EFFECT OF COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE CONDITIONS ON SEVENTH GRADE STUDENTS' UNDERSTANDING OF CLASSIFICATION OF MATTER AND PHYSICAL AND CHEMICAL CHANGES

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

BY

ARZU (ÖZDEMİR) ERDEMİR

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

MARCH 2006

Approval of the Graduate School of Natural and Applied Sciences

Prof. Dr. Canan ÖZGEN
Director

I certify that this thesis satisfies all the requirements as a thesis for degree of Doctor of Philosophy.

Prof. Dr.Ömer GEBAN
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis degree of Doctor of Philosophy.

Prof. Dr.Ömer GEBAN
Supervisor

Examining Committee Members

Prof. Dr. Hamide Ertepınar	(METU, ESME)	
Prof. Dr. Ömer Geban	(METU, SSME)	
Assoc. Prof. Dr. Ceren Tekkaya	(METU, ESME)	
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Assist. Prof. Dr. Yezdan Boz	(METU, SSME)	

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Arzu Erdemir

ABSTRACT

EFFECT OF COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE CONDITIONS ON SEVENTH GRADE STUDENTS' UNDERSTANDING OF CLASSIFICATION OF MATTER AND PHYSICAL AND CHEMICAL CHANGES

ERDEMİR, Arzu

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

Supervisor: Prof. Dr. Ömer GEBAN

March 2006, 184 pages

The main purpose of this study was to compare the effectiveness of the cooperative learning based on conceptual change conditions and traditionally designed science instruction on 7th grade students' understanding of chemical and physical changes and classification of matter concepts and attitudes toward science as a school subject.

In this study 102 seventh grade students from four classes of a Science Course instructed by the two teachers from ODTÜ G.V. Özel İlköğretim Okulu took part. One of the classes of each teacher was randomly assigned as experimental group, which were instructed with cooperative learning based on conceptual change conditions and the other classes were assigned as control group, which were instructed traditionally. This study was conducted during the 2004-2005 fall semester over a period of four weeks.

In this study, to examine the effect of the treatment on dependent variables; science achievement related to chemical and physical changes and classification of matter concepts measured with Classification and Changes of Matter Concepts Test, and science attitude scores measured with Attitude Scale Toward Science as a school subject. Science Process Skills Test was used at the beginning of the study to determine students' science process skills.

ANCOVA and ANOVA were used testing the hypotheses of the study. The results showed that the cooperative learning based on conceptual change conditions group had a significantly higher scores with respect to achievement related to chemical and physical changes and classification of matter concepts than the traditionally designed science instruction group. However, there is no significant difference between the mean scores of cooperative learning based on conceptual change conditions group and traditionally designed science instruction group with respect to attitudes toward science as a school subject. Science process skills were a strong predictor for the achievement related to chemical and physical changes and classification of matter concepts.

It may be useful to use the results of this study and instruments and strategies developed for this study for classroom teachers in order to help students to reduce or eliminate their misconceptions.

KEYWORDS: Cooperative Learning Based on Conceptual Change Conditions, Traditionally Designed Science Instruction, Misconception, Physical and Chemical Changes, Classification of Matter

ÖZ

KAVRAMSAL DEĞİŞİM KOŞULLARINA DAYALI İŞBİRLİĞİNE YÖNELİK ÖĞRENİM YAKLAŞIMININ YEDİNCİ SINIF ÖĞRENCİLERİNİN FİZİKSEL VE KİMYASAL DEĞİŞİMLER VE MADDENİN SINIFLANDIRILMASI KAVRAMLARINI ANLAMALARINA ETKİSİ

ERDEMİR, Arzu

Doktora, Orta Öğrenim Fen ve Matematik Alanları Eğitimi Bölümü

Tez Yöneticisi: Prof. Dr. Ömer GEBAN

Mart 2006, 184 sayfa

Bu çalışmanın başlıca amacı kavramsal değişim koşullarına dayalı işbirliğine yönelik öğrenim yaklaşımını yedinci sınıf öğrencilerinin fiziksel ve kimyasal değişimler ve maddenin element, bileşik, karışım olarak sınıflandırılması konularındaki kavramlarla ilgili başarılarına ve fen dersine olan tutumlarına etkisini geleneksel fen öğretim yöntemi ile karşılaştırmaktır.

Bu çalışma, ODTÜ G.V. Özel İlköğretim Okulundan iki öğretmenin ikişer sınıfındaki 102 yedinci sınıf öğrencisinin katılımıyla gerçekleştirilmiştir. Çalışma 2004–2005 eğitim ve öğretim yılı sonbahar döneminde gerçekleştirilmiştir. Her öğretmenin birer sınıfı rasgele deney grubuna seçilmiş, diğer sınıflar kontrol grubu

olarak alınmıştır. Deney grubuna kavramsal değişim koşullarına dayalı işbirliğine yönelik öğrenim yaklaşımı yöntemi, kontrol grubuna ise geleneksel fen öğretim yöntemi uygulanmıştır. Araştırma dört hafta sürmüştür. Maddenin Sınıflandırılması ve Değişimi Kavramları Testi, öğrencilerin fiziksel ve kimyasal değişimler ve maddenin element, bileşik, karışım olarak sınıflandırılması konularındaki başarılarının, Fen Dersi Tutum Ölçeği ise öğrencilerin fen dersine olan tutumlarının ölçülmesinde kullanılmıştır. Bilimsel İşlem Beceri Testi ile de çalışmanın başında öğrencilerin bilimsel işlem becerileri ölçülmüştür.

