grouping games could affect students' view about their learning, attitude, interpersonal relationship, and achievement.

The effects of cooperative learning on the achievement and attitudes of teachers were investigated in graduate statistics classes by Courtney, Courtney, and Nicholson (1992). They considered achievement, self-efficacy, motivation and anxiety and social cohesion. The control group and treatment group were randomly assigned. The control group was taught with traditional method and the treatment group was taught with cooperative learning method. This study was applied one semester and two and four members groups were used in cooperative learning method. Multiple-choice exams was used both treatment and control group. Although there were no significant differences in achievement, the results demonstrated that cooperative learning method had a positive effect on motivation, social cohesion, and self-efficacy.

George (1999) implemented a study that compared cooperative method with individual method on students' achievement and attitudes. Two college undergraduate educational psychology classes were assigned as control group with individual method and treatment group with cooperative learning method. The instruments were applied to measure students' achievement and attitudes based on instruction. The results showed that cooperative learning method was significantly different than individual method in terms of instructional quality, critical thinking improvement and method effectiveness. That is, this study verified that cooperative learning method could increase students' achievement when applied properly.

McManus and Gettinger (1996) investigated perceptions of teachers and students about cooperative learning and their observed attitudes of interactions. Two surveys and observational form were utilized in this study. They found that the teaching and learning were obviously associated with students' interactions. Besides, teachers and students who joined in cooperative groups generated academic, attitude, and social positive products. Thus, this study demonstrated that cooperative learning mainly increase academic, social and attitude positive outcomes, and effect on students' interactions.

Shachar and Fischer (2004) implemented the effects of Group Investigation (GI) cooperative learning method on students' motivation, achievement, and experiences. The study included 168 students in 11^{th} grade chemistry classes and took place two months. Harter's Motivation Questionnaire was used as an instrument for motivation and achievement. The students were randomly assigned as treatment and control group. It was found that treatment group demonstrated a decrease in motivation as compared to control group in qualitative measurement. In cooperative group classes, low and middle achieving students gained higher scores on the achievement test. The qualitative instruments, which were the letters of students about new method, showed that students considered 41.7 % of critical comments, 29.4 of improvement ways of new method, and 28.8 % of positive interpretations. They explained the decrease of motivation for treatment group that there was a bad feeling about Group Investigation method which cause a change in traditional teaching method.

Peterson and Miller (2004) investigated the students' experiences in cooperative learning compared to large group instruction. Undergraduate psychology students were assigned as cooperative groups and they used cooperative learning activities. The students' perceptions about their experiences were measured during cooperative learning activities. The students' whole learning increase was observed in cooperative learning while they were interrupted. It was also claimed that the interruption of students during cooperative activity stopped consideration process of the student but then learning should be started again. They reported that interruption of students during cooperative learning should not be done. Also, they suggested that more studies should be done to evaluate the usefulness of cooperative learning.

Siegel (2005) implemented a study with five middle school science and mathematics teachers about cooperative learning during two years. The teachers were educated based on Johnson and Johnson cooperative learning methods. Student and teacher roles, instructional time, curriculum requirements, and classroom management were stressed and paid attention in teacher training. Thus, the outcomes of this study were affected by teachers training about cooperative learning. Siegel implied that qualitative research could important contributions to cooperative learning literature.

Yamarik (2007) investigated the cooperative learning outcomes with three or four students cooperative groups in which the students were same during whole semester inside and outside the classroom in economics class. Teacher outcome evaluation, students study inside and outside of classroom in cooperative groups and teacher simplified cooperative learning activities were measured as three factors of this study. It was found that students showed higher exam scores in cooperative groups. The mean score increase was observed in exam score with 75 %.

Tsay and Brady (2010) examined the relationship between cooperative learning and academic performance in higher education in communication. Twenty-four undergraduate students were participated in this study in Northeastern University. At the beginning of the study, teacher assigned group which included four to six students to perform class research project and readiness assessment tests. The groups sat together whole semester. One day, the survey was conducted and each student answered questions of surveys individually. The survey included 13 items which measured students' active participation in cooperative learning. Selections were made based on Likert percentage scale from zero to a hundred. They evaluated the cooperative learning which included seven composing such as "group processing, motivation, competition, dependability, accountability, interactivity, and use of collaborative skills". The result showed that cooperative learning had a positive relationship with a student's academic performance. Totally, students who participated group work demonstrated positive behaviors such as helping to achieve group's goal, attending courses preparedly, giving positive answers to their peers and getting higher test scores and final course grades at the end of semester.

Law (2011) compared two different cooperative learning activities which were jigsaw and drama and traditional condition in students' reading comprehension achievement, reading performance, achievement goals and autonomous motivation. The participants were 279 students in grade five in Hong Kong. The students were assigned randomly to the two-research group and one control group. Two research groups were taught by a direct-instruction approach integrated with jigsaw groups and a direct-instruction approach integrated with drama activities. Besides, one control group was taught by a direct traditional instruction. Hong Kong Attainment Test, which was written in Chinese, was used as an instrument .The test included three parts that were basic language, reading comprehension, and written composition. The results showed that students in the jigsaw group higher performance compared to drama and control group in reading comprehension test. Also, it was found that students' higher-order reading performance could be increased by cooperative learning activities with well-organized scaffolding by teachers.

Many researchers propose that if cooperative learning is applied properly, it can be used to teach for all students, and it increase students' success and achievement (Lindauer, & Petrie, 1997; Sapon-Shevin, M., Ayres, B.J., & Duncan, J., 2002). Cooperative learning still has a great concern in education.

2.6. Cooperative Learning and Conceptual Change

The following studies related to the cooperative learning and conceptual change which has been found rarely in literature.

Basili and Sanford (1991) used conceptual change strategies in small cooperative groups in college chemistry classes. They investigated the effects of conceptual change strategies and cooperative group work about the laws of conservation of matter and energy, and the particulate nature of gases, liquids, and solids to overcome misconceptions. The study consisted of 62 students who have similar characteristics in sex, race, age and previous experience with chemistry. One treatment group worked in three or five member groups during the sixth class period. After group work an exam was applied to all groups. If all members of group got a 70 or better on the exam, the group members were given bonus five points. Control group was taught by regular lecture class. They also were used exam after class periods. The results showed that the treatment group who were assigned as small group had a significantly lower proportion of misconceptions about the laws of conservation of matter and energy and concepts of the particulate nature of liquids and solids than control group. In addition, the group work encouraged students to achieve conceptual change. At least four students accomplished all four conditions of the conceptual change process and took place change.

Lonning (1993) investigated the effects of cooperative learning on students' verbal interaction patterns and achievement in a conceptual change instructional model in secondary science. Present conceptual change instructional models notice the significance of student-student verbal interactions, but lack definite strategies of support these interactions. Cooperative learning was used to provide these strategies. The study included 36 low-ability tenth grade students in a suburban high school general science course. They were assigned as experimental and control group randomly. The experimental and control group were taught by conceptual change teaching about the particle model of matter. The experimental group utilized cooperative learning strategies including instruction in collaborative skills and group assessment. The control group used no collaborative skills and students were evaluated individually. The conceptual change instruction was based on the instructional models of Rosalind Driver (Driver & Oldham, 1986). In this model included four conditions as orientation, elicitation, restructuring, modification and extension, and application. The evaluation strategies applied in this study to show an effort to measure conceptual change. The findings showed that student-applied cooperative learning strategies had greater achievement and made greater use of verbal patterns that increase learning. The other important result was that cooperative learning strategies increase conceptual change instruction. He also suggested that more researches should be conducted to recognize the specific variables mediating the effects of cooperative learning strategies on conceptual change learning.

Bilgin and Geban (2006) searched the effects of the effects of the cooperative learning approach based on conceptual change conditions over traditional instruction on 10th grade students conceptual understanding and achievement of computational problems related to chemical equilibrium concepts. The study included 87 tenth grade students from two intact classrooms. The results of the study showed that the cooperative learning approach based on conceptual change conditions caused a statistically significantly better understanding of than the chemical equilibrium concepts traditional instruction. They reported that the performance level of students in chemistry problems was developed by the combination of cooperative learning and conceptual change.

Çelikten, İpekçioğlu, Ertepınar and Geban (2012) also reported that The effect of the conceptual change oriented instruction through cooperative learning on 4th grade students' understanding of earth and sky concepts. The sample was 56 fourth grade students from same elementary school. They also used experimental method and assigned as experimental and control group randomly. They showed that experimental group taught by change oriented instruction through cooperative learning had %73 correct answers while control group taught by traditional instruction had %62 correct answers in earth and sky concepts test. They reported that conceptual change oriented instruction through cooperative learning cause to better understanding in earth and sky concepts.

Kırık and Boz (2012) studied that cooperative learning instruction for conceptual change in the concepts of chemical kinetics. The participants were 110 eleventh grade students from two different schools which one was an Anatolian high school and the other one was an ordinary high school. The study conducted in two experimental and two control groups in one teacher from each school. The experimental and control groups were randomly assigned. "Reaction rate concept test (RRCT)" was developed to determine students' understanding on chemical kinetics concepts. It was used as pre-and post–test. It contained two parts that had 16 two-tier items and 7 multiple-choice items. The items were related to chemical kinetics concepts including reaction rate, collision theory, activation energy, heat of reaction, potential energy diagrams, reaction mechanisms, rate equations, and orders, and the factors affecting reaction rate. They also used “Motivated strategies for learning questionnaire (MSLQ)” to measure students’ motivational orientations and their use of different learning strategies. In the experimental group, STAD method of cooperative learning was applied while the traditional method was used in the control group. The results of the study demonstrated that cooperative learning group resulted better understanding of the concepts of chemical kinetics and improved students’ motivation to study chemistry for both schools.

In literature, there are several researches in cooperative learning and conceptual change separately. Based on literature, cooperative learning and conceptual change approach seem to be successful methods to increase students’ achievement and understanding. However; both cooperative learning and conceptual change approach has been investigated so rarely. Even both of them have not been examined in chemical bonding. Thus, there is no study and it is questionable about the effects of cooperative learning based on conceptual change approach in chemical bonding. Therefore, it can be said that this study can fill the gap in literature about the effects of cooperative learning based on conceptual change approach in chemical bonding.

CHAPTER 3

PROBLEMS AND HYPOTHESES

The main problem, sub-problems, and related hypotheses were presented in this chapter.

3.1. The Main Problem and the Sub-Problems

3.1.1. The Main Problem

The main purpose of this study is to investigate the effectiveness of learning based on conceptual change conditions over traditionally designed chemistry instruction on 9th grade students' understanding of chemical bonding concepts and attitudes towards science as a school subject.

3.1.2. The Sub-Problems

1. Is there a significant mean difference between the effects of traditionally designed chemistry instruction and cooperative learning based on conceptual change approach on students' understanding of chemical bonding concepts and students' attitude toward chemistry?

2. Is there a significant mean difference between the means of males and females with respect to understanding of chemical bonding concepts and students' attitude toward chemistry?

3. Is there a significant effect of interaction between treatment and gender differences with respect to students' understanding of chemical bonding concepts and students' attitude toward chemistry?

4. Is there a significant difference between the effects of traditionally designed science instruction and cooperative learning based on conceptual change approach on students' attitudes toward science as a school subject?

5. Is there a significant difference between the mean of males and females' attitudes toward science as a school subject?

6. Is there a significant effect of interaction between treatment and gender difference on students' attitudes toward science as a school subject?

3.2. Hypotheses

$H_0$1: There is no significant difference between mean scores of the students taught with traditionally designed science instruction and those taught with cooperative learning based on conceptual change approach with respect to understanding of chemical bonding concepts and students' attitude toward chemistry.

$H_0$2: There is no significant difference between the means of males and females with respect to understanding of chemical bonding concepts and students' attitude toward chemistry.

$H_0$3: There is no significant effect of interaction between treatment and gender difference on understanding of chemical bonding concepts and students' attitude toward chemistry.

$H_0$4: There is no significant mean difference between the effects of traditionally designed science instruction and cooperative learning based on conceptual change approach on students' with respect to their attitudes towards chemistry as a school subject.

$H_0$5: There is no significant difference between the means of males and females' attitudes toward science as a school subject.

$H_0$6: There is no significant effect of interaction between treatment and gender difference on students' attitudes toward science as a school subject.

CHAPTER 4

DESIGN OF THE STUDY

In this chapter, the research design, population, and subjects of the study, instruments used in this study, treatment, treatment verification and fidelity, internal validity threats, assumptions and limitations were presented.

4.1 Experimental Design

The non-equivalent control group design that is a type of quasi-experimental design was used in this study. The random assignment of students to the group was not achieved, because at the beginning of the semester the groups had already organized by the school. Thus, formed groups were used and one of the classes was assigned as experimental group and another was assigned as control group.

The experimental group was taught by cooperative learning instruction based on conceptual change approach. The control group was taught by traditionally designed chemistry instruction. While the experimental group was arrange as cooperative small groups, the control group studied individually. Both groups were taught by same teacher experienced chemistry teacher. Before treatment, the teacher was trained about aim of the study and cooperative learning based on conceptual change approach. Also, Science Process Skill Test, Chemical Bonding Achievement Test and Attitude Scale toward Chemistry were applied to both groups to control the equivalence of the groups at the beginning of the study.

The research design of the study is presented in Table 4.1 as below:

Table 4.1 Research Design of the Study

Groups	Pre-test	Treatment	Post-test
EG	CBCT ASTC SPST	CLCCA	CBCT ASTC
CG	CBCT ASTC SPST	TDCI	CBCT ASTC

The explanations of the abbreviations are given as below:

EG: Experimental Group

CG: Control Group

CBCT: Chemical Bonding Concept Test

ASTC: Attitude Scale toward Chemistry

SPST: Science Process Skill Test

CLCCA: Cooperative Learning based on Conceptual Change Approach

TDCI: Traditionally Designed Chemistry Instruction

4.2 Population and Subjects of the Study

The target population of the study is all 9^{th} grade general high school students enrolled in a chemistry course in Turkey. Yet it was very difficult to cope with target population, accessible population should be defined. The accessible population contained all 9th grade general high school students in Çankaya, Ankara.

This study included 72 ninth grade students (32 males and 40 females) from two classes of chemistry courses instructed by the same teacher in Sokullu

High School in the 2011-2012 spring semesters. It was chosen randomly as the control group and another as the experimental group.

Most of the students' socio-economic statuses, including the educational level of their parents, their family income were assumed as same. The experimental and control groups respectively contained 35 and 37 students. The ages of the students were almost 15 or 16 years old.

4.3 Variables

4.3.1. Independent Variables

There are two independent variables that one of them is type of instruction such as cooperative learning instruction based on conceptual change approach and traditional designed instruction and gender. Treatments or types of instructions and gender were considered as categorical variables and were measured on nominal scale.

4.3.2. Dependent Variables

The dependent variables of this study were students' understanding of chemical bonding concepts measured by Chemical Bonding Achievement Test and students' attitude scores toward chemistry as a school subject measured by Attitude Scale toward Chemistry. These variables are interval and continuous variables.

4. 4 Instruments

In this study, Chemical Bonding Concept Test, Science Process Skills Test and Attitude Scale toward Chemistry were used to investigate hypothesizes. Chemical Bonding Concept Test was applied as pre- and post-test to define students' understanding of chemical bonding concepts. Science Process Skills Test was given as pre-test to control students' intellectual abilities about science as covariate. Attitude Scale toward Chemistry was used as pre- and post-test to identify the effect of treatment on students' attitude toward chemistry. Besides, semi-structured interviews were applied to students in experimental groups. The classroom observations were used to control the application of treatment in experimental group.

4.4.1. Chemical Bonding Concept Test

This test was constructed by the researcher. The aim of the test was to investigate students' understanding of bond formation, polarity, intermolecular forces and shape of molecules. The test included 20 questions and two parts. In the first part, there were ten two-tier questions. The first tier was a response part in which students were asked to select one of the two response choices. The other tier was a reason part in which students were asked to give logical reason for their answer in the first part. A student's answer to an item was accepted as correct if the student selected the correct choice for both tiers. In the second part, there are ten multiple-choice questions including one correct answer with four distracters. These distracters consisted of students' misconceptions on chemical bonding presented in literature.

During the developmental stage of the test, the instructional objectives of chemical bonding concepts were determined based on chemistry curriculum

(Appendix B). Then, students' misconceptions in chemical bonding concepts were determined by examining related literature (Butts and Smith, 1987; Tan and Tragust, 1999; Birk and Kurtz, 1999; Coll and Taylor, 2001; Nicoll, 2001). Lastly, the test items were formed according to students' misconceptions that were considered in each question. The students' misconceptions were summarized and taxonomy of these misconceptions was presented as below:

Misconceptions in Chemical Bonding

Bonding

- Metals and nonmetals form molecules
- Metals and nonmetals combine to form molecules consisting of oppositely charged ions
- Atoms of a metal and a nonmetal share electrons to form molecules
- A metal is covalently bonded to a nonmetal to form a molecule
- Bonds are material connections rather than forces
- Bonds are only formed between atoms that donate or accept electrons
- Metals and nonmetals form strong covalent bonds
- Ionic compounds exist as molecules formed by covalent bonding
- Bonding must be either ionic or covalent
- In ionic bonding, the number of electrons transferred depends only on the number of electrons that the atoms of the nonmetal need to achieve a stable octet

Bond Polarity

- Equal sharing of the electron pair occurs in all covalent bonds
- The polarity of a bond is dependent on the number of valence electrons in each atom involved in the bond

- Ionic charge determines the polarity of the bond
- Nonbonding electron pairs influence the position of the shared pair and determine the polarity of the bond
- The largest atom exerts the greatest control over the shared electron pair

Polarity of Molecules

- Nonsymmetrical molecules with polar bonds are polar
- Nonpolar molecules form only when atoms in the molecule have similar electronegative
- A molecule is polar because it has polar bonds
- Molecules of the type OF_2 are polar as the nonbonding electrons on the oxygen form a partial negative charge

Molecular Shape

- The shape of molecules is due only to the repulsion between bonding pairs
- The shape of molecules is due only to the repulsion between nonbonding pairs
- Bond polarity determines the shape of a molecule

Intermolecular Forces

- Intermolecular forces are the forces within a molecule
- Strong intermolecular forces exist in a continuous covalent solid
- Covalent bonds are broken when a substance changes state
- The strength of intermolecular forces is determined by the strength of the covalent bonds present in the molecules
- Molecular solids consist of molecules with weak covalent bonding between the molecules
- Metals and nonmetals form molecules with weak intermolecular forces

Table 4.2 Taxonomy of Student's Misconceptions

Misconception	Item
Bonding	1,2,8,12,13,17,18,19
Bond Polarity	5,11,20
Polarity of Molecules	4,9,16
Molecular Shape	7,10
Intermolecular Forces	3,6,14,15

Cronbach- alpha coefficient of the test was calculated as 0.74 to measure of the reliability of test score in this study. The content validity of the test was provided by the chemistry teachers and chemistry education experts for the appropriateness of the questions. Also, the test was controlled with respect to its grammatical aspects and understandability by the same specialist. The test was prepared and applied in Turkish. This test was applied to experimental and control groups as pre-test to identify students' understanding of chemical bonding at the beginning of treatment. It was also used for both groups as post- test to compare two instructions methods about their effects on students' understanding of chemical bonding (Appendix B).