Bu çalışmanın hipotezlerini test etmek için Ortak Değişkenli Varyans Analizi ve Varyans Analizi kullanılmıştır. Analiz sonuçları, kavramsal değişim koşullarına dayalı işbirliğine yönelik öğrenim yaklaşımı yöntemi ile öğretilen öğrencilerin fiziksel ve kimyasal değişimler ve maddenin element, bileşik, karışım olarak sınıflandırılması kavramları ile ilgili başarılarının, geleneksel fen anlatımı ile öğretilen öğrencilere göre daha yüksek olduğunu göstermiştir. Ancak kavramsal değişim koşullarına dayalı işbirliğine yönelik öğrenim yaklaşımı yöntemi ile öğretilen öğrencilerin fen dersine olan tutumları ile geleneksel fen öğretiminden faydalanan öğrencilerin fen dersine olan tutumları arasında anlamlı bir fark olmadığı gözlenmiştir. Bilimsel işlem becerisi ise öğrencilerin fiziksel ve kimyasal değişimler ve maddenin element, bileşik, karışım olarak sınıflandırılması konularındaki başarıları için güçlü bir belirleyicidir.

Bu araştırmanın sonuçlarının, geliştirilen araç ve yöntemlerin fen bilgisi öğretmenleri tarafından kullanılması, öğretmenlerin öğrencilere kavram yanılgılarının giderilmesi konusunda yardım edebilmesi açısından faydalıdır.

ANAHTAR SÖZCÜKLER: Kavramsal Değişim Koşullarına Dayalı İşbirliğine Yönelik Öğretim, Geleneksel Fen Bilgisi Anlatım Yöntemi, Kavram Yanılgısı, Fiziksel ve Kimyasal Değişimler, Maddenin Sınıflandırılması

ACKNOWLEDGEMENTS

I would like to extent my gratitude to Prof. Dr. Ömer Geban, the supervisor of my thesis. I owe a special word of gratitude to him for his continuous encouraging efforts, constructive criticism and invaluable suggestions through the study.

I would like to thank to Nalan Yıldırım who applied my teaching materials in her classroom for his valuable suggestions and contributions. .

To my husband Hakan and my daughter Elifnur, I offer sincere thank for their moral support.

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CLCC : Cooperative Learning Based on Conceptual Change Conditions

TDSI : Traditionally Designed Science Instruction

CG : Control Group

EG : Experimental Group

CCMT : Classification and Changes of Matter Test

ASTS : Attitude Scale Toward Science

SPST : Science Process Skills Test

p, α : Significance level

DF : Degrees of Freedom

SS : Sum of Squares

MS : Mean Square

F : F Statistic

$\overline{X}$: Mean of the Sample

CHAPTER 1

INTRODUCTION

Since the mid-1970s there has been an increasing awareness of the importance of the ways students conceptualize and think about the phenomena they encounter in science class. For many years, teachers have accepted the notion that students come to the classroom with minds that are essentially blank slates. However, some teachers believe that students hold incorrect understandings about a number of topics prior to instruction and traditional modes of instruction will easily replace these misunderstandings. (Gilbert, Osborne, & Fensham, 1982; Pope & Gilbert, 1983) On the other hand, research has shown that the students do not come to the classroom with blank slates; rather, they come with well-established understandings about how and why everyday things behave as they do. (Posner, Strike, Hewson & Gertzog, 1982) The cognitive structure of the learner prior to new instruction determines the ease and fate of the learning process. The memory structure of stored knowledge such as concepts, schemes, rules and etc. are referred to as the cognitive structure of the learner (Ausubel, 1978). According to cognitive model, students build understandings of the events and phenomena in their world from their own point of view. (Osborne & Wittrock, 1983) Students have views and explanations of natural phenomena that differ from the views held by scientist before instruction. (Osborne, 1982; Wandersee, Mintzes, & Novak, 1994) These different concepts have been described as preconceptions or misconceptions. (Driver & Easley, 1978)

Students learn more about the natural world that they develop new or revised concepts based on their interpretation of this information from the viewpoint of their existing ideas and beliefs. Their concepts that are not consistent with accepted scientific knowledge are called alternative conceptions. These different forms of understanding of phenomena have been referred to by a great number of terms such as alternative frameworks (Driver & Erickson, 1983), children's science (Osborne & Freyberg, 1985) and students' descriptive and explanatory systems. (Champagne et al., 1985)

Piaget was one of the first researchers to determine the presence of preexisting understandings in children and alternative frameworks students bring to learning situation. Many research studies have been based on the questions concerning the nature of student misconceptions, the source of these misconceptions and the effect of instruction on these misconceptions. Everyday conceptions arise from the everyday life experiences. Everyday conceptions are supported and reinforced through everyday conversation and reading books. Therefore these everyday conceptions reflect a shared view represented by a shared language. This shared view is used to describe and explain the world.

(Driver et al., 1994) Some documented sources of student misunderstandings have been traced to teachers and textbooks. (Helm, 1980; Weiss, 1978; Stake & Easley, 1978; Harmes & Yager, 1981) Students' misconceptions are so powerful that students resist scientific explanations. Stofflett and Stoddart (1994) called the task of changing alternative conceptions and restructuring schemas "remediation." Remediating students' alternative conceptions has been a research focus for a number of years.

Many students at all levels are often unsuccessful when learning chemistry. Discovering the reasons has been the aim of many studies. One possible reason is that many students are not constructing appropriate understandings of fundamental chemical concepts from the very beginning of their studies. (Frank et al., 1987) Therefore; they can not understand more advanced topics. In order to identify and analyze misconceptions, interviews (Bowen, 1994; Osborne & Gilbert, 1980; Posner & Gertzog, 1982, Sutton, 1980), paper and pencil tests like multiple choices, free response tests and concept maps
(Novak & Govin, 1984), word association tests (Sutton, 1980) have been used. Griffiths and Preston (1992) conducted interviews and have showed that students had a lot of misconceptions about atoms and molecules. Peterson and Treagust (1989) used a paper and pencil test and identified eight misconceptions that dealt with bond polarity, molecular shape, molecular polarity, intermolecular forces and octet rule. Osborne and Cosgrove (1983) investigated students' conceptions about

phase changes. Research studies also showed that students have misconceptions about chemical equations (Yarroch, 1985; Ben-Zwi, Eylon & Silverstein, 1987), physical and chemical changes (Ben-Zwi, Eylon & Silverstein, 1987; Stavridou & Solomonidou, 1989; Solsona & Izquerdo, 2003), chemical equilibrium (Gussarsky & Gorodetsky, 1990, Wheeler & Kass, 1978; Bergquist & Heikkinen, 1990; Piquette & Heikkinen, 2005), various aspects of matter (Liu & Leisniak, 2005; Nakhleh et. al 2005)

The chemical change is a central concept in the chemistry curriculum for the secondary school. Students should learn to interpret this concept in two domains: the macroscopic domain and the microscopic domain. The macroscopic domain deals with substances and their properties, science processes and phenomena. The micro-domain deals mainly with corpuscular models, such as molecules, atoms and ions (Solsona & Izquerdo, 2003). In the last two decades, a great deal of research has been focused on students' difficulties in understanding the concept of chemical change (Hesse & Anderson, 1992; Brinkman and de Jong 1996; Izquerdo and Solsona 1999; Johnson 2000, 2002). Several more specific studies have been carried out focusing on element and compound (De Vos and Verdonk 1987, Ramsden 1997) and the distinction between physical and chemical changes (Brosnan 1990).

Stavridou and Solomonidou (1989) indicated that half of the students incorrectly classified physical and chemical changes. Also students thought that physical changes were reversible while chemical changes were always seen as irreversible. Schollum (1981, 1982) investigated students' understandings about chemical change and combustion. Hesse and Anderson (1992) were other researchers studied chemical change concept. The analysis showed that the students had difficulties on the following aspects: i. Chemical knowledge; ii. Conservation reasoning; and iii. Explanatory ideas.

Differences between elements, compounds and mixtures form the basis for understanding chemical reactions. Barker (1995), Briggs and Holding (1986) and Ben-Zvi et al. (1986) have studied students' thinking about elements, compounds and mixtures. Interviews showed the students seemed to understand the macroscopic nature of elements, compounds and mixtures, but did not use particle ideas.

In this study, students' conceptions about physical and chemical changes, and the classification of matter as elements, compounds and mixtures were investigated. In order to reduce misconceptions the cooperative learning based on conceptual change conditions was used.

The resent researches aim taking everyday conceptions into account and helping students to understand and accept basic scientific concepts. According to constructivist view, learning is viewed as a process of active construction which is shaped by the students' prior knowledge and conceptions. Posner et al. (1982) developed a model of learning as conceptual change which was thinking of learning as change in students' conceptions. In this view, learning is the result of interaction between what the student is taught and his current ideas and concepts.

Instructional strategies that based on constructivist perspective are considered to be successful contributions for effective and meaningful instruction; learning the material, evaluating student progress, teaching laboratory techniques and concepts. (Ausubel, 1978) According to Ausubel's meaningful learning theory; "Meaningful learning is the nonarbitrary, substantive, non-verbatim incorporation of new knowledge into cognitive structure." Rote learning is opposite of meaningful learning. The common aim of science education researchers is to lead to meaningful learning. To assure meaningful learning, students should be enabling to construct and organize their knowledge in order to use needed information accurately.

The most important factor affecting students' learning in science is what the learner already knows. (Mintzes & Wandersee, 1998) But students' alternative conceptions are very resistant to change so that many students hold alternative conceptions even after formal instruction. As a result, many of instructional strategies and materials are developed such that students' alternative conceptions are changed into scientific conceptions.