4.4.2. Science Process Skill Test (SPST)

This test was generated by Okey, Wise, and Burns (1982). The Turkish form was prepared by Geban, Aşkar, and Özkan (1992). The test was comprised of 36 four-alternative multiple-choice questions. The reliability of the test was measured as 0.85. The test evaluates mental capacity of students consisting of defining variables, stating hypotheses, discussing investigations, analyzing graphs and commenting data. It was applied to both experimental and control group before the treatment (Appendix E).

4.4.3. Attitude Scale toward Chemistry (ASTC)

This instrument was generated by Geban, Ertepınar, Yılmaz, Altın, and Sahbaz (1994). It was used to measure students' attitudes toward science as a school subject. The scale was applied to both groups as pre- and post-test to observe the effect of treatment on students' attitudes. It was comprised of 15 items with 5-point likert type scale: fully agree, agree undecided, disagree, and fully disagree. The reliability of scale was measured as 0.83. In scale, there were positive and negative sentences (Appendix D).

4.4.4. Interview about Chemical Bonding Concepts

Semi-structured individual interviews were conducted to make sure the reliability of this study and to observe more information about students' conceptions about their responses to post –test by the researcher. During the interviews, students were asked to explain their reasons of their answers about chemical bonding. In the study, 12 students 6 from experimental and 6 from control group were interview after treatment in class environment. These students were selected based on post-test scores. Two of them were high achievers, two of them were middle achievers, and two of them were low achievers in both groups. Each interview continued approximately 15 minutes and all interviews were recorded on audio taped.

4.4.5. Interview about Cooperative Learning based on Conceptual Change Approach

Apart from interview about chemical bonding concepts, students from experimental groups were interviewed to obtain information about students' perceptions on cooperative work experiences. The questions of interview were prepared based on literature related to cooperative work. During the interview, students were asked to explain their opinions about cooperative work. These interviews also continued approximately 20 minutes and audiotape record was done.

4.4.6. The Classroom Observation Checklist

The Classroom Observation Checklist was developed by researcher to observe the implementation of treatment in the experimental group. The checklist was prepared according to the rules of cooperative learning instruction based on conceptual change. It consisted of 17 items with three point likert type scale: yes, no and partially. With this checklist, interaction of student-student in group work, interaction of teacher-student, participation of students to group work, classroom environment were observed. During treatment, the researcher sat silently and took notes on observation checklist (Appendix F).

4.5 Treatment

This study was carried out over six weeks during the second semester of 2011-2012 academic years. The study included 72 students from four different ninth grade classes. There were two groups as experimental and control groups. The control group and the experimental group were assigned randomly. The experimental group was instructed by cooperative learning based on conceptual change approach and the control groups were instructed by traditionally designed chemistry instruction. Both groups were taught by same chemistry teacher. The teacher was trained about cooperative learning based on conceptual change approach before treatment. Also, for each of lesson, detailed lesson plans were prepared based on cooperative work with conceptual change by the researcher. The applied worksheet was generated by the researcher with opinions of teacher according to curriculum. Besides, the teacher was acquainting with students' possible misconceptions about the chemical bonding.

Chemical Bonding Achievement Test, Attitude Scale toward Chemistry and Science Process Skill Test were applied to both groups before treatment. Chemical Bonding Achievement Test was given to see level of students' understanding and achievement about chemical bonding. Attitude Scale toward Chemistry was used to evaluate students 'attitude toward chemistry as a school subject. Science Process Skill Test was applied to examine students 'level of science process skills. After treatment, Chemical Bonding Achievement Test and Attitude Scale toward Chemistry were given again as post-test to examine the effect of treatment.

The regular classroom instruction was two 45 minutes per week .The chemical bonding concept was instructed as part of chemistry curriculum during the treatment. The chemical bonding concept included bonding, bond polarity, polarity of molecules, shape of molecules and intermolecular forces.

In the control group, traditionally designed chemistry instruction in which the teacher used lecturing and discussion was conducted. The instruction primarily based on teacher 'presentation, textbook and discussion. The teacher played central role in learning process. Students were passive and only sat and listened to their teacher. There is no active student-student interaction as in cooperative learning. During instruction, the teacher explained the concept and asked students to some questions. Also, the teacher created discussion environment when students asked questions or did not understand some part. However, while explaining the concept she did not consider students' misconceptions or previous knowledge. After lecturing, the worksheet was applied to students individually. While studying on worksheet, students asked some questions to teacher and teacher tried to explain their questions. After application of worksheet, it was corrected and scored with students. The students saw their mistakes and again asked some questions to understand properly. At the end of lesson, the teacher gave homework to students.

In the experimental group, the cooperative learning based on conceptual change approach was used. The cooperative learning method STAD (Standard Teams' Achievement Divisions) that was developed by Slavin was used in this study. Cooperative learning (STAD) based on conceptual change instruction was used in experimental groups. This treatment included four components. First component was teacher presentation. This presentation involved direct explanation of concept. Second and vital component was team study. Teams were constituted with four students to be heterogeneous. Then, the worksheet was given students to study together. The teacher monitored teams to be sure to study each member of teams on the worksheet. Teams were arranged based on face-to-face work. Third component was testing. After team study, two quizzes were given to students. These quizzes were answered individually and graded by the teacher. After grading, quizzes were given back to students to see their performance and mistakes. In addition to quizzes, mainly Chemical Bonding Concept Test was applied for testing and team scores. The team scores were calculated by seventy-five percent of score of Chemical Bonding Concept Test and twenty-five percent of score of two quizzes. The test was performed individually and not to permit students to help each other. At the beginning of team arrangement, the students were informed about individual testing and calculation of team scores to encourage students help each other in team study. The last component was team recognition. Team scores were announced and the members of team which has highest score were rewarded.

The teams comprised of four students one from higher achievers, one from lower achievers and two of them from average achievers. Students' levels were obtained according to their teacher's exam results. These heterogeneous groups were encouraged to help, teach and support each other. Each member of groups was assigned to be responsible from each other to learn concept. During treatment, all students collaborated with each other and teach other member of team. Meanwhile, the teacher toured group to group to monitor group study. Also, she encouraged students to asked questions and answers each other. The worksheet studied by experimental groups was prepared based on conceptual change in cooperative learning groups. Main important issues of treatment were student-student and teacher-student interaction.

The instruction was designed according to conceptual change conditions to replace students' misconceptions with scientific conceptions. The worksheet was applied to activate students' misconceptions. Then, the teacher informed students about their misconceptions and tried to replace their misconceptions with scientific ones by explaining correct forms of concept. In this study, the teacher used teaching strategy based on conceptual change described by Posner et al. (1982). This teaching strategy was presented in Table 4.5.1.

Table 4.3 Teaching Strategy of Cooperative Learning Based on Conceptual Change Approach

Strategies	**Conceptual Change Conditions**
Discussions in small groups	Dissatisfaction
Basic explanations of peers	Intelligibility
Details explanations of teacher	Intelligibility, Plausibility
Clear examples of teacher	Plausibility
Solving new problems and generalizations for new problems	Fruitfulness

In cooperative learning small groups, students studied with their peers. They discussed, shared, and compared their preconceptions with their friend, that is, they saw different view of friends. The example of lesson as below:

Teacher starts to lesson with the questions: “What is the chemical bonding? What does it mean?” The purpose is to activate students’ previous knowledge and determine their existing ideas. Some of the students try to answer the questions and the discussion environment takes place in the classroom. After students’ answers and discussions, teacher begins class presentation. While explaining the concept, teacher mainly focuses on students’ misconceptions and concepts which students have struggle.

After presentation, teacher organizes students to make cooperative groups which have four students each. Teacher gives a worksheet to study together. Students share their ideas, discuss their knowledge, and ask questions each other. During group work process, they recognize different perspective than their own. This causes the *dissatisfaction* that is the first and important step for conceptual change approach.

After students’ discussions on worksheet in cooperative groups, teacher gives extra explanation for students’ questions in greater detail. These explanations help students understand the concept and clarification ambiguities about the concept. With this understanding, the *intelligibility* that is the second step in conceptual change approach takes place.

To increase students’ understanding and provide the *plausibility* that is the third step in conceptual change, teacher continues with examples and problems about the chemical bonding.

When solving new problems, students generalize their knowledge to other situations and noticed the utility of new concept. This leads to the *fruitfulness* step that is the last step of conceptual change.

4.6 Treatment Verification and Treatment Fidelity

Throughout the treatment, the researcher monitored the experimental and control group to make certain that the teacher implemented the treatments as experimental and control group conditions. The classroom observation checklist was prepared and rated. The checklist showed that the treatments were applied as requested. The researcher also observed that the worksheet was studied in group works properly and the teacher guided students during group work. Furthermore, some students were interviewed to ensure the treatments were carried out as requested. The interviews verified the checklist that confirmed that the experimental groups were implemented as cooperative learning based on conceptual change approach and the absence of cooperative learning in control groups.

Treatment fidelity is defined as the strategies that monitor and enhance the accuracy and consistency of an intervention to ensure it is implemented as planned (Taylor, Daunic &Smith, 2007). To provide treatment fidelity, the criterion checklist was prepared for experimental and control groups. This list includes what should be needed in the methods applied in experimental and control groups. The other step was that the lesson plan was formed involved the criterion list and objectives of lesson. Also, the instruments and activities were checked by chemistry professor, chemistry education professor and two teachers. Their thoughts were taken into consideration. Furthermore, the teacher was trained before the study based on lesson plan and activities for experimental and control groups to make sure for treatment fidelity.

4.7 Internal Validity Treats

Fraenkel and Wallen (2006) defined internal validity that observed differences on the dependent variable are directly related to the independent variable, and not due to some other unintended variable. These unintended variables affecting the dependent variables are called as the threats of internal validity of a treatment (Gay & Airasian, 2000). There are many different threats of internal validity such as subject characteristics, maturation, history, instrumentation, mortality, testing, novelty and experimenter effects (Gay & Airasian, 2000; Fraenkel & Wallen, 2006).

Subject characteristics means that the selection of people for a study may cause the individuals differing from one another in unintended ways that are related the performance on the dependent variable (Fraenkel & Wallen, 2006). Pre-tests which are chemical bonding concept test, attitude toward chemistry test and science process skills test were applied to control this treat.

Maturation means the changes during a treatment may be because of factors related to passing of time rather than to treatment (Fraenkel & Wallen, 2006). The treatment was continued six weeks that is not too long time to cause changes in students. Also, the instruments were implemented in the same week for both groups. Thus, this threat was controlled.

History means that one or more unexpected events may occur during the study which can affect the answers of subjects (Gay & Airasian, 2000). The researcher attended all of the courses and monitored the students during the treatment. Also, the teacher gave information about students to researcher. Occurance of any unexpected events was not determined during the treatment.

Instrumentation threat means that the nature of the instrument lead to different interpretations of results or invalid assessment of instruments (Gay & Airasian, 2000). The all instruments used in the study were same for both groups and their reliabilities were adequated. Also, data collector characteristics and data collector bias were controlled since the researcher collected all the data for both groups in same conditions.

Mortality means that losing some of the subjects as the study progresses (Fraenkel & Wallen, 2006). However, nobody left from the study.

Testing means the improvement in the instruments due to the use of the pre-test (Fraenkel & Wallen, 2006). The time gap between pre- and post-tests was six weeks. It is supposed that this time was enough for desensitization.

Novelty means that increased interest and engagement of the students due to doing something new or different cause improvement of post-test scores (Gay & Airasian, 2000). Conducting the treatment in sufficient period of time provides to control this treat. However, the study continued over six weeks and it is not sufficient time for desensitization. Thus, the experimental group students' performances might be affected and increase the score of post-tests.

Experimenter effect means that the researcher can affect, usually subtly and subconsciously, the procedures and assessment of performance (Gay & Airasian, 2000). The researcher tried to behave similarly to both groups students. Also, the experimental group students were not informed that they learn the chemical bonding with a new method to prevent the feeling of special attention. Thus, it was assumed that experimenter effect was controlled.

4.8 Analysis of Data

All hypotheses were analyzed by Multivariate Analysis of Variance (MANOVA) and Analysis of Variance (ANOVA). MANOVA was used to decided effectiveness of two different instructional methods on students' achievement about chemical bonding concepts and students' attitude toward chemistry. Two-way ANOVA was used to determine the effect of treatment and gender difference on students 'attitudes toward chemistry as a school subject and students' understanding.

4.9 Assumptions

1. There was no interaction between groups
2. The teacher was not biased during the treatment
3. The tests were conducted under standard conditions
4. The participants answered the questions of instrument properly.
5. Students' interviews were applied under standard conditions.

4.10 Limitations

1. The study was limited to chemical bonding in chemistry.
2. The subjects of the study were limited to 132 ninth grade students in public high school in Ankara

CHAPTER 5

RESULTS AND CONCLUSIONS

This chapter mainly included analyses of the hypotheses presented in Chapter 3. Furthermore, in the first part, descriptive statistics about pre- and post-test were presented. In the second part, inferential statistics about hypotheses were given. Then, the results of students' interviews and the result of classroom observations were explained. Lastly, the conclusion based on the results of the research was stated.

5.1 Descriptive Statistics

Descriptive statistics associated with students' chemical bonding concept pre- and post-test scores, science process skills test scores and attitude scale toward pre- and post-test scores of experimental and control groups were presented in Table 5.1.

Table 5.1 Descriptive statistics associated with students' Chemical Bonding Concept Test (CBCT), Science Process Skills Test (SPST) and Attitude Scale toward Test scores of students in Control Group (CG) and Experimental Group (EG)

Group	Test	N	Min	Max	Mean	SD	Skewness	Kurtosis
CG	Pre-CBCT	37	1	5	2.45	1.19	.678	-.078
	Post-CBCT	37	4	10	7.18	1.64	-359	-.756
	Pre-ASCT	37	19	52	34.56	7.92	-246	-.282
	Post-ASCT	37	19	58	36.62	9.71	.254	-.358
	SPST	37	8	17	12.70	2.73	-.099	-.981
EG	Pre-CBCT	35	1	5	2.40	.881	1.00	1.28
	Post-CBCT	35	8	18	12.37	1.98	.858	1.65
	Pre-ASCT	35	18	55	35.42	8.78	.189	-.686
	Post-ASCT	35	24	67	46.88	11.16	.082	-.862
	SPST	35	8	17	12.38	2.53	-.088	-.807

As presented in Table 1, the pre-Chemical Bonding Concept Test scores ranged from 1 to 5 with a mean of 2.5 in the control group and ranged from again 1 to 5 with a mean of 2.4 in the experimental group. Although the min. and max. values were same and the mean values were almost the same, the post- Chemical Bonding Concept Test scores ranged from 4 to 10 in the control group and ranged 8 to 18 in the experimental group. With regard to the mean values, the control group mean was 7.1 while the experimental group mean was 12.3. The mean score difference in the control group was 4.6 whereas the difference in the experimental group was 9.9. The mean score increase in the experimental group was more distinctive than the mean score increase in the control group.

The students' attitude scale toward chemistry scores ranged from 19 to 52 with a mean of 34.5 in the control group and ranged from 18 to 55 with a mean of 35.4 in the experimental group before the treatment. After treatment, the mean scores of students in the attitude scale toward chemistry were 36.6 for control group and 46.8 for experimental group. As seen in the mean scores differences, the mean score increase in the experimental group much larger than the mean score increase in the control group after treatment. This higher test score showed more positive attitude toward chemistry in the experimental group despite almost the same mean values before treatment.

With regard to students' science process skills test scores, the both group scores ranged from 8 to 17. The mean score of the control group and the experimental group were 12.7 and 12.3 respectively. The mean scores were almost the same and this showed that the students in the experimental group had same abilities with the students in the control group in solving science problems.

Apart from mean, minimum, and maximum values, the skewness and kurtosis values of the test scores were shown in the Table 5.1. As seen from the values ranged from -4 to +4 that indicated the normal distribution of the test scores. This also controlled with the histograms of post-CBCT and post-ASCT for the control and the experimental group as shown in Figure 5.1 and Figure 5.2.

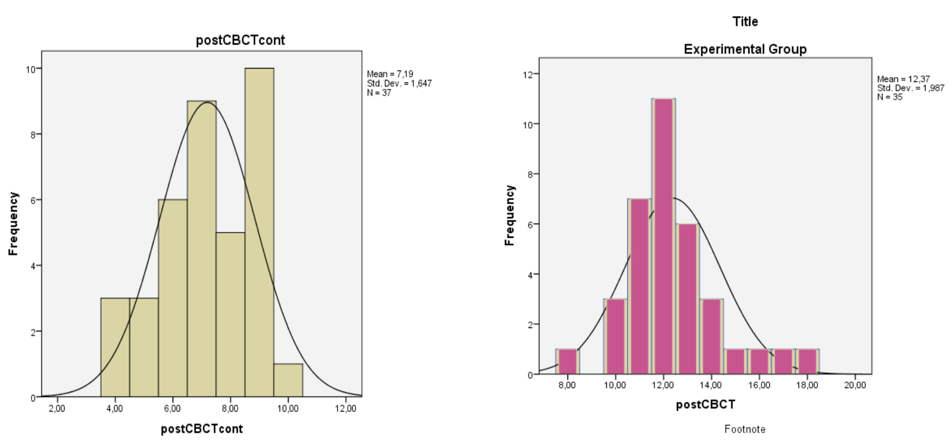


Figure 5.1 Histograms of post- Chemical Bonding Test Scores in the control and experimental group.