Conceptual change methods are designed to promote the acquisition of new conceptions as a consequence of the exchange and differentiation of the existing conceptions and the integration of new conceptions with existing conceptions. In a general sense, conceptual change denotes learning pathways from students' pre-instructional conceptions to the science concepts to be learned (Duit, 1999). Research results showed that conceptual change instructional strategies caused a significantly better acquisition of scientific conceptions and elimination of alternative conceptions than traditional instructional strategies that followed logical presentation of concepts usually seen in textbooks. In addition some constructivist science educators used conceptual change approaches in science education and demonstrated the effectiveness of conceptual change approach to science learning. (Gunstone & Northfield, 1992; Hewson & Hewson, 1988; Neale & Smith, 1989; Roth & Rosaen, 1991; Stofflet, 1991; Chambers & Andre, 1997; Hynd et al., 1994)

In the conceptual change model, student dissatisfaction with a prior conception was believed to initiate dramatic or revolutionary conceptual change and was embedded in radical constructivist epistemological views with an emphasis on the individual's conceptions and his/her conceptual development. If the learner was dissatisfied with his/her prior conception and an available replacement conception was intelligible, plausible and/or fruitful, accommodation of the new conception may follow. An intelligible conception is sensible if it is non-contradictory and its meaning is understood by the student; plausible means that in addition to the student knowing what the conception means, he/she finds the conception believable; and, the conception is fruitful if it helps the learner solve other problems or suggests new research directions. (Duit & Treagust; 2003)

Cooperative learning is a successful teaching strategy that uses a variety learning activities to improve students understanding of a subject. Cooperative learning methods generally involve heterogeneous small groups working on learning activities to help themselves and their teammates learn together. Both cognitive and social benefits can be gained as students explain their own understanding and share their ideas with each other as they interact within the group. (Deutsch, 1949) Conceptual change instructional models emphasize the importance of student-student verbal interactions, but often lack specific strategies to encourage these interactions. Cooperative learning may provide student-student verbal interactions. Basili and Sanford (1991) concluded that students who engaged in a high frequency of verbal interactions that were believed to play an important role for conceptual change didn't undergo any sort of alteration in concept understanding as a result of instruction.

In this study, whole class has been initially instructed by the teacher. The students are divided into 5-member teams according to their average grades on science general exam and assigned tasks. The task consists of: (1) Performing laboratory experiments about physical and chemical changes and answering discussion questions. (2) Discussing questions about classification of matter as elements, compounds and mixtures structured to facilitate conceptual change. (3) Completing clay modeling activity about related concepts. Afterwards, students were given the classification and changes of matter test individually. The members of group having the highest average grade took rewards and bonus points.

Related research literature demonstrated that cooperative learning strategies enhance conceptual change. Positive effects were found for outcomes such as self-esteem, inter-group relations, and ability to work cooperatively. Johnson & Johnson (2000) have claimed that cooperative learning experiences promote higher achievement than do competitive and individualistic learning experiences.

In the present study, the cooperative learning based on conceptual change conditions was used to remediate misconceptions related to physical and chemical changes and classification of matter as elements, compounds and mixtures. In addition, the effects of Science Process Skills on understanding of related concepts were examined. Also, the effect of cooperative learning based on conceptual change conditions on students' attitudes toward science as a school subject was investigated.

CHAPTER 2

REVIEW OF RELATED LITERATURE

The science education literature contains many studies dealing with students' understanding and misunderstandings of scientific concepts. In order to solve a given problem, students must understand the concepts involved. However, many students are not constructing appropriate understandings of fundamental chemical concepts from the very beginning of their studies. (Gabel et al., 1987) Therefore they can not fully understand the more advanced concepts that build upon the fundamentals. Only a meaningful understanding of concepts and clear conceptual connections between them can lead to desired behavior in problem solving. (Ausubel, 1978) Learning new knowledge will be meaningful to the degree that learners can relate it to the existing cognitive structure and actual experiences.

According to constructivist theory, learning is an active process occurring within and influenced by the learner as much as by the instructor and the school. So, learning outcomes do not depend on what the teacher presents. Rather, they are an interactive result of what information is encountered and how the student processes it based on existing personal knowledge. As students learn more about natural world they developed new or revised concepts based on their interpretation of this new information from the viewpoint of their existing ideas and beliefs. Their concepts that are not consistent with scientific concepts are called alternative conceptions. These alternative conceptions play a large role in learning science. For this reason, today one of the most important goals of science education is to provide conceptual change from alternative to scientific conceptions.

An understanding of basic concepts such as physical and chemical changes, elements, compounds and mixtures is fundamental to the learning of chemistry. Therefore, any misconception will have an effect on further learning in chemistry. Students' understanding of these basic concepts depends upon the students' prior knowledge based on everyday life experiences. The question of how instruction can make explicit use of students' prior knowledge is addressed by thinking of learning as a change in student's conceptions. The instructional strategy has to be designed in such a way that the student is convinced that the scientific conception is more useful than the existing alternative conception. Basili and Sanford (1991) provided evidence that students in the treatment groups who had engage in small group work on concept-focused tasks had a significantly lower proportion of misconceptions on the posttest. Therefore, this study was constructed to identify the alternative conceptions about physical and chemical changes, elements, compounds and mixtures and investigate the effect of cooperative learning based on conceptual change conditions on conceptual change from alternative to scientific conceptions. On this ground, we shall examine the existing relevant literature dealing with the important variables (e.g. misconceptions, misconceptions in physical and chemical changes, elements, compounds and mixtures, and cooperative learning based on conceptual change conditions)