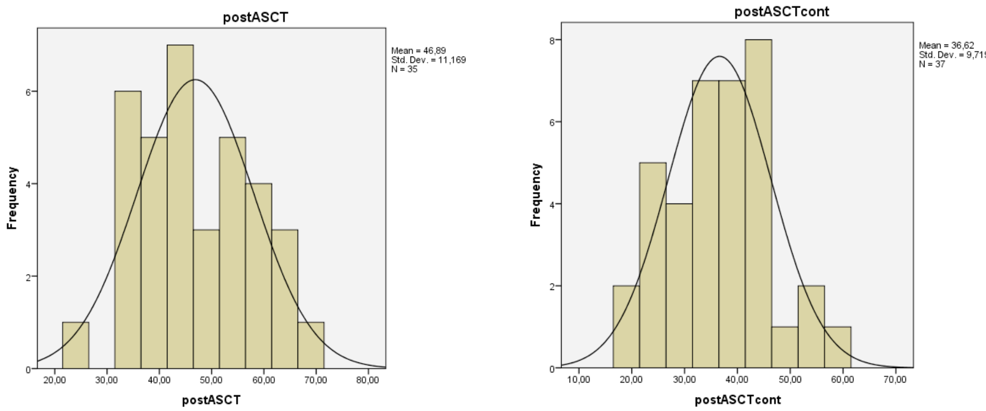


Figure 5.2 Histograms of post- Attitude Scale toward Chemistry Test Scores in the control and experimental group.

5.2 Inferential Statistics

In this part, the analyses of six null hypotheses were given. The hypotheses were analyzed by using Multivariate Analysis of Variance (MANOVA) and Analysis of Variance (ANOVA) and at a significance level of .05. Statistical analyses were done by using Statistical Package for Social Sciences for Personal Computers (SPSS/PC).

Independent t-test analyses were carried out to control whether there was a significant mean difference between the experimental and control group in terms of students' understanding of chemical bonding concept evaluated by pre-Chemical Bonding Concept Test (CBCT), students' attitude toward chemistry evaluated by pre-Attitude Scale toward Chemistry Test (ASCT) and science abilities of students evaluated by Science Process Skill Test (SPST) before the analyses of null hypotheses.

Based on the result of independent sample t-test, it was seen that there was no significant mean difference between the experimental and control group with respect to students' understanding of chemical bonding concept (t (70) = -.566, p= .573), their attitude toward chemistry (t (70) = -.437, p= .663), and their science process skills (t (70) = -.532, p= .596).

5.2.1 Null Hypothesis 1

This hypothesis stated that there is no significant difference between mean scores of the students taught with traditionally designed science instruction and those taught with cooperative learning based on conceptual change approach with respect to understanding of chemical bonding concepts and students' attitude toward chemistry. Multivariate Analysis of Variance (MANOVA) was used to test this hypothesis. The all assumptions of MANOVA were checked before conducting the analysis.

The first assumption of MANOVA was multivariate normality. It was seen from the skewnees and kurtosis values in the descriptive statistics that chemical bonding concept test scores were normally distributed which shows the univariate normality. It may also indicate multivariate normality.

The second assumption was independence of observation within and between groups. It was supposed that the test was conducted in standard conditions and there was no interaction within and between groups during the conducting of test. Besides, the researcher and the teacher made observations during the test and it can be said that there was no interaction between students.

The third assumption was the homogeneity of variances and covariance. It was tested by Box's test and Levene's test. Box's test indicated that the covariance matrices of the dependent variables were equal across groups F (3, 982677) = .620, p=. 602. The result of Levene's tests showed that the homogeneity of variances was met as presented in Table 5.2.

Table 5.2 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Post-CBCT	.104	1	70	.744
Post-ASCT	1.452	1	70	.232

Finally, MANOVA was run after testing all assumptions. The results were presented in Table 5.3.

Table 5.3 MANOVA of Post-CBCT and Post-ASCT

Source	Wilks' Lambda	Hypothesis df	Error df	Multivarite F	Sig. p	Eta Squared	Obs. Power
Treatment	.295	2	69	82.405	.000	.705	1.00
Gender	.988	2	69	.417	.661	.012	.115
Gender* Treatment	.954	2	67	1.600	.209	.046	.327

The results demonstrated that there was a significant mean difference between experimental and control group with respect to understanding of chemical bonding concepts and students 'attitude toward chemistry, F (2, 69)=82.405, p< .05. The multivariate η^2=. 70 showed that 70% of multivariate variance of the dependent variables was associated with treatment. The power value that found as 1 showed that the difference between control and experimental group arise from the treatment effect and this difference had practical significance.

ANOVA was conducted to recognize the effect of treatment on dependent variables. The results of analysis were presented Table 5.4. As seen from table, the results showed that there was significant mean difference between experimental and control groups with respect to understanding of chemical bonding concepts and students' attitude towards chemistry. As shown in Table 5.1, the scores of students instructed by cooperative learning based on conceptual change approach ($\overline{X}$ (EG) = 12.3) significantly higher than those instructed by traditionally designed conditions $\overline{X}$ (CG) = 7.1).

Table 5.4 ANOVA Results of Post-CBCT and Post-ASCT

Source	Dependent Variable	df	F	Sig. P	Eta Squared	Obs. Power
Treatment	Post-CBCT	1	145.837	0.000	.676	1.00
	Post-ASCT	1	17.356	0.000	.199	.984

The percentages of correct responses of experimental and control groups in the post-CBCT scores were given in Figure 5.3. The figure showed that there were big differences in the percentages of correct responses in the questions numbered by 2, 3,5,6,7,9,15, and 19 between experimental and control groups.

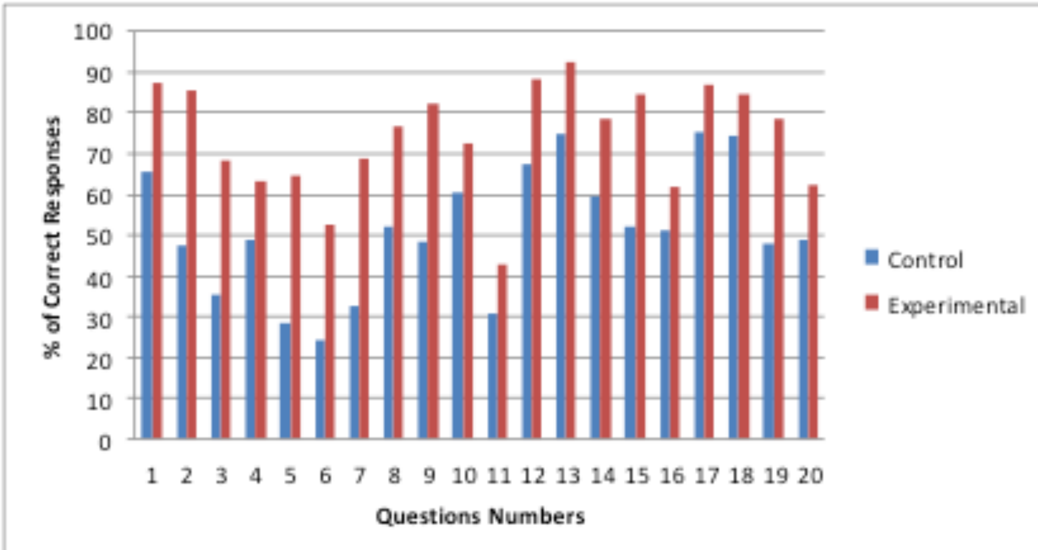


Figure 5.3 Comparisons between Post-CBCT Scores of the Experimental and Control Group

In the second question, students were first asked to choose whether the statement that phosphorus formed covalent compound with flour was true or false. The second part of question required the reason of answer. Before the treatment, most of the students in the both experimental and control groups (74.2 % for experimental group, 76.4% for control group) chose correct answer in the first part of question. However, many of the students (54.8 % for experimental group, 52.4% for control group) selected the misconception reason of forming covalent compound that phosphorus element donated its three electrons each flour element. They considered that bonds were only formed between atoms that donate or accept electrons. After the treatment, the majority of the students (85.3%) in the experimental group selected two parts correctly while this percentage was only 47.3% in the control group.

Students were asked that intermolecular or intramolecular forces explained of the higher boiling point of ammonia than nitrogen trifluoride despite of similar structure and formula in the first part of third question. The second part of question again required the reason of answer. Before the treatment, a few of students (47.6% for experimental group, 43.9% for control group) selected correct answer for the first part. However, minority of the students (28.4% for experimental group, 25.6% for control group) selected correctly in two parts of questions. After the treatment, 68.4% of the students in the experimental group and 35.4 % of students in the control group chose correct answers in the two parts of questions. The most common misconception was that the strength of intermolecular forces was determined by the strength of the covalent bonds present in the molecules. The students with the percentage 24.2% in the experimental group and 42.8 % in the control group selected this misconception. The percentages of students' answers in both groups in the post-CBCT test were given in Table 5.6.

Table 5.5 The percentages of students 'answers for question 3

Question 3: The reason of the higher boiling point of ammonia than nitrogen fluoride despite of similar structure and formula was that	Percentage of the students' responses (%)	
	Experimental Group	Control Group
Alternative 1 Covalent bonds of ammonia were easily broken while covalent bonds of nitrogen trifluoride were not broken	24.2	42.8
Alternative 2 Ammonia has a stronger intermolecular Van der Waals forces	2.1	7.2
Alternative 3* Ammonia has a hydrogen bonding between molecules	68.4	35.4

*	Table 5.5 (continued)		
	Alternative 4 While ammonia contains ionic bonds, nitrogen trifluoride contains covalent bonds	5.3	14.6

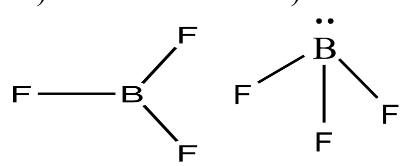
Correct Alternative

With regard to question 5, students were first asked to select whether the statement that the bonds of ammonia molecules were polar was true or false. The reason of their selection was required in the second part. Before the treatment, 22.6% of the students in the experimental and 18.4% of the students in the control group selected the correct answer in two parts. Most of the students (47.8% in the control group, 49.2% in the control group) in both groups chose the common misconception that equal sharing of the electron pair occurs in all covalent bonds. After the treatment, 64.7% of the students in the experimental group selected the correct answer that nitrogen and hydrogen do not share electron pairs equally while this percentage was only 28.3% in the control group.

In the sixth question, students were first asked to select whether the statement that the solubility in the water of the nitrogen trifluoride was higher than nitrogen molecule was true or false. The second part of question was needed a reason of the first part. Before the treatment, majority of the students (52.4 for the experimental group and 56.8 for the control group) selected the most common misconception that nitrogen trifluoride was polar molecule because of their polar bonds. However, 52.4% of the students in the experimental group chose the correct answer whereas 24.2% of the students in the control group chose the correct answer after the treatment.

As concerns question seven, the shape of the boron trifluoride and the reason of this asked to students. 38.6% of the students in the experimental group and 41.4% of the students in the control group selected the most common misconception that the repulsion between the nonbonding pairs of boron and bonding pair electrons caused to shape of molecule previously. After the treatment, 68.8% of the students in the experimental group chose the correct answer while 32.4% of the students in the control group chose the correct answer. The percentages of the students in both groups were shown in Table 5.7.

Table 5.6 The percentages of students 'answers for question 6

Question 6: The shape of BF_3 molecule was shown by A) B)  Because	Percentage of the students' responses (%)	
	Experimental Group	Control Group
Alternative 1 The repulsion between the nonbonding pairs of boron and bonding pairs electrons caused to shape of molecule	18.3	36.8
Alternative 2* The bonding pairs electrons arranged to decrease interaction of electrons	68.8	32.4
Alternative 3 The bonding pairs were strongly attracted by the fluorine which has high electronegativity	6.4	23.1
Alternative 4 Equal sharing of electrons was occurred between fluorine and boron	6.5	7.7

*Correct Alternative

As for question nine, the statement asked whether the hydrogen sulfide molecule was polar or nonpolar and the reason of selection. Before the treatment, some of the students (24.7% for the experimental group, 22.4% for the control group) chose the misconception that nonsymmetrical molecules with polar bonds were polar. Some of them (18.5% for the experimental, 20.4% for the control group) selected the other misconception that the hydrogen sulfide molecule was polar because of their polar bonds. After the treatment, most of the students (82.3%) in the experimental group selected the correct answer while this percentage was only 48.5% in the control group. The percentages of students in the post-test were presented in Table 5.8.

Table 5.7 The percentages of students 'answers for question 9

Question 9: The molecule of H_2S was A) Polar B) Nonpolar because	Percentage of the students' responses (%)	
	Experimental Group	Control Group
Alternative 1 The nonsymmetrical molecules with polar bonds were polar	12.4	16.5
Alternative 2 The bonds of hydrogen sulfide were polar	3.7	17.6
Alternative 3 Equal sharing of electrons was occurred between hydrogen and sulfur	1.6	17.4
Alternative 4* The vectorial sum of electrical dipole moment in the molecule was different than zero.	82.3	48.5

*Correct Alternative

Students were asked the intermolecular bonds of hydrogen fluoride in the question 15. Before the treatment, many of the students (36.4% for the experimental group, 42.3% for the control group) selected the wrong alternative that included covalent bonds as intermolecular bonds of hydrogen fluoride. Moreover, some of them (18.5% for the experimental group, 22.6% for the control group) selected the wrong alternative that not includes Van der Waals forces as intermolecular bonds of hydrogen fluoride. However, after the treatment, many of the students (84.7%) chose the correct answer in the experimental group, while this percentage again lower (52.2%) in the control group.

Regarding to question 19, students were asked the correct alternative for the sodium chloride compound. The most common misconception chose by the students was that sodium chloride has as a molecule structure before the treatment. The percentages of the students in the experimental and control group were 48.8% and 46.5% respectively. Another common misconception was that Na^+ and Cl^- ions were formed after breaking the bonds of sodium chloride in dissolving process. After the treatment, 78.6% of the students in the experimental group whereas 47.8% of the students in the control group chose the correct answer that stated that there were Na^+ and Cl^- ions in the aqueous solution. The percentages of the students in both groups in the post-test were represented in Table 5.9.

Table 5.8 The percentages of students 'answers for question 19

Question 9: What is the correct alternative for the sodium chloride?	Percentage of the students' responses (%)	
	Experimental Group	Control Group
Alternative 1 It conducts electricity in the solid state	5.6	7.4
Alternative 2 Na^+ and Cl^- ions are formed after breaking the bonds of sodium chloride in dissolving process	1.2	18.6
Alternative 3 It has covalent bonds	1.8	4.7
Alternative 4 It has a molecular structure	12.8	21.5
Alternative 5* There are Na^+ and Cl^- ions in the aqueous solution	78.6	47.8

*Correct Alternative

As shown from the percentages of the students, the students in the experimental group have better understanding of chemical bonding concept than those in the control group. The more students in the experimental group handled their misconception after instruction than the students in the control group.

5.2.2 Null Hypothesis 2

The second hypothesis stated that there is no significant difference between the means of males and females with respect to understanding of chemical bonding concepts and students' attitude toward chemistry. The hypothesis was analyzed by multivariate analysis of variance (MANOVA). Before conducting analysis, assumptions of MANOVA were checked.

As mentioned in null hypothesis, MANOVA was conducted after testing all assumptions. The results were presented in Table 5.3. They represented that there was no significant mean difference between female and male students with respect to understanding chemical bonding concepts and students' attitude toward chemistry (Wilks' Lambda=. 988 $F(2,69)= .417$, $p >.05$.)

5.2.3 Null Hypothesis 3

The third hypothesis stated that there is no significant effect of interaction between treatment and gender difference on understanding of chemical bonding concepts and students' attitude toward chemistry. Multivariate analysis of variance (MANOVA) was conducted to test this hypothesis. Table 5.3 also represented the interaction effect on understanding of chemical bonding concepts and students' attitude toward chemistry. The results showed that there was no significant interaction effect between gender and treatment on understanding of chemical bonding concepts and students' attitude toward chemistry $F(2,67)= 1.600$, $p >.05$.

5.2.4 Null Hypothesis 4

The fifth hypothesis stated that there is no significant mean difference between the effects of traditionally designed science instruction and cooperative learning based on conceptual change approach on students' with respect to their attitudes towards chemistry as a school subject. To test this hypothesis, two-way analysis of variance (ANOVA) was used. The assumptions of ANOVA were checked before conducting the analysis.

The first assumption of ANOVA was univariate normality. It was seen from the skewnees and kurtosis values in the attitudes towards chemistry scores were normally distributed.

The second assumption was independence of observation within and between groups. It was supposed that the test was conducted in standard conditions and there was no interaction within and between groups during the conducting of test.

The third assumption was the equal of variances. The Levene's Test of Equality was used to check this assumption. The result indicated that the equality of variance assumption was met $F(3, 68) = .960$, $p>.05$ as seen in Table 5.12.

Table 5.9 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Attitude	.960	3	68	.417

After testing all assumptions, ANOVA was conducted. The results were presented in Table 5.10.

Table 5.10 ANOVA Summary of ASTC

Source	Sum of Squares	df	MS	F	P
Gender	56.095	1	56.095	.527	.470
Class	1892.169	1	1892.169	17.781	.000
Class* Gender	339.995	1	339.995	3.195	.078
Error	7236.079	68	106.413		

The results showed that there was a significant mean difference between the students taught with traditionally designed science instruction and those taught with cooperative learning based on conceptual change approach with respect to with respect to attitudes toward chemistry as a school subject, F (1, 68) =3,195 p < .05. The experimental group students had significantly higher scores on attitude scale toward chemistry than the control group students ($\overline{X}$ (CG) = 36.62, $\overline{X}$ (EG) = 46.88).

5.2.5 Null Hypothesis 5

The sixth hypothesis stated that there is no significant difference between the means of males and females' with respect to attitudes toward science as a school subject. To test this hypothesis, two-way analysis of variance (ANOVA) was used. The assumptions of ANOVA were checked before conducting the analysis.

The first assumption of ANOVA was univariate normality. It was seen from the skewnees and kurtosis values in the attitudes towards chemistry scores were normally distributed.

The second assumption was independence of observation within and between groups. It was supposed that the test was conducted in standard conditions and there was no interaction within and between groups during the conducting of test.

The third assumption was the equal of variances. The Levene's Test of Equality was used to check this assumption. The result indicated that the equality of variance assumption was met F (3, 68) = .960, p>.05 as seen in Table 5.9.

After checking all assumptions ANOVA was conducted. As representing in Table 5.10, the results demonstrated that there was not a significant mean difference between post-test mean scores of females and males with respect to their attitudes towards chemistry as a school subject $F(1, 68) = .527$.

5.2.6 Null Hypothesis 6

The seventh hypothesis stated that there is no significant effect of interaction between gender and treatment on students‟ attitudes towards chemistry as a school subject. This hypothesis was tested by using ANOVA. Table 5.10 also showed the interaction effect on attitudes towards chemistry as a school subject. The results represented that there was no significant interaction effect between gender and treatment on students' attitudes toward chemistry as a school subject, $F(1, 68) = 3.195$, $p > .05$.

5.3 Students' Interviews about Chemical Bonding

Interviews were conducted to confirm reliability of the study and get more information about students 'conceptions in chemical bonding. Semi-structured individual interviews were applied with six students from experimental group and six students from control groups based on their post-test results after treatment in the class environment. Moreover, six students from experimental group also interviewed about cooperative work experiences.

In the first question, students were asked to how they could define chemical bonding. All the students from experimental group defined the chemical bonding correctly. However, most of the students except high achievers from control group had difficulties while explaining the chemical bonding. For example, a middle achiever student from control group said that the chemical bonding was a thing that sticks the elements together. When the thing was asked, the student could not explain. Also, he used “stick” term based on molecular diagrams on textbooks instead of forces of attraction. Another middle achiever said that the chemical bonding was occurred by atoms to provide only octet rule. The low achievers even could not define the chemical bonding. They knew some knowledge like octet rule, stability etc. but this knowledge was not enough to define the chemical bonding. According to this question, four students answered the question inadequately in the control group while all the students answered correctly in the experimental group.

In the second questions, students were asked to how they could compare the ionic and covalent bonding. Most of the students from experimental group gave the correct comparison except low achiever. His interview was conducted as follows:

A low achiever: Ionic bonding was occurred between metal and nonmetal but covalent bonding was occurred between two non-metals. Also, ionic bonding was took place with electron transfer while covalent bonding was took place with sharing of electrons.

Interviewer: What else? Can you compare the structure of ionic and covalent compound?

A low achiever: They were molecular structure

Interviewer: What about their states at room temperature?

A low achiever: Both ionic and covalent compounds stated as liquid, solid or gaseous at room temperature

Interviewer: How were their melting and boiling point?

A low achiever: Ionic compound had high melting and boiling point while covalent compounds had low melting and boiling point

The high achievers students from control groups compared exactly. However, middle and low achievers students had some misconceptions. It was seen that they did not understand the ionic and covalent bonding properly. They could compare which elements form ionic or covalent bonds. However, they could not compare the formation of ionic or covalent bonding, the structure of compounds or their melting and boiling point. As concern second question, five students gave correct explanations in the experimental group while two students answered correctly in the control group.

With regard to third question, students were asked to how they could explain the polar and nonpolar covalent bonds. Many of the students from control group and even two students from experimental group did not give exact explanation of question. Some of them had a misconception that equal sharing took place all covalent bonds and could not describe polar bonds. Some of them could explain that when same atoms formed covalent bonds, bonds were nonpolar and when different atoms formed covalent bonds, bonds were polar. However, they could not explain the reason of their explanations. They only memorized the knowledge. They could not talk about electronegativity of atoms. They knew that the formation of covalent bonding was occurred by electron sharing. However, the word “sharing “often considered to its social meaning and refer to “equally”. The example of this interview as follows:

Interviewee: Polar covalent bonds formed when different atoms covalently bonded and nonpolar covalent bonds formed when same atoms covalently bonded.
Interviewer: Ok. That was true. Why these occur?
Interviewee: Nonbonding electrons repelled the bonding electrons and determine the position of electrons and polarity of bonds.

Four students from experimental group could explain the polar and nonpolar covalent bonds exactly while one student from control group could explain that.

As concerns last question, students were asked to put in order hydrogen fluoride, sodium chloride, and hydrogen chloride according to their boiling point. One of the low achiever from experimental group interview as follows:

Interviewee: The boiling point of sodium chloride was the highest. Hydrogen chloride was higher than hydrogen fluoride.

Interviewer: Why did you put in order like that?

Interviewee: Because broken of bonds of sodium chloride was the most difficult. Then, broken of bonds of hydrogen chloride was more difficult than hydrogen fluoride.

Interviewee: Why?

Interviewer: Because sodium chloride was solid, hydrogen chloride was liquid and hydrogen fluoride was gaseous state.

The high achiever from control group interview as follows:

Interviewee: The boiling point of hydrogen fluoride was the highest. Hydrogen chloride was higher than sodium chloride

Interviewer: Why did you put in order like that?

Interviewee: Hydrogen fluoride has hydrogen bonding so it has the highest boiling point. Then, hydrogen chloride has dipole-dipole interaction so it has higher boiling point than sodium chloride.

Interviewer: What about sodium chloride?

Interviewee: It has only ionic bonding so it has least boiling point.

As mentioned above, many students even high achiever from control group had misconceptions. However, two students, which were low achievers from experimental group, had some difficulties while explaining the question. Some of the students thought that the boiling point depends on broken of bonds. Some of them considered that the strength of intermolecular forces only depends on strength of the covalent bonds. Some of them could not compare the boiling point of ionic compounds and covalent compounds. Four students from experimental group gave exact ordering and explanation to question while one student from control group did.

5.4 Students' Interviews about Cooperative Learning

Students from experimental group also interviewed about their perceptions about cooperative work based on conceptual change conditions. The interviews were conducted after treatment. The interview questions were related to how the treatment affects students' learning, students' motivation, and students' attitude towards chemistry and teacher's role in the treatment. The questions were presented in Table 5.11.

Table 5.11 Questions of Interview about Perceptions of Students about Treatment

Questions
1. What is the opinion about cooperative work based on conceptual change?
2. What are the weak and strong sides of cooperative work based on conceptual change?
3. Are there any differences in your attitude toward chemsitry lessons with cooperative work based on conceptual change?
4. How the cooperative work is based on conceptual change affect your learning?
5. How is the teacher role in the cooperative work based on conceptual change?
6. Do you want to make this instruction again in following lessons? Why?

According to students' interviews, all of the students said that they like to study with cooperative work. They thought that group work provided to show their deficiency about the concept at the beginning of the work. During the group work, they felt they should help their friends to achieve same goal for success of group. They also said that their learning motivation increase with group work. With regard to their learning, they said that they learned better with group work than learning alone because they could share their ideas and knowledge with their friends. Moreover, they said that the group work helped their understanding of reasons about chemical bonding concepts. Some of the students also said that they hesitated to ask questions to teacher but they could comfortably ask questions their friends. Also, they considered that their communication skills also improved with group work. Some of the students said that they liked chemistry lesson with group work in spite of disliking chemistry lessons. With the question about teacher's role, students said that teacher walked around and visited their group during cooperative work. They thought that teacher guided them in some troublesome concepts asking some questions. Besides, they thought that they had better interaction with teacher than traditional instruction. At the end of the interview, the students were asked to whether they wanted to make group work again in following lessons or not. Majority of students said that they wanted to make group work again because they thought that they learned better then learning alone.

Apart from positive perceptions, only one of the high achiever student said that I was the most successful student in the group so I had to help others but I did not learn from my friends. So I would rather prefer to study alone. Also, she said that there was noise in group and this disturbed me.

One of the examples of these interviews as follows:

Interviewee: What is the opinion about cooperative work based on conceptual change?

Interviewer: I like to study with group work

Interviewee: Why do you like it?

Interviewer: Because I recognized some deficiencies about chemical bonding concept while studying with my friends. Also, my friends helped me about handling these deficiencies.

Interviewee: What are the weak and strong sides of cooperative work based on conceptual change?

Interviewer: I think that there was no negative side of group work. But it has many strong sides. For example; I learned better with group work. Also, group work increased my learning motivation. I believe that interaction with my friends and teacher improved.

Interviewee: Are there any differences in your attitude toward chemsitry lessons with cooperative work based on conceptual change?

Interviewer: Actually, I already like chemistry lesson and I like much with group work

Interviewee: How is the cooperative work based on conceptual change effect your learning?

Interviewer: I learned better in group work with the help of my friends. Also, I believe that I learned deeply because I learned the reasons of some concepts.

Interviewee: How is the teacher role in the cooperative work based on conceptual change?

Interviewer: Teacher guided us by asking questions and directed us to some important points

Interviewee: How is the teacher interaction? Is traditional instruction or this method better?

Interviewer: I think this method is better because teacher walked around and visited all group. Teacher communicated all of us and answered our questions.

Interviewee: Finally, do you want to make this instruction again in following lessons? Why?

Interviewer: Yes, I want to make again. Because I believe that this method is more useful for me to learn.

5.5 The Classroom Observations

The classroom observation was done by the researcher by sitting on the back in the classroom silently and taking notes based on instruction conditions to ensure treatment verification. Both experimental and control groups were observed with the different aims. The experimental group was monitored to observe interaction of student-student in group work, interaction of teacher-student, and participation of students to group work and classroom environment, that is; conditions of cooperative work based on conceptual change. However, the control group was monitored to observe traditional instruction method.

The treatment was conducted over six weeks in a public school in Ankara. The researcher attended all 45 minutes courses in both groups. Both groups were instructed same teacher with same curriculum.

In the experimental group, students were instructed with cooperative learning based on conceptual change approach. This instruction included four parts. In the first part, there was a teacher presentation. Second and important part was group work. While generating groups, there was some noise in the classroom. The teacher experienced some classroom management problems. After making groups, quite atmosphere of classroom was achieved. At the beginning of the group work, some students had little contribution to group study. These students were encouraged by the teacher with asking some questions. In the following lessons, interaction of student-student in group work, interaction of teacher-student, and participation of students to group work were much better according to first week. All students participated to group work, asked questions to their friends and teacher. During the treatment, the teacher walked around, visited all groups, and asked some questions as required. Also, she guided properly while the students studying on worksheet.

In the control group, the students were instructed with traditional method. She used lecturing method at the beginning of lesson. While explaining the concepts, she tried to generate discussion environment. However, she did not interact with students adequately. So, many students talked with each other while teacher explaining concepts. After lecturing, she gave worksheet to students to make individually. With the end of worksheet, she answered questions of worksheet but she never mentioned misconceptions or previous knowledge of students. She only answered question on the blackboard. Thus, she lost the control of classroom many times. Students' motivation to participate learning activity was very low compared to experimental group.

According to classroom observation results, cooperative learning based on conceptual change approach was more effective than traditional method. The students were more motivated, more activated and more eager to learn in cooperative learning based on conceptual change approach than traditional method.

5.6 Conclusions

Based on results of analyses, the following conclusions can be reached:

1. The cooperative learning based on conceptual change approach caused a significantly better acquisition of scientific conceptions related to chemical

bonding concepts and elimination of misconceptions than the traditionally designed chemistry instruction.

2. The cooperative learning based on conceptual change approach caused a significantly better achievement in chemical bonding concepts than the traditionally designed chemistry instruction.

3. There was no significant effect of gender on students' understanding of chemical bonding concepts, students' achievement in chemical bonding concepts and students' attitudes toward chemistry.

4. The cooperative learning based on conceptual change approach caused more positive attitudes toward chemistry as a school subject than the traditionally designed chemistry instruction.

CHAPTER 6

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

In this chapter, the summary of the study, discussions based on results, implications of the results and some recommendations for further studies were came out.

6.1 Summary of the Study

At the beginning of the study, the misconceptions of students on chemical bonding were investigated in literature. Based on the investigation of misconceptions, chemical bonding concept test was prepared. Apart from misconceptions, cooperative learning and conceptual change approach also were investigated in literature. After literature search, learning activities, worksheet and lesson plans were prepared.

The main purpose of this study was to search the effectiveness of cooperative learning based on conceptual change approach on 9^{th} grade students understanding of chemical bonding concept and attitude toward chemistry as a school subject. The study consisted of 72 ninth grade students from two intact classes of a chemistry course. One of the classes was assigned as experimental and the other one was control group. The experimental group included 35 students while the control group included 37 students. The experimental group was instructed by cooperative learning based on conceptual change approach and the control group was instructed by traditional instruction. The study was conducted over six weeks.

Before conducting the study, CBCT, ASTC, and SPST were given to both groups as pre-tests to examine whether there were differences between two groups. T-test analysis was used to analysis of the results of pre-tests. As seen from these analyses, there was no significant difference between two groups in terms of their understanding of chemical bonding concept, attitude toward chemistry and science skill process at the beginning of the study. After pre-tests, the treatment was applied. Then, students' interviews were done in two groups to get more information about students 'conceptions in chemical bonding. Besides, only some experimental group students were interviewed to about their perceptions about cooperative work based on conceptual change condition. To investigate the effect of treatment, CBCT and ASCT were administered as post-tests for both groups. MANOVA and two-way ANOVA were used to analyze the results.

6.2. Discussion

The term of "misconception" was emerged when the scientific community found that students' understandings could not consistent with the scientifically accepted ones (Fensham, 1972; McCloskey, 1988). Students' ideas altered gradually as they experienced new knowledge and ideas in higher grades. However, as the years passing there were still differences between students' ideas and what they were taught by science (De Posada, 1997). Also, these misconceptions prevented students to learn new concepts and develop new scientific ideas. This awareness cause many studies on misconceptions in many different fields such as chemistry, physics, mathematics etc.

Then, many educational researchers tried to proposed new ideas to handle these misconceptions. The *conceptual change* was introduced as a new approach to overcome these misconceptions (Posner, 1982). There are many studies in many different fields about application of conceptual change to rectify misconceptions.

Based on literature, conceptual change was a successful instruction method to increase students' understanding and help students handle their misconceptions. It could be used many abstract and difficult concepts in chemistry education. Furthermore, conceptual change approach was combined with other learning strategies to provide more effectiveness in learning. For this reason, it was decided that conceptual change can be used with other successful learning method such as cooperative learning. In literature, there have been many studies in both conceptual change and cooperative learning. However, the combinations of these two successful learning methods are rare. Even, there is no research about effect of conceptual change and cooperative learning together in chemical bonding concepts.

It was seen from literature, students had many misconceptions in chemistry. The microscopic world of chemistry was the primary reason of this. Because students could not be experience this world in their daily lives. There are many abstract and microscopic level concepts in chemistry like chemical bonding. Chemical bonding is the core of chemistry curriculum because understanding nature of matters needs understanding of chemical bonding. Also, it relates different scientific area topic such as forces that has difficult and abstract concepts in physics. Thus, chemical bonding is considered by students, teachers, and chemists to be a very complex concept in the literature (Gabel, 1996; Levy Nahum, 2007, Taber, 1998, 2001). Furthermore, Teichert and Stacy (2002) claimed that chemical bonding is taught by traditional instruction problematically and understood incorrectly. Therefore, many students could not understand the nature of bonding and they hold many misconceptions. For instance; they thought that chemical bonding is only simple connections and they could not explain exactly what the chemical bonding is. Thus, new instruction method about chemical bonding should be developed to handle misconceptions and provide a deep understanding of concept. Therefore, the main purpose of this study was to investigate the effectiveness of cooperative learning based on conceptual change approach on 9^{th} grade understanding of chemical bonding.

According to statistical analysis results, it was concluded that cooperative learning based on conceptual change approach caused a significantly better acquisition of scientific conceptions related to chemical bonding and elimination of misconceptions than traditionally designed chemistry instruction.

In this study, cooperative learning based on conceptual change approach was applied in the experimental group. The main objectives of instruction were disclosing students' misconceptions, displacing them with scientific conceptions, and associating their previous conceptions with new concept. At the beginning of the lesson, the presentation of teacher which was the first part of cooperative learning method (STAD) was achieved. Then, each student was assigned to four members groups. To activate students' prior knowledge and misconceptions, the worksheet was given to students. They discussed, shared, and compared their preconceptions with their friend during worksheet, that is, they saw different views of friends. This could provide *dissatisfaction* that is the essential step of conceptual change. During students' studying on worksheet, students made some simple explanations to friends due to responsibility of learning of each other that is the main point of cooperative learning. This could provide *intelligibility* that is the second step of conceptual change. After peer discussions, the teacher gave detail explanations by using analogies. This also created *intelligibility* for students. While explanation, teacher gave some clear examples about concept. This strategy provided students to understand concept and students considered that the concept was reasonable and consistent with other knowledge. With this awareness, *plausibility* step that is the third step took place. After explanations and examples, students generalized their knowledge to other conditions while working on worksheet. They noticed the availability of new concept. Also, the teacher solved new problems different from worksheet. This fact corresponded with *fruitfulness* step that is the last step of conceptual change.

On the other hand, the control group was instructed by traditional designed chemistry instruction. She presented the concept on the board based on lecturing method. Then, she wrote some important parts of concept on the board while students only sitting and writing the board on their notebooks. After explaining the concepts, she distributed the worksheet. The students worked on worksheet alone. When students had some questions, she explained the concept without considering students' prior knowledge and their misconceptions. The students were only passive listeners. The teacher played the active role and transmitted facts to the students. When the students did not understand the some part of concept, the teacher gave extra and direct explanations that did not lead students use problem-solving skills or higher-order thinking.

In the experimental group, the social interaction was prerequisite for cooperative learning. The main point of cooperative learning is student-student and teacher-student interactions. After teaching, the worksheet was done by group work. This study included discussions about problems, helping each other for understanding, correcting any misunderstanding. These discussions also provided awareness of their misunderstandings and their friends' ideas. Therefore, these discussions cause students to change their present ideas with scientific ones. Also, more meaningful learning was achieved by students' interactions (McManus and Gettinger, 1996). In short, students' active participation that was increased by treatment may cause higher students' understanding of chemical bonding concepts and handling their misconceptions. However, the students in the control group were passive learners, not actively involved in learning process and not aware their misconceptions. In the control group, there was a modest interaction between teacher and students. They did not have opportunity to aware of other's views and misconceptions or discuss their misunderstandings. This might cause a low degree of understanding of control group students and they were not as successful as students in the experimental group.

Traditionally designed chemistry instruction mainly based on teacher-centered. Teacher plays an active role in the learning process but students are passive listeners. Thus, students make only memorization such as definition of bond or types of bonds but they are unable to deep understanding. They can't explain why or how the chemical bonding occurs. However, cooperative learning based on conceptual change approach provided deeper understanding, awareness of misunderstanding and meaningful learning. Students could discuss and critize their knowledge with their peers. This might lead to different score of control and experimental group students in the concept test.