2.1. Misconceptions

It is a common belief that learning is the result of the interaction between what the student is taught and his current ideas or concepts. (Ausubel, 1968) Research into conceptions held by students has shown that there can be significant differences between conceptions of same phenomenon. More significantly, students often hold conceptions which are at variance with the scientifically acceptable conceptions, even after formal instruction. These conceptions are called as alternative conceptions. These different concepts have been variously described by different researchers as preconceptions (Driver, R. & Erickson, G., 1983), misconceptions (Driver, R; Erickson, G., 1983), alternative frameworks (Driver, R. & Easley, J., 1978), children's science (Osborne, R. & Freyberg, P., 1985), and students' descriptive and explanatory systems (Champagne, A. B., Klopfer, L. E. & Gunstone, R. F.,1985)

Once integrated into a students' cognitive structure, these misconceptions will interfere with subsequent learning. The student doesn't connect new information into the cognitive structure appropriately since it already holds inappropriate knowledge. Thus, weak understandings or misunderstandings of the concepts will occur. (Nakhleh, 1992)

The information students use to construct their concepts comes from two sources: public knowledge as presented in texts and lectures; and information prior to knowledge from everyday experiences, parents, peers, commercial products and the common meaning of scientific terms. (West et al., 1985)

Science education researchers have used interviews, written tests, concepts maps or combinations of these methods in order to identify and analyze misconceptions. After these studies, researchers identified many misconceptions about chemical concepts such as particulate nature of matter (Novick, & Nussbaum, 1978, 1981), various matter concepts (Liu & Lesniak, 2005), atoms and molecules (Griffits, & Preston, 1989; Cros, Maurin, Amouroux, Chastrette, Leber, & Fayol, 1986) phase changes (Osborne, & Cosgrove, 1983; Bodner, 1991, Ben-Zvi, Eylon, & Silberstein, 1987, 1988; Anderson, 1986; Stavridou, & Solomonidou, 1989), gases (Furio Mas, Perez, & Harris, 1987; Stavy, 1988; Nurrenbern, & Pickering, 1987; Pickering, 1990), chemical equations (Yarroch, 1985; Ben-Zvi, Eylon, & Silberstein, 1988, 1987), chemical and physical changes (Ben-Zvi, Eylon, & Silberstein, 1987; Anderson, 1986; Stavridou, &

Solomonidou, 1989), and chemical equilibrium (Gussaryky, & Gorodetsky, 1990; Hackling, & Garnett, 1985; Piquiette & Heikkinen, 2005).

These alternative conceptions are so powerful that students resist scientific explanation. In order to change alternative conceptions to scientific conceptions, identifying misconceptions and understanding some reasons for their persistence is important.

2.2. Misconceptions in Physical and Chemical Changes, Elements, Compounds and Mixtures

It is commonly agreed that chemistry is a difficult subject for young students. Because the topics are very abstract and some words from everyday language are used with different meanings. Therefore, students do not construct appropriate understandings of fundamental chemical concepts from the very beginning of their studies (Gabel & Samuel, 1987). Studies showed that students have great difficulties in understanding the introductory concepts which are seen as building blocks for further learning. So, there is a need for further investigate the students' understandings of these introductory concepts such as elements, compounds, mixtures, physical and chemical changes. This will help both to find possible source of misconceptions and ways to overcome or remediate these misconceptions.

Nakhleh, Samarapungavan & Sağlam (2005), examined middle school students' developing understanding of the nature of matter. The interview probed students' understanding of the composition and particulate (atomic/molecular) structure of a variety of material substances; the relationship between particulate structure and macroscopic properties such as fluidity and malleability; as well as understanding of processes such as phase transition and dissolving. They indicated that most of the middle school students knew the matter was composed of atoms and molecules but some of them were unable to use this knowledge to explain some of the processes such as phase transition of water. The middle school students did not have consistent knowledge frameworks because their ideas were very fragmented. The fragmentation of ideas about matter probably reflects the difficulty of assimilating the microscopic level scientific knowledge acquired through formal instruction into students' initial macroscopic knowledge frameworks.

Recently researchers investigated students' understandings about chemical change and combustion in various countries and at different educational levels. Schollum (1981, 1982) showed that Australian junior high school students did not perceive an active role for air in burning and did not think that substances were transformed during burning. Meheut, Saltiel and Tiberghien (1985) demonstrated that French junior high school students did not use chemical interpretations in their attempts to explain combustion. In the United States, Hesse (1988) found that high school students explained chemical change based on some visible aspects of the change, preferred explanations based on everyday analogies, and indicated that chemical explanations differed from their personal explanations only in the use of technical terms. In addition, Basili (1989) showed that college students were confused between the science and everyday meanings of the terms “create” and “destroy” and that this confusion prevented full understanding of the law of conservation of matter, a law that is essential for understanding chemical change.