As this study, the effectiveness of conceptual change and cooperative learning were investigated in literature (Basili &Sanford, 1991; Bilgin & Geban, 2006; Geban & Ertepınar, 2012 and Kırık & Boz, 2012). Basili and Sanford investigated the effects of conceptual change strategies and cooperative group work about the laws of conservation of matter and energy, and the particulate nature of gases, liquids, and solids to overcome misconceptions in their case study. Bilgin and Geban used same method to dispel students' misconceptions on understanding chemical equilibrium. Also, Geban and Ertepınar applied conceptual change and cooperative learning instruction on 4th grade students' understanding of earth and sky concepts. Lastly, Kırık and Boz investigated cooperative learning instruction for conceptual change in the concepts of chemical kinetics. These studies concluded that the combination of conceptual change and cooperative learning method is an effective instructional method for increasing understanding of concepts and reducing the number of misconceptions. The results of this study also support their findings. The findings of this study also consistent with the finding of Lonning's (1993) study that cooperative learning strategies increase conceptual change instruction.

On the other hand, it was also found that even the some experimental group students still had some misconceptions in chemical bonding after treatment in spite of effectiveness of cooperative learning based on conceptual change approach. This finding was in agreement with the studies that students' misconceptions were robust and resistant to change (Novak, 1988; Boujaoude, 1991 and Taber, 2001). It was seen from interviews that the most common misconception was related to octet rule. Many students considered that the main reason for chemical bonding was to achieve octet rule and fill outer shells. Taber (2003) described those misconceptions as the octet framework.

Apart from interview about the chemical bonding, the experimental group students also interviewed about cooperative learning based on conceptual change approach. Interviews showed that this treatment provided student- student and teacher-student interaction and cause many discussion mediums. These discussions contributed students to share their ideas and knowledge, related their prior knowledge with new concept and develop their knowledge effectively. Thus, students learned the chemical bonding concept easily. Moreover, this treatment not only improved students understanding about chemical bonding but also increased their social abilities. Based on interviews, students believed that this treatment help their learning, increased their learning motivation and enjoyed while working in group. In the light of these interviews, it can be said that cooperative learning based on conceptual change approach help students' learning and increased their social skills. The findings of interviews were also consistent with literature (Acar and Tarhan 2008; Johnson and Johnson 1990; Slavin 1996).

Another aim of the this study was to examine whether there was a significant difference between male and female in terms of their understanding of chemical bonding concept. It was found that there was no significant difference between male and female in terms of their understanding of chemical bonding concept. This finding supported some researches that gender difference was not effective in understanding of concepts (Azizoglu, 2004; Greenfield, 1997; Cakır, 2002, Uzuntiryaki, 2003). On the other hand, some of the researchers found contradictory results that gender differences were effective in understanding chemistry concepts (Chambers and Andre, 1997; Cetin, 2009). Furthermore, it was found that there was no significant effect of interaction between gender and treatment on students" understanding in chemical bonding.

It was known that students' conceptions and attitudes were important in their learning; our other purpose was to investigate the effect of cooperative learning based on conceptual change approach on students' attitudes toward chemistry. The results demonstrate that cooperative learning based on conceptual change approach was more effective than traditionally designed chemistry instruction in terms of students' attitude toward chemistry. These results were also supported by classroom observations and students' interviews. During the treatment it was observed that students in the experimental group were more willing to discuss, eager to learn and enjoy while learning. Besides, student' interviews proved this finding obviously. They said that they liked the treatment and enjoyed while learning. Even some students said that they disliked chemistry lesson but they liked it with this treatment. This instruction model encouraged students to involve active learning. They also liked sharing their ideas with friends, helping with each other and discussed together. As mentioned before, this treatment increased students' motivation and social skills. Thus, their attitudes' toward chemistry were positively affected. Besides, in this positive contribution to attitude, teacher's role should not be forgotten. Teacher's guidance and greater communication were very effective in this contribution. In literature, there were many researches to support this finding (Sungur and Tekkaya, 2003; Uzuntiryaki, 2003, Cetin, 2009).

The effect of gender with respect to students' attitudes toward chemistry was examined in this study. It was found that there was no significant mean difference between male and female students with respect to their attitudes toward chemistry as a school subject. Moreover, the results showed that there was no significant interaction effect between gender and treatment with respect to students' attitudes toward chemistry as a school subject. There were many researches that support no gender effect (Uzuntiryaki, 2003, Cetin, 2009; Kaya, 2011). However, some researches also contradictory results about gender effect on attitude (Barnes, 2005; Simpson and Oliver, 1985).

To conclude, this study showed that cooperative learning based on conceptual change approach provide better understanding of chemical bonding concepts. The treatment causes students to have deeper understanding and meaningful learning and awareness of their misunderstanding. Also, it leads significant interaction between student-student and teacher-student. Thus, it causes students to increase positive attitudes toward chemistry.

6.3 Implications

According to findings and results of study, the below implications are proposed:

1. The misconceptions are very important in students' learning and understanding. They can block the learning of new knowledge and concepts. Thus, teachers should be aware of students' misconceptions

while preparing teaching strategies. They should identify students' misconceptions before instruction. Based on this identification, they should design lesson to handle these misconceptions.

2. Well-prepared cooperative learning based on conceptual change approach can make happen significantly better learning of new knowledge and remediation of misconceptions.
3. Cooperative learning based on conceptual change approach also increase students' motivation and social skills.
4. Teachers should be informed about cooperative learning based on conceptual change approach. They can use this instruction in planning and designing teaching process.
5. Curriculum designer should be informed about cooperative learning based on conceptual change approach. They can use this method while designing and preparing chemistry curriculum.
6. Instruction of chemical bonding concepts should involve student-student and teacher-students discussions, active participation of students and cooperative learning.
7. The one of the purpose of chemistry education is to increase positive attitude toward chemistry because of the relationship between attitude and learning. Thus, teachers can use cooperative learning based on conceptual change approach to increase students' attitude toward chemistry.
8. Students have many difficulties in learning chemical bonding concepts because of its microscopic level and abstract concepts. So, new teaching strategies may help students overcome this obstacle.

6.4 Recommendations

According to results, the following recommendations are suggested for further researches:

1. The effect of cooperative learning based on conceptual change approach can be conducted different topics and different grades.
2. To generalize the results, the similar studies can be applied in different schools with larger sample size.
3. The effectiveness of cooperative learning based on conceptual change approach can be investigated in students' understanding and achievement other chemistry concepts.
4. Further studies can be conducted to investigate the effectiveness of conceptual change approach with other teaching strategies in students' learning and handling students' misconceptions.
5. The effectiveness of cooperative learning with other methods can be investigated in students' understanding and achievement.
6. Apart from attitude, other issues such as motivation or self-efficacy can be investigated in further studies.

REFERENCES

Acar B., & Tarhan L. (2008) Effects Of Cooperative Learning On Students' Understanding Of Metallic Bonding, *Research in Science Education*, 401-420.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York: Holt Rinehart, and Winston, Inc. Aronson, E., Blaney, N., Stephin, C, Sikes, J. & Snapp, M. (1978). The jigsaw classroom. Beverly Hills, CA: Sage Publishing Company

Azizoglu, N. (2004). *Conceptual change oriented instruction and students' misconceptions in gases*. Unpublished doctoral dissertation, Middle East Technical University, Ankara, Turkey.

Barnes, G., McInerney, D. M., & Marsh, H. W. (2005). Exploring sex differences in science enrolment intentions: An application of the general model of academic choice. *Australian Educational Researcher*, 32(2), 1-23.

Baser, M., & Geban, O. (2007). Effectiveness of conceptual change instruction on understanding of heat temperature concepts. *Research in Science and Technological Education*, 25(1), 115-133.

Basili, P. A., & Sanford, J. P. (1991). Conceptual Change Strategies and Cooperative Group Work in Chemistry. *Journal of Research in Science Teaching*, 28(4), 293-304.

Bilgin, İ., & Geban, Ö. (2006) The Effect of Cooperative Learning Approach Based on Conceptual Change Condition on Stundents' Understanding of Chemical Equilibrinm Concepts. *Journal of Science Education and Technology*, 15(1), 31-46

Birk, J.P., & Kurtz, M.J. (1999). Effect of experience on retention and elimination of misconceptionsabout molecular structure and bonding. *Journal of Chemical Education*, 76(1), 124-128.

Boo, K.H. (1998). Students' understandings of chemical bond and the energetics of chemical reactions. *Journal of Research in Science Teaching*, 35(5), 569-581.

Bodner, G. M. (1986). Constructivism: A theory of knowledge. *Journal of Chemical Education*, 63, 873-878.

BouJaoude, S. (1991). A study of the nature of students' understandings about the concept of burning. *Journal of Research in Science Teaching*, 28(8), 689-704.

Butts, B. and Smith, R. (1987). HSC chemistry students' understanding of the structure and properties of molecular and ionic compounds. *Research in Science Education*, 17, 192-201.

Cakir, O. S., Uzuntiryaki, E., & Geban, O. (2002). Contribution of conceptual change texts and concept mapping to students' understanding of acids and bases. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, New Orleans, LA.

Caramaza, A., McCloskey, M., & Green, B. (1981). Naive beliefs in "sophisticated" subjects: Misconceptions about the trajectories of objects. *Cognition*, 9(2), 117-123.

Carey, S. (2000). Science education as conceptual change. *Journal of Applied Developmental Psychology*, 21, 13-19.

Cetin, P. S. (2009). *Effects of conceptual change oriented instruction on understanding of gases concepts*. Unpublished doctoral dissertation, Middle East Technical University, Ankara, Turkey

Ceylan, E., & Geban, Ö. (2009). "Facilitating Conceptual Change in Understanding State of Matter and Solubility Concept Sbyusing 5E Learning Cycle Model", *Hacettepe University Journal of Education*, 36: 41-50.

Chang, C. (2002). Does computer assisted instruction + problem solving = Improved science outcomes? A pioneer study. *Journal of Educational Research*, 95 (3) 143-150.

Chambers, S. & Andre, T. (1997). Gender, prior knowledge, interest, and experience in electricity and conceptual change text manipulations in learning about direct current. *Journal of Research in Science Teaching*, 34(2), 107-123.

Chi, M. T. H., Slotta, J. D., & de Leeuw, N. (1994). From things to processes: A theory of conceptual change for learning science concepts. *Learning and Instruction*, 4, 27-43.

Coll, R. K., & Treagust, D. F. (2001). Learners' mental models of chemical bonding. *Research in Science Education,* 31(3), 357-382.,

Coll, R. K. & Taylor, N. (2001). Alternative conceptions of chemical bonding held by upper secondary and tertiary students. *Research in Science and Technological Education*, 19(2), 171-191.

Courtney, D.P., Courtney, M., & Nicholson, C. (1992). The effect of cooperative Learning as an instructional practice at the college level. *College Students Journal*, 28(4), 471-477

De Posada, J. M. (1997). Conceptions of high school students concerning the internal structure of metals and their electric conduction: structure and evolution, *Science Education*, 81, 445-467.

Driver, R. & Easley, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent science students. *Studies in Science Education*, 5(1), 61-84.

Driver, R., & Oldham, V. (1986). A constructivist approach to curriculum development in science. *Studies in Science Education*, 13, 105-122.

Duit, R., & Treagust, D. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education*, 25, 671-681.

Ebenezer, J. V., & Fraser, D. (2001). First year chemical engineering students' conceptions of energy in solution process: Phenomenographic categories for common knowledge construction. *Science Education*, 85, 509-535.

Edwards, K.S., & Devries, D.L., (1974), "*The effects of Teams-Games-Tournaments and two structural variations on classroom process, student attitudes and student achievement*", Report #172, Center for Social organization of Schools", The Johns Hopkins University.

Fisher, KN, & Lipson, J., (1985) 'Information processing interpretation of errors in college science learning', *Instructional Science* (14), 49-74.

Gabel, D.L. (1993).Use of particle nature of matter in developing conceptual understanding. *Journal of Chemical Education*, 70, 193-194.

Geban, Ö., Askar, P. and Özkan, S. (1992). Effects of computer simulated experiments and problem solving approaches on high school students. *Journal of Educational Research*, 86, 5 - 10.

Geban, Ö., Ertepınar, H., Yılmaz, G., Altın, A. and Sahbaz, F. (1994). *Bilgisayar destekli eğitimin öğrencilerin fen bilgisi başarılarına ve fen bilgisi ilgilerine etkisi*. I. Ulusal Fen Bilimleri Eğitimi Sempozyumu: Bildiri Özetler Kitabı, s:1 - 2, 9 Eylül Üniversitesi, İzmir

Gilbert, J. K., Osborne, R. J., & Fensham, P. J. (1982). Children‟s science and its consequences for teaching. *Science Education*, 66(4), 623-633.

Greenfield, T. A. (1997). Gender and grade level differences in science interest and participation. *Science Education*, 81(3), 259-276.

Groves, F. H., & Pugh, F. (2002). Cognitive illusions as hindrances to learning complex environmental issues. *Journal of Science Education and Technology*, 11, 381-390.

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

Harrison, A. G., & 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(3), 352-381.

Hewson, P. W. & Hewson, M. G. (1988). An appropriate conception of teaching science: a view from studies of science learning. *Science Education*, 72(5), 597-614.

Hewson, P. W. (1982). A case study of conceptual change in special gravity.The influence of prior knowledge in learning. *European Journal of Science Education*, 4, 61 - 78.

Hewson, P. W. & Thorley, N. R. (1989). The conditions of conceptual change in the classroom. *International Journal of Science Education*, 11(5), 541-553.

Hewson, P. W. (1981). A conceptual change approach to learning science. *European Journal of Science Education*, 3(4), 383-396.

Hewson, P. W. (1991). *Conceptual change instruction.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Fontane, WI.

Hewson, M. G. & Hewson, P. W. (1983). Effect of instruction using students" prior knowledge and conceptual change strategies on science learning. *Journal of Research in Science Teaching*, 20(8), 731-743.

Hewson, P. W. & Hewson, M. G. (1984). The role of conceptual conflict in conceptual change and the design of instruction. *Instructional Science*, 13(1), 1-13.

Henderleiter, J., Smart, R., Anderson, J., & Elian, O. (2001). How Do Organic Chemistry Students Understand and Apply Hydrogen Bonding? *Journal of Chemical Education*, 78(8), 1126-1130.

Hynd, C. R., & Alvermann, D. E. (1986). The role of refutation text in overcoming difficulty with science concepts. *Journal of Reading*, 29, 440-446.

Hynd, C.R., McWhorter, J.Y., Phares,V.L. & Suttles, C.W. (1994). The role of instruction in conceptual change in high school physics topics. *Journal of Research in Science Teaching*, 31, 933-946

Hynd, C., Alvermann, D., and Qian, G. (1997). Preservice elementary school teachers' conceptual change abaut projectile motion: refutation text, demonstration, affective factors and relevance. *Science Education*, 81, 1-27.

Johnson, D. W., & Johnson, R. T.(1989). Social skills for successful group work. *Educational Leadership*, 47(4), 29-33.

Johnson, D. W., & Johnson, R. T. (1992). Implementing cooperative learning. *Contemporary Education*, 63, 173-180.

Johnson, D. W., & Johnson, R. T.(2000). The eight steps of ensuring diversity is aresource. *Newsletter of the Cooperative Learning Institute*, 15(1).

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (1994). *Cooperative learning in the classroom*. Alexandria, VA: Association for Supervision and Curriculum Development.

Johnson, D. W., Johnson, R., & Holubec, E. (1998). *Cooperation In The Classroom* (6th Edition). Edina, MN: Interaction Book Company.

Kaya, E. (2011) *The effect of conceptual change based instruction on students 'understanding of rate of reaction concepts,* Unpublished doctoral dissertation, Middle East Technical University, Ankara, Turkey

Kırık, Ö., & Boz, Y. (2012) Cooperative learning instruction for conceptual change in the concepts of chemical kinetics. *Chemistry Education Research and Practice*, 13, 221–236

Kiboss, J.K., 2002, Impact of a computer-based physics instruction program on pupils' understanding of measurement concepts and methods associated with social science: *Journal of Science Education and Technology*, 11, 193-198.

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

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

Levy Nahum, T. (2007). *Teaching the concept of Chemical Bonding in high-school: Developing and implementing a new framework based on the analysis of misleading systemic factors*. Unpublished Doctoral Dissertation, TheWeizmann Institute of Science, Rehovot (In Hebrew).

Lindauer, P., & Petrie, G., (1997). A review of a cooperative learning: An alternative to everyday instructional strategies, *Journal of Instructional Psychology*, 24(3), 183-187.

Lonning, R.A.Effect of cooperative learning strategies on student verbal interactions and achievement during conceptual change instruction in 10th grade general science. *Journal of Research in Science Teaching*, 30(9), 1087-1101.

McCloskey, M. (1983). Intuitive physics. *Scientific American*, 248(4), 122-130.

McManus, S., & Gettinger, M. (1996). Teacher and student evaluations of cooperativelearning and observed interactive behaviors. *The Journal of Educational Research*, 90, 13-22.

Morgil, İ., Özyalçın Oskay, Ö.,Yavuz, S. & Arda, S. (2003). The Factors that Affect Computer-assisted Education Implemenations in the Chemistry Education and Comparison of Traditional and Computer Assisted Education Methods in Redox Subject", *The Turkish Online Journal of Educational Technology*, 2, 4.

Muir-Herzig, R. G. 2004. Technology and its impact in the classroom. *Computers and Education*, 42 (2), 111-131.

Nakhleh, M. B. (1992). Why some students don't learn chemistry. *Journal of Chemical Education*, 69(3), 191-196.

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

Niaz, M., (2002). Facilitating conceptual change in students' understanding of electrochemistry. *International Journal of Science Education*, 24, 425-439.

Novak, J. D. (1988). Learning science and the science of learning. *Studies in Science Education*, 15(1), 77-101.

Novak, J.D. (2002). Meaningful learning: the essential factor for conceptual change in limited or appropriate propositional hierarchies (LIPHs) leading to empowerment of learners. *Science Education*, 86(4), 548-571.

Okey, J. R., Wise, K. C. and Burns, J. C. (1982). *Integrated Process Skill Test*, Department of Science Education, University of Georgia, Athens, GA, 30602).

Okşan, Ç., Sevgi, İ., Ertepınar, H., & Geban, Ö. (2012) The effect of the conceptual change oriented instruction through cooperative learning on 4th grade students' understanding of earth and skyconcepts. *Science Education International*, 23(1), 84-96.

Othman, J., Treagust, D. F., & Chandrasegaran, A. L. (2008). An investigation into the relationship between students‟ conceptions of the particulate nature of matter and their understanding of chemical bonding. *International Journal of Science Education*, 30(11), 1531- 1550.

Özkaya, A. R., Üce, M., Sarıçayır, H. & Şahin, M. (2006). Effectiveness of a Conceptual Change-Oriented Teaching Strategy to Improve Students' Understanding of Electrochemistry Concerning Galvanic Cells. *Journal of Chemical Education*, 83, 17-19.

Özmen, H. (2004). Some student misconceptions in chemistry: A literature review of chemical bonding. *Journal of Science Education and Technology*, 13, 146-159.

Peterson, R. F., & Treagust, D. F. (1989). Grade 12 students' misconceptions of covalent bonding and structure. *Journal of Chemical Education*, 66(6), 459-460.

Peterson, R. F. & Treagust, D. F. (1989). Grade-12 students' misconceptions of covalent bonding and structure, *Journal of Chemical Education*, 66, 459-460.

Peterson, R., Treagust, D., & Garnett, P. (1986). Identification of secondary students misconceptions of covalent bonding and structure concepts using a diagnostic instrument. *Research in Science Education*, 16, 40-48.

Peterson, R. F., Treagust, D. F., & Garnett, P. (1989). Development and application of a diagnostic instrument to evaluate grade-11 and -12 students' concepts of covalent bonding and structure following a course of instruction. *Journal of Research in Science Teaching*, 26(4), 301-314.

Peterson, S. E. & Miller, J. A. (2004). Comparing the quality of students' experiences during cooperative learning and large-group instruction, *The Journal of Educational Research*, 97(3), 123 – 133.

Posner, G. J., Strike, K. A, Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66(2), 211-227.

Rompayom,P., Tambunchong,C., Wongyounoi S.,& Dechsri P.(2011). *Using Open-Ended Questions to Diagnose Students' Understanding of Inter- and Intramolecular Forces*. US-China Education Review B1, 12-23.

Sanger, M. J. & Greenbowe, T.J. (1997). "Common Student Misconceptions in Electrochemistry: Galvanic, Electrolytic, and Concentration Cells." *Journal of Research in Science Teaching*, 34(4), 377-398.

Sapon-Shevin, M., Ayres, B. J. & Duncan, J. (2002). Cooperative Learning and Inclusion. In Thousand, J. S. , Villa, R. A. & Nevin, A. I. (Eds.). *Creativity and collaborative learning: the practical guide to empowering students, teachers, and families*. Baltimore, MD: Paul H. Brookes Publishing.

Scott, P. H. Asoko, H. M., & Driver, R. H. (1991). *Teaching for conceptual change: a review of strategies*. In: R. Duit, F. Goldberg, and H. Niedderer, (Eds) Research in physics learning: Theoretical issues and empirical studies. Proceedings of an International Workshop. Retrieved from http://www.physics.ohio-state.edu/~jossem/ICPE/C5.html

Shachar, H. and S.Fischer. 2004. Cooperative learning and the achievement of motivation and perceptions of students in 11th grade chemistry classes. *Learning and Instruction,* 14(1): 69-87

Slavin, R. E. (1984). "Component Building: A Strategy for Research-Based Instructional Improvement." *Elementary School Journal*, 84, 255-269.

Slavin, R. E. (1985). *Team-Assisted Individualization: Combining Cooperative Learning and Individualized Instruction in Mathematics."* Learning to Cooperate, Cooperating to Learn. Eds. R. E. Slavin, S. Sharan, R. Hertz-Lazarowitz, C. Webb, and R. Schmuck. New York: Plenum. 177-209.

Slavin, R. E (1990). *Cooperative Learning: Theory, Research and Practice*. Englewood Cliffs, NJ: Prentice-Hall .

Slavin, R. E. (1995). *Cooperative learning: Theory, research, and practice* (2nd Ed.). Boston: Allyn & Bacon.

Slavin, R. E. &Karweit, N. (1984). Mastery learning and students'teams:A factorial experiment in urban general mathematics classes. *American Educational Research Journal*, 21, 727-726

Siegel, C. (2005). Implementing a research-based model of cooperative learning. *Journal of Educational Research*, 98(6), 339-348.

Smith, E. L., Blakeslee, T. D., & Anderson, C. W. (1993). Teaching strategies associated with conceptual change learning in science. *Journal of Research in Science Teaching*, 30(2), 111-126.

Smith, S.W., Daunic, A.P., Taylor, G.G. (2007). Treatment Fidelity in Applied Educational Research: Expanding the Adoption and Application of

Measures to Ensure Evidence-Based Practice. *Education and Treatment of Children*, 30(4), 121-134.

Simpson, R. D. & Oliver, J. S. (1985). Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten. *Science Education*, 69(4), 511-525.

Stieff, M., & Wilensky, U. (2003). Connected Chemistry–Incorporating interactive simulations into the chemistry classroom. *Journal of Science Education & Technology*, 12 (3), 285-302.

Strike, K.A., & Posner, G.J. (1982). Conceptual change and science teaching. *European Journal of Science Education*, 4,231-24

Smith, E. L., Blakeslee, T. D., & Anderson, C. W. (1993). Teaching strategies associated with conceptual change learning in science. *Journal of Research in Science Teaching*, 30(2), 111-126.

Strike, K. A. & Posner, G. J. (1990). *A revisionist theory of conceptual change*. In R. Duschl & R. Hamilton (Eds.), Philosophy of science, cognitive science, and educational theory and practice. Albany, NY: SUNY Press.

Sungur, S., Tekkaya, C., & Geban, O. (2001). The contribution of conceptual change texts accompanied by concept mapping to students' understanding of the human circulatory system. *School Science and Mathematics*, 101(2), 91-101.

Sungur, S. & Tekkaya, C. (2003). Students" achievement in human circulatory system unit: The effect of reasoning ability and gender, *Journal of Science Education and Technology*, 12(1), 59-64.

Taber,K.S.(1995).Development of student understanding: A case study of stability and liability in cognitive structure. *Research in Science and Technological Education*, 13(1), 89-99.

Taber, K. S. (2006). Beyond constructivism: the progressive research programme into learning science. *Studies in Science Education*, 42, 125-184.

Taber, K. S. (1998). An alternative conceptual framework from chemistry education. *International Journal of Science Education*, 20(5), 597-608.

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

Taber, K. S. (2003). Mediating mental models of metals: acknowledging the priority of the learner's prior learning. *Science Education*, 87, 732-758.

Taber, K. S. (1997). *Understanding Chemical Bonding: The development of a level students' understanding of the concept of chemical bonding.* University of Surrey.

Tan K. D. & Treagust D. F. (1999). Evaluating students' understanding of chemical bonding. *School Science Review*, 81(294), 75-83.

Teichert, M. & 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 D.F., (1988), Development and use of diagnostic tests to evaluate students' misconceptions in science, *International Journal of Science Education*, 10, 159-169.

Tsay, M., & Brady, M. (2010). A case study of cooperative learning and communication pedagogy: Does working in teams make a difference? *Journal of the Scholarship of Teaching and Learning*, 10(2), 78 – 89.

Uzuntiryaki, E. (2003). *Effectiveness of constructivist approach on students' understanding of chemical bonding concepts*. Unpublished doctoral dissertation, Middle East Technical University, Ankara, Turkey.

Vosniadou, S. (2001). What can persuasion research tell us about conceptual change that we did not already know? *International Journal of Educational Research*, 35, 731-737.

Vosniadou, S., & Ioannides, C. (1998). From conceptual development to science education: A psychological point of view. *International Journal of Science Education*, 20, 1213-1230

Viennot, L. (1979). Spontaneous reasoning in elementary dynamics. *European Journal of Science Education*, 1, 205-221.

Yamarik, S. (2007). Does cooperative learning improve student learning outcomes? *Journal of Economic Education*, 38 (3), 259-278.

Zoller, U., (1990). Students' Misunderstandings and Alternative Conceptions in College Freshman Chemistry (General and Organic), *Journal of Research in Science Teaching*, 27(10), 1053-1065.

APPENDIX A

INSTRUCTIONAL OBJECTIVES

1. To define chemical bonding.
2. To explain how chemical bonding occurs.
3. To class types of bonds.
4. To define ionic and covalent bonding.
5. To differentiate intermolecular and intramolecular bonds
6. To seperate Van der Waals, Dipol-dipol and Hydrogen bonding.
7. To draw Lewis structures of compounds.
8. To draw shape of molecules.
9. To identify polarity of bonds.
10. To distunguish polarity of bonds and polarity of molecules.
11. To explain properties of covalent and ionic compounds.
12. To give examples of ionic, covalen and metallic bonding.
13. To guess the types of bonds of substances.
14. To estimate physical properties based on intermolecular bonds
15. To discriminate polar and non-polar covalnet bonds.
16. To explain metallic bonding.

APPENDIX B

KİMYASAL BAĞLAR KAVRAM TESTİ

PART A

1) $_{12}X$ elementi ile $_{17}Y$ elementinin oluşturduğu XY_2 bileşiği;

A) İyonik B) Kovalent

Çünkü:

1.X elementi bir çift elektronunu Y elementi ile paylaşarak XY_2 kovalent bileşiğini oluşturur.

2.X elementi Y elementine bir elektron vererek XY_2 iyonik bileşiğini oluşturur.

3.Xelementi iki elektronunu her bir Y elementine vererek XY_2 iyonik bileşiğini oluşturur.

4.Y elementi bir çift elektronu Xelementi ile paylaşarak XY_2 kovalent bileşiğini oluşturur.

2) $_{15}P$ elementi ile $_{9}F$ elementinin oluşturduğu PF_3 kovalent bileşiktir.

A) Doğru B) Yanlış

Çünkü:

1. P elementi üç elektronunu her bir F elementi ile paylaşarak PF_3 kovalent bileşiğini oluşturur.

2. P elementi her bir F elementine üç elektron vererek PF_3 iyonik bileşiğini oluşturur.

3. F elementi, üç elektronunu P elementi ile paylaşarak PF_3 kovalent bileşiğini oluşturur.

4. F elementi, P elementine üç elektron vererek PF_3 iyonik bileşiğini oluşturur.

3) NH_3 ile NF_3 benzer kimyasal formül ve yapı gösterir. Ancak NH_3'ün kaynama noktasının NF_3'ün kaynama noktasından yüksek olması;

A) molekül içi kuvvetler B) moleküller arası kuvvetler

ile açıklanır.

Çünkü:

1. NF_3'deki bağlar kolayca kırılırken NH_3'deki bağlar kırılmaz.
2. NH_3'ün moleküller arasındaki Van der waals bağları daha kuvvetlidir.
3. NH_3'ün molekülleri arasında hidrojen bağları bulunmaktadır.
4. NH_3, molekül içi iyonik bağ içerirken; NF_3, molekül içi kovalent bağ içerir.

4) CH_4 molekülü;

A) Polar B) Apolar

Çünkü:

1. C atomu üzerinde bir çift bağ yapmamış elektron vardır.
2. Elektronlar C ve H arasında eşit olarak paylaşılmamıştır.
3. CH_4 suda iyi çözünür.
4. C-H bağlarının vektörel toplamı sıfırdır.

5) NH_3 molekülünün molekül içi bağları polardır.

A) Doğru B) Yanlış

Çünkü:

1. Azot üzerindeki bağ yapmamış elektronlar, bağ yapmış elektronları itmiştir.

2. Azotun iyon yükü, bağı apolar yapmıştır.

3. Kovalent bağlı bileşiklerde elektron çiftleri eşit paylaşılır.

4. Elektronlar, azot ve hidrojen arasında eşit olarak paylaşılmamaktadır.

6) NF_3'ün sudaki çözünürlüğü N_2'in sudaki çözünürlüğünden daha fazladır.

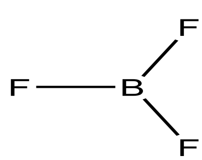
A) Doğru B) Yanlış

Çünkü:

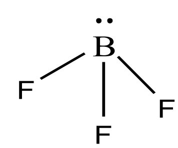
1. NF_3 molekülünde elektronlar eşit paylaşıldığından apolar moleküldür.
2. N_2 molekülünde N atomu bağ yapmamış elektronlar bulundurduğundan polardır.
3. NF_3 molekülünde N atomunun bağ yapmamış elektronları bulundurduğundan polardır.
4. N_2 molekülü suda çözündüğünde azot iyonları oluşur.

7) BF_3 bileşiğinin gösterimi nasıldır? ($_5B$,$_9F$)

A)



B)



Çünkü:

1. B atomu üzerindeki bağ yapmamış elektronlar ortaklaşan elektronları itmiştir.
2. Bağ elektonları, elektron etkileşimini en aza indirecek şekilde dizilmiştir.
3. Bağ elektronları, elektronegatifliği çok yüksek olan flor atomları tarafından çok kuvvetli çekilmektedir.
4. Bor ve flor kovalent bağ oluşturduklarından elektronlar eşit olarak paylaşılır.

8) $AlCl_3$ bileşiği, ($_{13}Al$, $_{17}Cl$)

A) İyonik bileşik B) Kovalent bileşik

Çünkü:

1. Alüminyum elementi üç elektronunu, her bir flor elementi ile paylaşır.

2. Alüninyum elementi üç elektron kaybederken, her bir flor elementi bir elektron kazanır.

3. Flor elementi üç elektron kaybederken, alünimyum elemneti üç elektron kazanır.

4. Alüminyumun üç elektronu, her bir flor atomu ile eşit paylaşılır.

9) H_2S molekülü;

A) Polar B) Apolar

Çünkü:

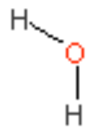
1. Simetrik olmayan polar bağlı moleküller polardır.

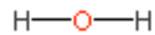
2. Bağlar polardır.

3. Hidrojen ve kükürt arasında elektronlar eşit paylaşılmaktadır.

4. Molekül içindeki elektriksel polarlık vektörü sıfırdan farklıdır.

10) H_2O molekülünün gösterimi nasıldır?

a) 

b) 

Çünkü:

1. Molekülün şekli, sadece bağ yapmış elektronlara bağlıdır.
2. Bağ polaritesi molekülün şeklini oluşturur.
3. Bağ yapmamış elektronların itici etkisi sebep olmuştur.
4. Elektronlar, oksijen ve hidrojen arasında eşit paylaşılmaktadır.

11) CCl_4 molekülünde bağlar polar ve molekül apolardır.

A) Doğru B) Yanlış

Çünkü:

1. Elektronlar eşit olarak paylaşılmadığından her ikiside polardır.
2. Bağ yapmamış elektron çiftinin itme gücünden dolayı molekül polardır.
3. Bağlar polar ancak toplam elektriksel polarlık vektörü sıfırdır.
4. Bağlar polar olduğundan molekül de polardır.

PART B

12) Kimyasal bağlar için aşağıdakilerden hangisi yanlıştır?

A) İyonik bağlar, kovalent bağlardan daha kuvvetlidir.

B) Atomlar bağ oluşturduklarında daha kararlı hale geçerler.

C) Bağ oluşurken açığa çıkan enerji, bu bağı kırmak için gereken enerjiye eşittir.

D) Bağ enerjilerinin büyüklüğü, molekülün kararlılığının bir ölçüsüdür.

E) Bağ oluşurken ısı alır.

13) Kimyasal bağlar için aşağıdakilerden hangisi yanlıştır?

A) Ametaller kendi aralarında elektron ortaklaşması ile kovalent bağ oluşturur.

B) Metaller ile ametal arasında iyonik bağlar oluşur.

C) Hidrojen bağları, iyonik bağlardan zayıf, van der waals bağlarından kuvvetlidir.

D) Metaller kendi aralarında kovalent bağ oluşturur.

E) Kovalent bağlar hidrojen bağından kuvvetlidir.

14) Aşağıda verilen moleküllerin hangilerinde sıvı fazda molekülleri arasında hidrojen bağı vardır?

I.HF II.NH_3 III.CH_4 IV. H_2 V.CH^3-OH

A) I-II B) I-III C) I-II-V D) III-IV-V E) I-II-III-IV

15) Sıvı HF molekülleri arasında;

I. Van der Waals bağı,

II.Hidrojen bağı,

III.Kovalent bağ,

IV.Dipol-dipol etkileşimi

bağlarından hangisi yada hangileri bulunur?

A) I-III B) II-IV C) I-II-IV D) III-IV E) I-III-IV

16) $_1H$, $_7N$, $_8O$, $_9F$, atomlardan oluşan aşağıdaki moleküller ile ilgili;

I.NH_3 molekülü polardır.

II.HF molekülü apolardır.

III.H_2O molekülü polardır.

IV.NF_3 molekülü apolardır.

bilgilerden hangisi yada hangileri doğrudur?

A) I-III B) I-II-III C) I-IV D) III-IV E) II-IV

17) İyonik bağlar için aşağıdakilerden hangisi yanlıştır?

A) Metaller ile ametaller arasında iyonik bağ oluşur.

B) Sıvı fazda iyonik bağlı bileşikler elektrik akımını iletir.

C) İyonik bileşikler moleküler yapıdadır.

D) İyonik bağlar elektron elış-verişi ile oluşur.

E) İyonik bağlar, kovalent bağlardan daha kuvvetlidir.

18) Kovalent bağlar için aşağıdakilerden hangsi doğrudur?

A) Bütün kovalent bağlarda bağ yapan elektron eşit paylaşılır.

B) Hidrojen bağları kovalent bağlardan daha kuvvetlidir.

C) Metaller kendi aralarında kovalent bağlı bileşikler oluşturur.

D) Kovalent bağlı bileşikler kristal yapıdadır.

E) Hidrojen ile ametaller arasında polar kovalent bağlı bileşikler oluşur.

19) Aşağıdakilerden hangisi NaCl bileşiği için yanlıştır?

A) Katı halde elektrik akımını iletmez.

B) Suda çözündüğünde iyonik bağları kırılarak Na^+ ve Cl^- iyonları oluşur.

C) İyonik bağlı bir bileşiktir.

D) NaCl kristal yapıdadır.

E) Sulu çözeltisi elektrik akımın iletir.