Learning about chemical change must not be as simple and straightforward as it seems. Although most students could state the definition of a chemical reaction and balance chemical equations, they still seemed confused about chemical changes, especially about chemical changes in real-world situations. (Ben-Zvi, Eylon, & Silberstein, 1987; Yarroch, 1985; Hesse, & Anderson, 1992) Learning about the nature of chemical change is actually far more complicated than it appears. Although the rules for writing and balancing chemical equations are relatively simple, the equations that result are meaningful only when they are embedded in a complex “conceptual ecology” an array of facts, theories, and beliefs about the nature of matter and the functions of scientific explanation that chemists have developed over time. (Posner, Strike, Hewson, & Gertzog, 1982; Toulmin, 1972)

However, the students do have their own set of theories and beliefs about the nature of matter and the functions of explanations and these beliefs may lead them to understand and explain chemical change in quite different ways. Thus, learning about the nature of chemical change is not just a matter of learning a few facts and rules. Instead, it is a complex process of conceptual change involving many aspects of the students' conceptual ecologies. (Hesse & Anderson, 1992)

Hesse & Anderson (1992) studied not only issues directly relevant to chemical change but also related aspects of the students' conceptual ecologies. They investigated three related but different types of conceptual ecologies that beginning chemistry students must gain in order to produce an explanation of a chemical change. These were: (a) chemical knowledge including specific facts and theories associated with the change being described, (b) an understanding of how conservation of matter applies to chemical changes, and (c) an understanding of chemists' explanatory ideals for chemical change. They used a written test followed by an oral examination. In the written instrument the students were shown three chemical changes. Open-answer questions required students to describe what they saw, explain how it happened and make predictions about the masses of the reactants and products. Afterwards, a clinical interview was conducted that focused on students' responses to the written test and compared them to the hypothetical responses. They concluded that:

- A majority of students regularly substituted everyday materials and energy for chemical substances in their explanations of chemical reactions.
- Of the eleven students, only one student was able to shift his focus of explanation from the visible aspects of the changes he was observing to the atomic-molecular level of chemistry.
- Four students consistently ignored both the existence and the substantive nature of gaseous products and reactants. Four other students sometimes did this.
- Many students reached incorrect conclusions about the mass of the products of chemical reactions because they applied to chemical reactions conservation reasoning that was more appropriate for physical changes. Only two of the students reasoned chemically about conservation for all three reactions.
- Students in the sample demonstrated a preference for explanations based upon everyday analogies.
- A majority of the students indicated that analogies with everyday events were sufficient for their personal explanations and those chemical explanations were different mainly in their technical vocabulary.

Many students do not grasp chemical concepts such as atoms, molecules, ions or bonding between these particles, nor element and compounds and their characteristics, physical and chemical changes or changes of the state of matter. According to popular opinions, many of these difficulties are caused by daily life experiences of chemical phenomena which students bring into the classroom.

Nieswandt (2001) focused on the term "everyday conception" because he suggested that some students' notions were useful and helpful for explaining scientific everyday phenomena. The analysis assessed the effect of this form of pre-instructional knowledge on the learning of chemistry concepts. For these everyday conceptions he concerned four basic conceptions. These were:

- Substances have properties and these properties can change without the substance itself undergoing any drastic change. (Hesse & Anderson, 1992; de Vos & Verdonk, 1985, 1987) One example for these conceptions is that when copper is heated in air a black layer forms. Students describe this phenomenon as "copper has become black." Since they think that copper has been given a new characteristic, this is incorrect from the chemical point of view.

- Phenomena during chemical reactions are interpreted as being a result of mixing and separating substances. (Anderson, 1986, 1990; Hesse & Anderson, 1992)

- During burning the burnt substances are viewed as having been irretrievably destroyed (e.g. paper, wool, coal) or as changing their status (e.g. melting of wax and plastic, evaporation of alcohol) The burnt substance then appears as a solid product (e.g. frozen) or as a liquid (e.g. drops which smell like alcohol)

- As far as the structure of the substances is concerned most consider solid matter and liquids to be on continuum and the evaporation of liquids and the dissolving of salt in water do not contradict this. In these processes, particles are thought to be created which did not exist previously. To the extent that the concept of particles is accepted, it is imagined that particles of gases are embedded in the air (Anderson, 1990; Griffiths & Preston, 1992; Jonston, 1990; Nussbaum, 1985; Renström et. al. 1990; Stavy, 1990, 1994)

Nieswandt (2001) aimed to improve students' learning of basic concepts of chemistry. For this reason, he developed six teaching units. The general teaching strategy of the course was: (1) make students aware of their own relevant everyday conceptions and (2) engage students in "planned cognitive conflicts." At the end of the study he showed that there was a decrease in everyday conceptions of students while the proportion of students that held scientific conceptions was increased.

Some science education researchers have linked concept understandings and alternative conceptions to preexisting knowledge and instructional exposure to scientific concepts. (Baker, 1991; Driver & Oldham, 1986; Osborne & Wittrock, 1983) However Abraham and Williamson (1994) have suggested a link between concept understanding and formal reasoning ability. They investigated the influence of grade level and reasoning ability on the understanding of selected chemistry concepts. One of these concepts is chemical change. In addition, they investigated the number and type of alternative conceptions held by students after varying amounts of instruction in chemistry, and the use of atomic and molecular explanations by students who have had varying amounts of instruction in chemistry. The study consisted of 100 junior high school students, 100 high school and 100 college students. All concepts were taught at all levels and were explained in terms of atomic and molecular models in the textual materials used by the students. Item 1, which measured understanding of the chemical change concept, required students to explain the source of a black film when a glass rod was held in a candle flame.