20) Aşagıdaki bileşiklerden hangisinde molekül içi bağlar polar kovalent olduğu halde moleküller arasında sadece van der waaals bağı bulunur?

A) CCl_4 B) NaCl C) HI D) H_2O E) CH_3Cl

CEVAP ANAHTARI:

1) A3
2) A1
3) B3
4) B4
5) A1
6) A3
7) A2
8) A2
9) A4
10) A3
11) A3
12) E
13) D
14) C
15) C
16) A
17) C
18) E
19) B
20) A

APPENDIX C

ÇALIŞMA TESTİ

1. Aşağıdaki moleküllerin Lewis yapısını ve molekül geometrisini gösteriniz?

   ($_{1}H$, $_{3}B$, $_{8}O$, $_{7}N$,$_{9}F$)

   A) H_2O

   B) NH_3

   C) BF_3

2. Aşağıdaki bileşiklerin molekül içi ve moleküller arası bağ çeşitlerini yazınız?

   A) $CaCl_2$:

   B) H_2O :

   C) NaCl:

   D) NH_3 :

3. Aşağıdaki soruları yukardaki atomlara göre cevaplayınız.

   A) A atomu B atomuna kaç elektron verecek?

B) B atomu A atomundan kaç elektron alacak?

C) A atomu elektronu verince yükü ne olacak?

D) B atomu elektron alınca yükü ne olacak?

E) Oluşan bileşiğin formülü ne olacak?

F) Oluşan Bağ türü nedir?

4. İyonik ve Kovalent Bağları karşılaştıarak 3 farklı özelliğini yazınız?

5. CF_4 molekülü için,

A) Lewis yapısını gösteriniz.

B) Molekül şeklini gösteriniz.

C) Atomlar arası bağ türü nedir?

D) Molekül iyonik, polar ya da apolar mı? Nasıl tahmin yaptınız?

6. BH_3 molekülü için,

A) Lewis yapısını gösteriniz.

B) Molekül şeklini gösteriniz.

C) Atomlar arası bağ türü nedir?

D) Molekül iyonik, polar ya da apolar mı? Nasıl tahmin yaptınız?

7. İyonik bağlar metal ile ametal arasında gerçekleşirken kovalent bağlar iki ametal arasında gerçekleşmektedir. Bunun nedenini açıklayınız?

8. Elektronegatiflik ile bağın polarlığı arasındaki ilişki nasıldır?

9. Aşağıdaki bileşikleri kaynama noktalarına göre sıralayınız?

   NF_3, H_2, $MgCl_2$, BH_3, H_2O

10. HF molekülünün kaynama noktasının HCl ve HBr'den daha yüksek olmasının sebebi nedir?

APPENDIX D

KİMYA DERSİ TUTUM ÖLÇEĞİ

Bu ölçekte, kimya dersine ilişkin tutum cümleleri ile her cümlenin karŞısında "Tamamen Katılıyorum", "Katılmıyorum", " Kararsızım", "Katılmıyorum" ve "Tamamen Katılmıyorum" olmak üzere be seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

	Tamamen Katılıyorum	Katılıyorum	Karasızım	Katılmıyorum	Hiç Katılmıyorum
1. Kimya çok sevdiğim bir alandır.					
2. Kimya ile ilgili kitapları okumaktan hoşlanırım.					
3. Kimyanın günlük yaşantıda çok önemli yeri yoktur.					
4. Kimya ile ilgili ders problemlerini çözmekten hoşlanırım.					
5. Kimya konularıyla ilgili daha çok şey öğrenmek isterim.					
6. Kimya dersine girerken sıkıntı duyarım.					
7. Kimya derslerine zevkle girerim.					
8. Kimya derslerine ayrılan ders saatinin daha fazla olmasını isterim.					
9. Kimya dersini çalışırken canım sıkılır.					
10. Kimya konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim.					
11. Düşünce sistemimizi geliştirmede kimya öğrenimi önemlidir.					
12. Kimya, çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir.					
13. Dersler içinde Kimya dersi sevimsiz gelir.					
14. Kimya konularıyla ilgili tartışmaya katılmak bana cazip gelmez.					
15. Çalışma zamanımın önemli bir kısmını kimya dersine ayırmak isterim.					

APPENDIX E

BİLİMSEL İŞLEM BECERİ TESTİ

AÇIKLAMA: Bu test, özellikle Fen ve Matematik derslerinizde ve ilerde üniversite sınavlarında karşınıza çıkabilecek karmaşık gibi görünen problemleri analiz edebilme kabiliyetinizi ortaya çıkarabilmesi açısından çok faydalıdır. Bu test içinde, problemdeki değişkenleri tanımlayabilme, hipotez kurma ve tanımlama, işlemsel açıklamalar getirebilme, problemin çözümü için gerekli incelemelerin tasarlanması, grafik çizme ve verileri yorumlayabilme kabiliyetlerini ölçebilen sorular bulunmaktadır**. Her soruyu okuduktan sonra kendinizce uygun seçeneği işaretleyiniz**.

1. Bir basketbol antrenörü, oyuncuların güçsüz olmasından dolayı maçları kaybettiklerini düşünmektedir. Güçlerini etkileyen faktörleri araştırmaya karar verir. Antrenör, oyuncuların gücünü etkileyip etkilemediğini ölçmek için aşağıdaki değişkenlerden hangisini incelemelidir?

a. Her oyuncunun almış olduğu günlük vitamin miktarını.

b. Günlük ağırlık kaldırma çalışmalarının miktarını.

c. Günlük antrenman süresini.

d. Yukarıdakilerin hepsini.

2. Arabaların verimliliğini inceleyen bir araştırma yapılmaktadır. Sınanan hipotez, benzine katılan bir katkı maddesinin arabaların verimliliğini artırdığı yolundadır. Aynı tip beş arabaya aynı miktarda benzin fakat farklı miktarlarda katkı maddesi konur. Arabalar benzinleri bitinceye kadar aynı yol üzerinde giderler. Daha sonra her arabanın aldığı mesafe kaydedilir. Bu çalışmada arabaların verimliliği nasıl ölçülür?

a. Arabaların benzinleri bitinceye kadar geçen süre ile.

b. Her arabanın gittiği mesafe ile.

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

3. Bir araba üreticisi daha ekonomik arabalar yapmak istemektedir. Araştırmacılar arabanın litre başına alabileceği mesafeyi etkileyebilecek değişkenleri araştırmaktadırlar. Aşağıdaki değişkenlerden hangisi arabanın litre başına alabileceği mesafeyi etkileyebilir?

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

4. Ali Bey, evini ısıtmak için komşularından daha çok para ödemesinin sebeplerini

merak etmektedir. Isınma giderlerini etkileyen faktörleri araştırmak için bir hipotez kurar. Aşağıdakilerden hangisi bu araştırmada sınanmaya uygun bir hipotez değildir?

a. Evin çevresindeki ağaç sayısı ne kadar az ise ısınma gideri o kadar fazladır.

b. Evde ne kadar çok pencere ve kapı varsa, ısınma gideri de o kadar fazla olur.

c. Büyük evlerin ısınma giderleri fazladır.

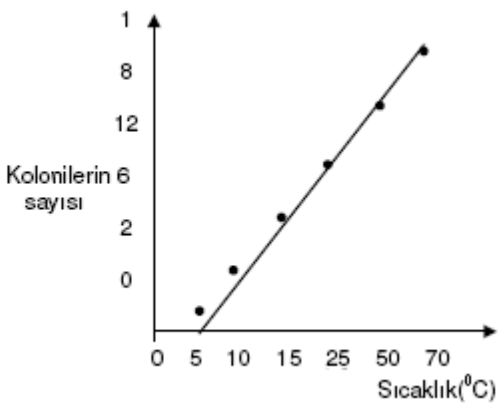
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir

5. Fen sınıfından bir öğrenci sıcaklığın bakterilerin gelişmesi üzerindeki etkilerini araştırmaktadır. Yaptığı deney sonucunda, öğrenci aşağıdaki verileri elde etmiştir:

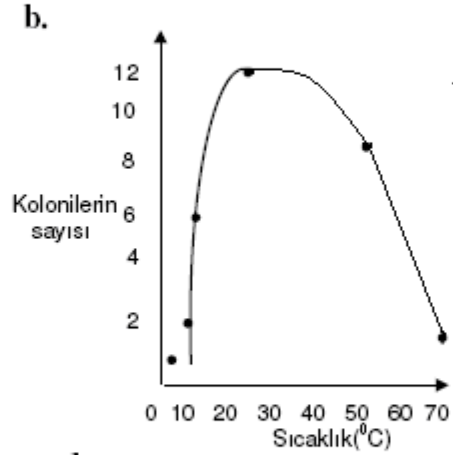
Deney odasının sıcaklığı (^{0}C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

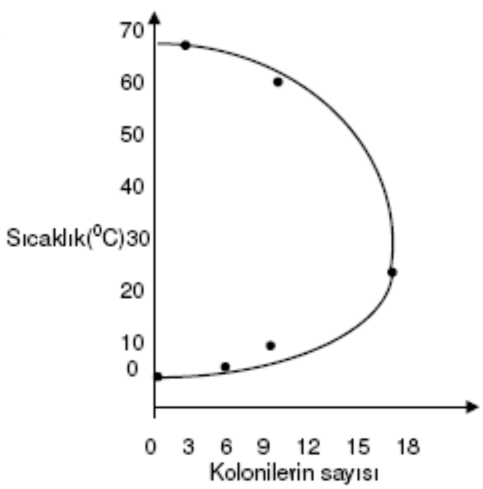
a.



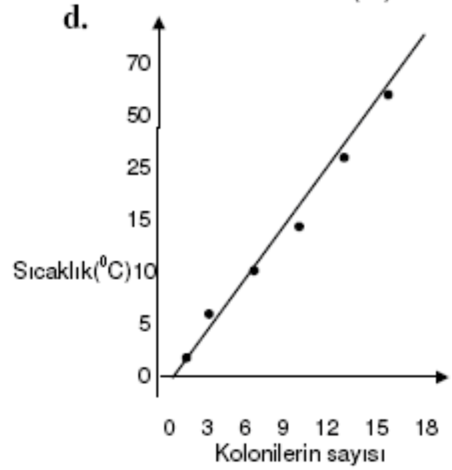
b.



c.



d.



6. Bir polis şefi, arabaların hızının azaltılması ile uğraşmaktadır. Arabaların hızını etkileyebilecek bazı faktörler olduğunu düşünmektedir. Sürücülerin ne kadar hızlı araba kullandıklarını aşağıdaki hipotezlerin hangisiyle sınayabilir?

a. Daha genç sürücülerin daha hızlı araba kullanma olasılığı yüksektir.

b. Kaza yapan arabalar ne kadar büyükse, içindeki insanların yaralanma olasılığı o kadar azdır.

c. Yollarda ne kadar çok polis ekibi olursa, kaza sayısı o kadar az olur.

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

7. Bir fen sınıfında, tekerlek yüzeyi genişliğinin tekerleğin daha kolay yuvarlanması üzerine etkisi araştırılmaktadır. Bir oyuncak arabaya geniş yüzeyli tekerlekler takılır, önce bir rampadan (eğik düzlem) aşağı bırakılır ve daha sonra düz bir zemin üzerinde gitmesi sağlanır. Deney, aynı arabaya daha dar yüzeyli tekerlekler takılarak tekrarlanır. Hangi tip tekerleğin daha kolay yuvarlandığı nasıl ölçülür?

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

c. Her iki deneyde kullanılan tekerlek tiplerinin yüzey genişlikleri ölçülür.

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

8. Bir çiftçi daha çok mısır üretebilmenin yollarını aramaktadır. Mısırların miktarını etkileyen faktörleri araştırmayı tasarlar. Bu amaçla aşağıdaki hipotezlerden hangisini sınayabilir?

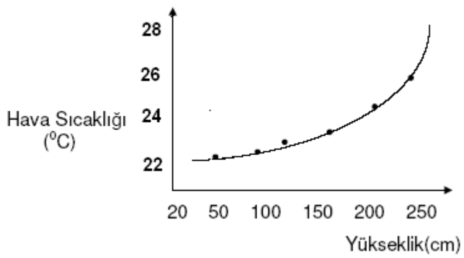
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

b. Ne kadar çok mısır elde edilirse, kar o kadar fazla olur.

c. Yağmur ne kadar çok yağarsa , gübrenin etkisi o kadar çok olur.

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

9. Bir odanın tabandan itibaren değişik yüzeylerdeki sıcaklıklarıylala ilgili bir çalışma yapılmış ve elde edilen veriler aşağıdaki grafikte gösterilmiştir. Değişkenler arasındaki ilişki nedir?



a. Yükseklik arttıkça sıcaklık azalır.

b. Yükseklik arttıkça sıcaklık artar.

c. Sıcaklık arttıkça yükseklik azalır.

d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

10. Ahmet, basketbol topunun içindeki hava arttıkça, topun daha yükseğe sıçrayacağını düşünmektedir. Bu hipotezi araştırmak için, birkaç basketbol topu alır ve içlerine farklı miktarda hava pompalar. Ahmet hipotezini nasıl sınamalıdır?

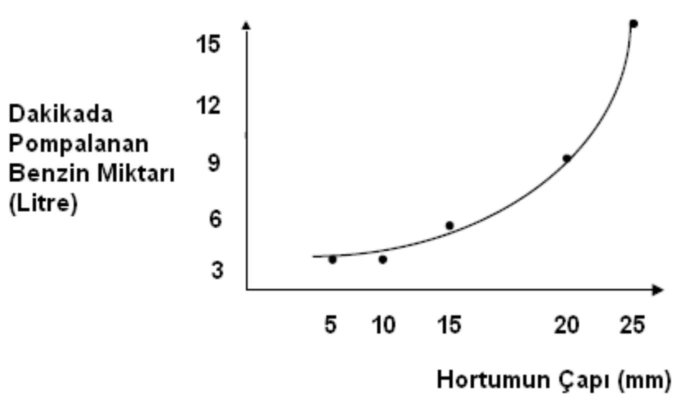
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

b. İçlerinde farlı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.

c. İçlerinde aynı miktarlarda hava olan topları, zeminle farklı açılardan yere vurur.

d. İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

11. Bir tankerden benzin almak için farklı genişlikte 5 hortum kullanılmaktadır. Her hortum için aynı pompa kullanılır. Yapılan çalışma sonunda elde edilen bulgular aşağıdaki grafikte gösterilmiştir.



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

a. Hortumun çapı genişledikçe dakikada pompalanan benzin miktarı da artar.

b. Dakikada pompalanan benzin miktarı arttıkça, daha fazla zaman gerekir.

c. Hortumun çapı küçüldükçe dakikada pompalanan benzin miktarı da artar.

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

Önce aşağıdaki açıklamayı okuyunuz ve daha sonra 12, 13, 14 ve 15 inci soruları açıklama kısmından sonra verilen paragrafı okuyarak cevaplayınız.

Açıklama: Bir araştırmada, bağımlı değişken birtakım faktörlere bağımlı olarak gelişim gösteren değişkendir. Bağımsız değişkenler ise bağımlı değişkene etki eden faktörlerdir. Örneğin, araştırmanın amacına göre kimya başarısı bağımlı bir değişken olarak alınabilir ve ona etki edebilecek faktör veya faktörler de bağımsız değişkenler olurlar.

Ayşe, güneşin karaları ve denizleri aynı derecede ısıtıp ısıtmadığını merak etmektedir. Bir araştırma yapmaya karar verir ve aynı büyüklükte iki kova alır. Bunlardan birini toprakla, diğerini de su ile doldurur ve aynı miktarda güneş ısısı alacak şekilde bir yere koyar. 8.00 - 18.00 saatleri arasında, her saat başı sıcaklıklarını ölçer.

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

a. Toprak ve su ne kadar çok güneş ışığı alırlarsa, o kadar ısınırlar.

b. Toprak ve su güneş altında ne kadar fazla kalırlarsa, o kadar çok ısınırlar.

c. Güneş farklı maddeleri farklı derecelerde ısıtır.

d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

16. Can, yedi ayrı bahçedeki çimenleri biçmektedir. Çim biçme makinesiyle her hafta bir bahçedeki çimenleri biçer. Çimenlerin boyu bahçelere göre farklı olup bazılarında uzun bazılarında kısadır. Çimenlerin boyları ile ilgili hipotezler kurmaya başlar. Aşağıdakilerden hangisi sınanmaya uygun bir hipotezdir?

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gürenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

d. Bahçe ne kadar engebeliyse çimenleri kesmekte o kadar zor olur.

17, 18, 19 ve 20 inci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.

Murat, suyun sıcaklığının, su içinde çözünebilecek şeker miktarını etkileyip etkilemediğini araştırmak ister. Birbirinin aynı dört bardağın her birine 50 şer mililitre su koyar. Bardaklardan birisine 0 ^{0}C de, diğerine de sırayla 50 ^{0}C, 75 ^{0}C ve 95 ^{0}C sıcaklıkta su koyar. Daha sonra her bir bardağa çözünebileceği kadar şeker koyar ve karıştırır.

17. Bu araştırmada sınanan hipotez hangisidir?

a. Şeker ne kadar çok suda karıştırılırsa o kadar çok çözünür.

b. Ne kadar çok şeker çözünürse, su o kadar tatlı olur.

c. Sıcaklık ne kadar yüksek olursa, çözünen şekerin miktarı o kadar fazla olur.

d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

21. Bir bahçıvan domates üretimini artırmak istemektedir. Değişik birkaç alana domates tohumu eker. Hipotezi, tohumlar ne kadar çok sulanırsa, o kadar çabuk filizleneceğidir. Bu hipotezi nasıl sınar?

a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.

b. Her sulamadan bir gün sonra domates bitkisinin boyunu ölçer.

c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.

d. Her alana ektiği tohum sayısına bakar.

22. Bir bahçıvan tarlasındaki kabaklarda yaprak bitleri görür. Bu bitleri yok etmek gereklidir. Kardeşi “Kling” adlı tozun en iyi böcek ilacı olduğunu söyler. Tarım uzmanları ise “Acar” adlı spreyin daha etkili olduğunu söylemektedir. Bahçıvan altı tane kabak bitkisi seçer. Üç tanesini tozla, üç tanesini de spreyle ilaçlar. Bir hafta sonra her bitkinin üzerinde kalan canlı bitleri sayar. Bu çalışmada böcek ilaçlarının etkinliği nasıl ölçülür?

a. Kullanılan toz yada spreyin miktarı ölçülür.

b. Toz yada spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.

c. Her fidede oluşan kabağın ağırlığı ölçülür.

d. Bitkilerin üzerinde kalan bitler sayılır.