Misconceptions concerning chemical change were held by 73.3% of the students, whereas 9.3% had no understanding. These misconceptions were:

- Burning of a candle was a physical change because the candle had undergone a phase change or was the same substance.
- Black film on the glass rod was oxygen from air, gas from the flame, or burning of the rod.
- Black material on the rod came from the combustion of the wick not the wax.
- Burning was physical because the wax was unchanged or chemical since the wick was burned.
- The black film on the rod was due to burning of the rod or breakdown of the glass.
- Burning of candle was a physical process. Because it was only a phase change.
- Burning of candle was a physical process. Because it is irreversible.

They concluded that (1) both reasoning ability and experience with concepts account for the understanding of chemistry concepts, (2) students at all levels tended not to use atomic and molecular explanations for chemical phenomena. Although the use of atomic and molecular models increases with increased exposure to chemical concepts, it is still surprisingly low even among college students, (3) there were no predictable patterns in the frequency of alternative conceptions with respect to experience with the concept.

Abraham et al. (1992) designed a study to find out what misconceptions do eight grade students have concerning the chemistry concepts from their textbooks. Problems concerning the chemical change, dissolution, conservation of atoms, periodicity and phase change were given to 247 eight-grade students to assess the students' degree of understanding of chemistry concepts and to identify specific misconceptions. The level of understanding of chemical change concept was assessed by using the following problem:

"As a candle burns it gives off light and heat when a glass rod is held in the yellow part of the flame a black film forms on the rod.

A. What is the source of the black film on the rod?
B. Is the burning of the candle a chemical or a physical change?"

In order to show understanding of the chemical change concept, students were expected to identify that a chemical change had taken place because a transformation had occurred and that a new substance was formed, not just a different form of the original substance. 37 students (about 15%) showed some understanding of this concept. Another 15% showed specific misconceptions. Some of these responses indicated some understanding of a chemical change but then provided evidence of physical change. (Change of shape or form) Some responses said the change was physical because no chemicals were involved. 70% of the students showed no understanding of this concept. Some students confused the source of the black film with an identification of the soot and 33 mentioned oxygen, carbon dioxide or air. Heat was mentioned by 50 students as being the source of black film.

Many students also invoke static models to explain chemical changes. Anderson (1986) studied students, ranging in age from 12 to 15 years, from Sweden where chemistry instruction starts in grade 7 or 8. At least 90% of the students had studies oxidation. He asked the students:

> "Why shiny copper water pipes do turn dull and tarnished? or
>
> What happens when a nail rusts?"

in order to find out student explanations about the appearance and disappearance of substances in a chemical change. He found that the students' answers tended to fall into five categories. (1) It's just that way: Students were uninterested in the change. They noticed happens. (2) Displacement from one physical location to another occurs: students envisioned that a coating simply materializes, either from the air, as with rust on a nail or from the water inside the pipes. (3) The material is modified: students thought that what appears to be a new substance was actually modified form of original substances and it continued to be the same substance, although it looked different. (4) Transmutation occurs: Students viewed that atoms changed into a new kind of atom. For example, they explained that steel wool grains weight as it burns because the steel wool was changed to carbon which was heavier. (5) Chemical interaction occurs: This category involved acceptable answers. For example students said that oxygen in the air reacted with the copper pipe to form a copper oxide coating on the pipe. Above categories except the last one represent responses that show that the students lacks on understanding of the following underlying conceptions:

- The matter is composed of particles.
- That these particles are in constant motion.
- That these particles can react with each other by breaking or forming bonds.

A static representation of chemical change was also found by Ben-Zvi, Eylon & Silberstein, (1987). They asked grade 10 students, who had been studying chemistry for a half a year, to draw what they thought the following electrochemical equations meant.

$2KF(l) \longrightarrow 2K(s) + F_2(g)$ and $Cu^{+2}(aq) + 2e^- \longrightarrow Cu(s)$

They found that 58% of the students drew static representations. Only 38% drew any kind of dynamic representation.

Ben-Zvi, Eylon & Silberstein (1987, 1988) also noted that some students seem to have an additive model of reaction; compounds are viewed as being formed by simply sticking fragments together, rather than as being created by the breaking and reforming of bonds. For example when asked if NO could be formed by a reaction between O_2 and N_2 could be decomposed. This type of answer is consistent with a static model of matter.

Stavridou and Solomonidou (1989) studied Greek students ranging in age from 8 to 17 years as they attempted to classify events as physical changes or chemical changes. Over half of their students incorrectly classified a chemical change as "no change." These students seem to use a very static model for these events. They also reported that these students seem to focus on the "external manifestations" of phenomena, which led them to incorrect conclusions. In addition, some of the students who did have a concept of change nonetheless seem to think that only physical changes were reversible and chemical changes were always seen as irreversible.

Ben-Zvi, Eylon and Silberstein (1987) agree that balancing and interpreting equations is a formidable task. They argue that an appropriate interpretation of chemical equations requires that a learner understand many concepts such as the structure and the physical state of the reactants and products, particulate nature of matter, the quantitative relationships among the particles.