23. Ebru, bir alevin belli bir zaman süresi içinde meydana getireceği ısı enerjisi miktarını ölçmek ister. Bir kabın içine bir litre soğuk su koyar ve 10 dakika süreyle ısıtır. Ebru, alevin meydana getirdiği ısı enerjisini nasıl ölçer?

a. 10 dakika sonra suyun sıcaklığında meydana gelen değişmeyi kaydeder.

b. 10 dakika sonra suyun hacminde meydana gelen değişmeyi ölçer.

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

24. Ahmet, buz parçacıklarının erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarının büyüklüğü, odanın sıcaklığı ve buz parçalarının şekli gibi faktörlerin erime süresini etkileyebileceğini düşünür. Daha sonra şu hipotezi sınamaya karar verir: Buz parçalarının şekli erime süresini etkiler. Ahmet bu hipotezi sınamak için aşağıdaki deney tasarımlarının hangisini uygulamalıdır?

a. Her biri farklı şekil ve ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

b. Her biri aynı şekilde fakat farklı ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

c. Her biri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

d. Her biri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izle

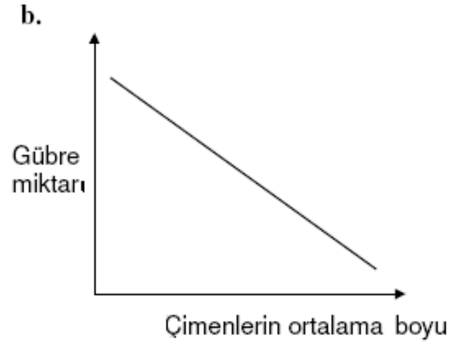
25. Bir araştırmacı yeni bir gübreyi denemektedir. Çalışmalarını aynı büyüklükte beş tarlada yapar. Her tarlaya yeni gübresinden değişik miktarlarda karıştırır. Bir ay sonra, her tarlada yetişen çimenin ortalama boyunu ölçer. Ölçüm sonuçları aşağıdaki tabloda verilmiştir.

Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

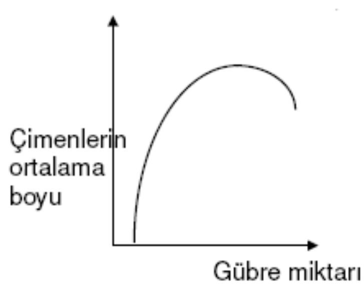
Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

a.

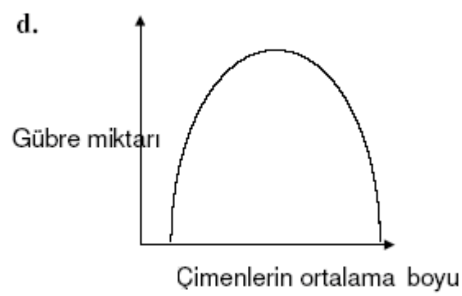
b.



c.



d.



26. Bir biyolog şu hipotezi test etmek ister: Farelere ne kadar çok vitamin verilirse o kadar hızlı büyürler. Biyolog farelerin büyüme hızını nasıl ölçebilir?

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

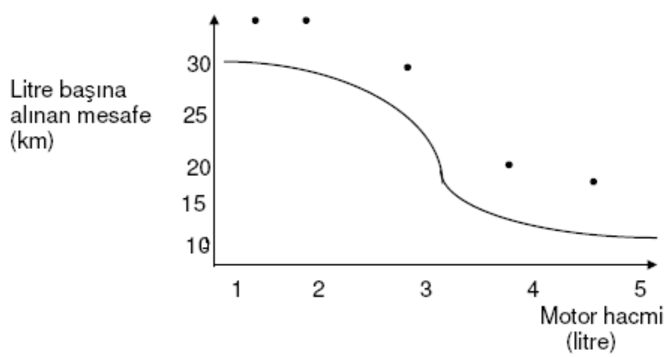
c. Her gün fareleri tartar.

d. Her gün farelerin yiyeceği vitaminleri tartar.

27. Öğrenciler, şekerin suda çözünme süresini etkileyebilecek değişkenleri düşünmektedirler. Suyun sıcaklığını, şekerin ve suyun miktarlarını değişken olarak saptarlar. Öğrenciler, şekerin suda çözünme süresini aşağıdaki hipotezlerden hangisiyle sınayabilir?

a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

b. Su soğudukça, şekeri çözebilmek için daha fazla karıştırmak gerekir.
c. Su ne kadar sıcaksa, o kadar çok şeker çözünecektir.
d. Su ısındıkça şeker daha uzun sürede çözünür.
28. Bir araştırma grubu, değişik hacimli motorları olan arabaların randımanlarını ölçer. Elde edilen sonuçların grafiği aşağıdaki gibidir:



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

a. Motor ne kadar büyükse, bir litre benzinle gidilen mesafe de o kadar uzun olur.
b. Bir litre benzinle gidilen mesafe ne kadar az olursa, arabanın motoru o kadar küçük demektir.
c. Motor küçüldükçe, arabanın bir litre benzinle gidilen mesafe artar.
d. Bir litre benzinle gidilen mesafe ne kadar uzun olursa, arabanın motoru o kadar büyük demektir.

29, 30, 31 ve 32 inci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.

Toprağa karıştırılan yaprakların domates üretimine etkisi araştırılmaktadır.

Araştırmada dört büyük saksıya aynı miktarda ve tipte toprak konulmuştur. Fakat birinci saksıdaki toprağa 15 kg., ikinciye 10 kg., üçüncüye ise 5 kg. çürümüş yaprak karıştırılmıştır. Dördüncü saksıdaki toprağa ise hiç çürümüş yaprak karıştırılmamıştır.Daha sonra bu saksılara domates ekilmiştir. Bütün saksılar güneşe konmuş ve aynı miktarda sulanmıştır. Her saksıdan elde edilen domates tartılmış ve kaydedilmiştir.

29. Bu araştırmada sınanan hipotez hangisidir?

a. Bitkiler güneşten ne kadar çok ışık alırlarsa, o kadar fazla domates verirler.

b. Saksılar ne kadar büyük olursa, karıştırılan yaprak miktarı o kadar fazla olur.

c. Saksılar ne kadar çok sulanırsa, içlerindeki yapraklar o kadar çabuk çürür.

d. Toprağa ne kadar çok çürük yaprak karıştırılırsa, o kadar fazla domates elde edilir.

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

33. Bir öğrenci mıknatısların kaldırma yeteneklerini araştırmaktadır. Çeşitli boylarda ve şekillerde birkaç mıknatıs alır ve her mıknatısın çektiği demir tozlarını tartar. Bu çalışmada mıknatısın kaldırma yeteneği nasıl tanımlanır?

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

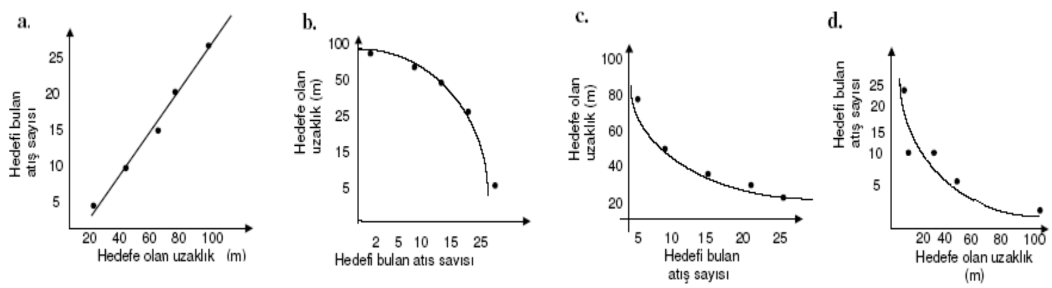
c. Kullanılan mıknatısın şekli ile.

d. Çekilen demir tozlarının ağırlığı ile

34. Bir hedefe çeşitli mesafelerden 25 er atış yapılır. Her mesafeden yapılan 25 atıştan hedefe isabet edenler aşağıdaki tabloda gösterilmiştir.

Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?



35. Sibel, akvaryumdaki balıkların bazen çok hareketli bazen ise durgun olduklarını gözler. Balıkların hareketliliğini etkileyen faktörleri merak eder. Balıkların hareketliliğini etkileyen faktörleri hangi hipotezle sınayabilir?

a. Balıklara ne kadar çok yem verilirse, o kadar çok yeme ihtiyaçları vardır.

b. Balıklar ne kadar hareketli olursa o kadar çok yeme ihtiyaçları vardır.

c. Su da ne kadar çok oksijen varsa, balıklar o kadar iri olur.

d. Akvaryum ne kadar çok ışık alırsa, balıklar o kadar hareketli olur.

36. Murat Bey'in evinde birçok elektrikli alet vardır. Fazla gelen elektrik faturaları dikkatini çeker. Kullanılan elektrik miktarını etkileyen faktörleri araştırmaya karar verir. Aşağıdaki değişkenlerden hangisi kullanılan elektrik enerjisi miktarını etkileyebilir?

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinasını kullanma sıklığı.

d. a ve c.

APPENDIX F

OBSERVATION CHECKLIST

	Evet	Hayır	Kısmen
1.Öğretmen öğrencilere konuyu etkili bir şekilde anlattı mı?			
2.Öğretmen ikisi orta seviyede, biri düşük ve biri yüksek seviyeli öğrencilerden dörtlü gruplar oluşturdu mu?			
3.Öğretmen grup çalışmasının amacını ve öğrencilerin yapmları gerekeni anlattı mı?			
4.Öğretmen çalışma testini dağıtıp açıklamalarda bulundu mu?			
5.Öğrenciler aktif olarak grup çalışmasına katıldılar mı?			
6. Grup çalışmalarında tartışma ortamları oluştu mu?			
7.Öğrenciler çalışma testlerinde arkadaşlarının öğrenmelerine yardımcı oldular mı?			
8.Öğrenciler grup çalışmasında karşılıklı etkileşime geçebildiler mi?			
9.Öğretmen gruplar arasında dolaşıp süreci izledi mi?			
10.Öğretmen gruplar arasında dolaşırken bazı sorular sorarak öğrencileri düşünmeye yönlendirdi mi?			
11.Öğretmen grup çalışmasına katılımı arttırıcı yardımcı sorular sordu mu?			
12.Öğrenciler grup çalışmasında sonra testi tek başına cevaplandırdı mı?			
13.Öğretmen öğrencilerin sorularına ayrıntılı olarak cevap verdi mi?			
14.Öğrenciler öğrendikleri konuyu yeni bir durum içerisinde uygulama fırsatı buldu mu?			
15.Öğrenciler dersin işlenmesinden hoşlandılar mı?			
16. Sınıfın fiziksel ortamı dersin planlandığı gibi işlenmesine uygun mu?			

APPENDIX G

SAMPLE LESSON PLAN

Teacher starts to lesson with the questions: What is the chemical bonding? What does it mean? The purpose is to activate students' previous knowledge and determine their existing ideas. Some of the students try to answer the questions and the discussion environment takes place in the classroom. After students' answers and discussions, teacher begins class presentation. While explaining the concept, teacher mainly focuses on students' misconceptions and concepts which students have struggle.

Teacher starts to explain chemical bonding:

"Although there are 118 elements in the periodic table and more, most of the substances around us are compounds. The reason of that atom can react with one another to form new substances called compounds. The resulting compound is unique and different from its atoms both chemically and physically. For example; the sodium element is silver colored metal that reacts with water to produce flames easily. The chlorine element is a greenish colored gas that is so poisonous. When they react and bonded chemically, these two dangerous elements form the compound sodium chloride that we eat it every day, namely table salt.

Chemical bonds are formed between atoms because electrons from the atoms interact with each other. Chemical bond is an attraction between atoms brought about sharing of electrons between the atoms or a complete transfer of electrons. That is, chemical bonds are forces that hold the atoms together. There are mainly two types of chemical bonding that are covalent and ionic bonding. Now we continue with ionic bonding". Teacher goes on her presentation with types of chemical bonding.

After presentation, teacher organizes students to make cooperative groups that have four students each. Teacher gives a worksheet to study together. Students share their ideas, discuss their knowledge, and ask questions to each other. During group work process, they recognize different perspective than their own. This causes the *dissatisfaction* that is the first and important step for Posner et al's (1982) conceptual change approach.

After students' discussions on worksheet in cooperative groups, teacher asked and got questions each group. Acccording to their answers and questions, teacher gives extra explanation in greater detail. She focused on students' misconceptions and the concepts that students had diffuculty.

After explanations, teacher agin asked what the chemical bonding is. Some students still thought that bonds were "thing" that holds atoms together but they could not define obviously what the "thing" was. At that time, teacher went on explainations.

"Some of you consider that chemical bonds are material connections. However, chemical bonds are forces that hold the atoms of elements together. These forces are called as "chemical bonds". The "thing" as you said is the electrostatic forces that hold the atoms together. You can think these forces as magnets. As you know same poles attract each other. This likes the attraction between electric charges. The attractions between atoms cause to chemical bonding and hold the structure together."

Teachers' explanations help students understand the concept and clarification ambiguities about the concept. With this understanding, the *intelligibility* that is the second step in conceptual change approach takes place.

To increase students' understanding and provide the *plausibility* that is the third step in conceptual change, teacher continues with examples and problems about the chemical bonding at the blackboard. Teacher asked who wants to show forming of NaCl at the blackboard. Some of the students raised their hands and teacher gave permission to one student who did not raise his hands. The students and teacher show the forming of NaCl together.

After plausibility, students generalize their knowledge to other situations and noticed the utility of new concept by solving new problems. This leads to the *fruitfulness* step that is the last step of conceptual change.

CURRICULUM VITAE

GÜLÜZAR EYMUR

Department of Secondary Science and Mathematics Education,
Middle East Technical University,
06531 Ankara, Turkey
E-mail: guluzarsaglam@yahoo.com

PERSONAL INFORMATION
Date of Birth: 05.04.1980
Place of Birth: Ordu, TURKEY
Gender: Female

EDUCATION

- 2008-2014 **Ph.D.** MIDDLE EAST TECHNICAL UNIVERSITY Department of Secondary Science and Mathematic Education, Ankara, Turkey
- 2005-2008 **M.Sc.** MIDDLE EAST TECHNICAL UNIVERSITY Department of Chemistry (Major Subject: Organic Chemistry)
- 2000-2005 **B.Sc.** MIDDLE EAST TECHNICAL UNIVERSITY Department of Secondary Science and Mathematic Education, Ankara, Turkey (Major Subject: Chemistry Education)

RESEARCH EXPERIENCES

- Acyl Anion Chemistry, Prof. Dr. Ayhan S. Demir, Gülüzar Eymur, Middle East Technical University, Chemistry Department, Turkey, 2005-2008
- Conceptual Change Approach,Prof.Dr.Ömer Geban, Gülüzar Eymur ,Middle East Technical University, Secondary Science and Mathematic Education Department, Turkey, 2008- 2013

JOB EXPERIENCES

- 2005- 2007 Chemistry Teacher at Seviye Teaching Instution
- 2007-2008 Chemistry Teacher at Ekol Teaching Instution
- 2008-2009 Chemistry Teacher at Muş Varto High School
- 2009-2013 Research Assistant at Middle East Technical University

LANGUAGES

- Turkish (*native*)
- English *(advanced)*
- German*(intermediate)*

PUBLICATIONS

- **<u>Gülüzar Eymur</u>,** Ömer Geban
  The Collaboration of Cooperative Learning and Conceptual Change: Enhancing the Students' Understanding of Chemical Bonding Concepts, *Chemistry Education Research and Practice ,***2014**, submitted

- Peruze Ayhan Eşiyok, Özlem Seven, **<u>Gülüzar Eymur</u>**, Gamze Bora Tatar, Didem Dayangaç Erden, Kemal Yelekçi, Hayat Yurter, Ayhan Sıtkı Demir
  Aryl Butenoic Acid Derivatives as a New Class of Histone Deacetylase Inhibitors: Synthesis, in Vitro Evaluation and Molecular Docking Studies, *Turkish Journal of Chemistry*, **2014**, in Press, KIM-1305-56

- **<u>Gülüzar Eymur</u>,** Pınar Seda Çetin, Ömer Geban
  Analysis of the Alternative Conceptions of Pre-service Teachers and High School Students Concerning Atomic Size, *Journal of Chemical Education,* **2013**, 90(8), 976-980

- **<u>Gülüzar Eymur</u>,** Ömer Geban
  An Investigation of Relationship between Motivation and Academic Achievement of Pre-service Chemistry Teachers, *Education and Science*, ***2011**, 32, 246-255.*

- Demir, A.S., Reis, B., Reis, Ö., Eymur, S., Tural, S., Göllü,M.,**<u>Sağlam (Eymur), G</u>**.
  Cyanide Ion Promoted Addition of Acyl Phosphonates to Ethyl Cyanoformate: Synthesis of Tertiary Carbinols via Tandem Carbon-Carbon Bond Formations., *Journal of Organic Chemistry***, 2007,** 72(19), 7439–7442.

CONFERENCE AND MEETINGS

- **Gülüzar Sağlam (Eymur),** Synthesis of New HDAC Inhibitors , *XXI. National Chemistry Congress*, İnönü Üniversitesi, 23-27 Ağustos, 2007, Malatya, Turkey

- **Gülüzar Sağlam (Eymur),** Investigation of Students' Achievement Based on Attribution theory , *XXII. National Chemistry Congress*, Doğu Akdeniz Üniversitesi, 7-10 Ekim, 2008, Mağusa, Cyprus

- **Gülüzar Eymur**, Ömer Geban, Investigation of Pre-Service Teachers' Motivation, *239th ACS National Meeting & Exposition*, San Francisco, CA, U.S.A. , March 21-25 ,2010.

- **Gülüzar Eymur,** Ömer Geban, Pınar Seda Çetin, Misconceptions of Pre-service Chemistry Teachers on Atomic Radius , *IX. National Science and Mathematics Education Congress* , 23-25 Eylül **2010**, İzmir.

- **Gülüzar Eymur,** Ömer Geban, Pınar Seda Çetin, Analysis of Conceptions of Pre-service Chemsitry Teachers and High School Students on Atomic Radius, *Eureopean Science Education Research Association* (ESERA), Lyon, France, 5-9 September, 2011