Many students perceive the balancing of equations as algorithmic exercise. Students were able to successfully balance the chemical equations but were not able to construct diagrams that were reasonable consistent with the notation of the balanced equation. Yarroch (1985) interviewed high school chemistry students on how they balanced the simple equations used to describe reactions such as:

$$N_2 + H_2 \longrightarrow NH_3$$

All of the students successfully balanced the equations. Then students managed to make diagrams of the equations. The diagrams that were made could be divided into two distinct groups based upon how the elementary particles in the diagrams were organized. The diagrams of the first group could be described as representing a valid chemical interpretation of the equation. The diagrams of the second group represented alternative interpretations of the equations. These alternative diagrams were most consistent with a simple mathematical interpretation of the numbers and symbols in the equations. As a result, half of the students could not draw a correct molecular diagram to explain the equations in the microscopic system. Although the unsuccessful students were able to draw diagrams with the correct number of particles, they seemed unable to use information contained in the coefficients and subscripts to construct the individual molecules.

BouJaoude (1991) investigated junior high school students' understanding about the concept of burning. He selected burning as the topic for investigation because: (a) It has different everyday and scientific meanings and (b) Numerous chemistry textbooks use burning to introduce the concept of chemical change. He used the interview-about-events technique to elicit eight-grade students' understandings about the concept of burning. He used demonstrations including, burning a candle, lighting an alcohol burner, lighting a gas burner, showing the students a piece of charred bread and heating sugar in a spoon and activities. He listed eight-grade students' understandings about burning:

- Wax, alcohol and oxygen are not actively involved in burning.
- Substances undergo no chemical change during burning.
- Terms such as evaporation and burning can be used interchangeably when describing burning alcohol.
- Phrases such as physical change and chemical change can be used interchangeably when describing burning things.

Solsona and Izquerdo (2003) thought that from a macro point of view chemical reactions are considered as a process by which some substances disappear and new substances appear. From a micro point of view chemical reactions are considered as a process by which particles are re-ordered. They deal with the problematic issue of how to interpret phenomena of change (substances disappearing and new ones appearing), in terms of unchanged entities (atoms). At end of the study they reported the development of secondary school students' processes of reasoning, taking into account that these students have to learn how to relate macro-descriptions of chemical change to micro-descriptions. Students were taught chemical change as a process of formation of new substances as well as a process of atomic re-ordering. Research data were obtained from students' essays about chemical change. The assays were written by the same students on two occasions: at the beginning of the second school year (grade 11) and one year later. They analyzed all the essays using a set of categories which was based on the method of linguistic analysis. In order to study this structure in a more specific way they developed maps of the text structures. By this way they identified four conceptual profiles of chemical change: the interactive profile, the meccano profile, the kitchen profile and the incoherent profile. The analysis of second essays showed that only 8% of students reasoned according to the interactive profile. This result showed that a vast majority (92%) of students were not able to understand the concept of chemical change in a balanced way, by relating the macroscopic meaning with the microscopic meaning of this concept.

Differences between elements, compounds and mixtures form the basis for understanding chemical reactions. Different definitions of element make the distinction. For example, Freemantle (1987) make the definition as "A pure substance which cannot be split up into any other pure substance". To understand this definition and phrase "cannot be split up", students have to understand the particulate nature of matter. On the other hand, Atkins (1989) define element as "a substance that consists of only one kind of atom". To understand this definition student must know the meaning of atom. This topic has received relatively little attention from researchers, although Barker (1995), Briggs and Holding (1986) and Ben-Zvi et al (1986) have studied students' thinking about these ideas.

Briggs ad Holding (1986) investigated how 15 years old students use their ideas about particulate nature of matter in understanding differences between elements, compounds and mixtures. They used colored dots to represent different atoms in diagrams of a mixture of two elements, a compound and an element alone. About 30% of respondents selected all diagrams correctly. But a number of students could not discriminate between particulate representations of compounds and elements. About half of the students regarded any diagram that contained different symbols for atoms as a representation of a mixture. Interviews showed that students seemed to understand the macroscopic nature of an element but did not use particle ideas. In addition, students were asked to identify an element from a list of four substances; each described using basic chemical terminology. Only 21% of students used particle ideas in making choice. In the same study, students were asked to consider if a substance was an element on the basis of specified results of tests. Some responses incorporated physical characteristics into a definition of element, for example,

> "…no element can have a melting point above 200 ^{0}C and dissolve
> in water to give a colorless solution."

Barker (1995) carried out a longitudinal study of the understanding of a range of basic chemical ideas among 250 16-18 year old students taking the UK post-16 chemistry course called Advanced (A) level. She found that almost all students starting A level courses in chemistry could distinguish correctly between the Briggs and Holding diagrams. She revealed that around 3% of 16 year olds beginning A level chemistry courses could give general tests to determine if a substance is an element or compound, a figure which increased to 17% at the end of course. She reports that about 43% could define element and compound correctly at the start of an A level course and that this figure remained unchanged at the end.

Ben-Zvi et al (1986) found that nearly half of 15 year olds attributed the bulk physical properties of copper to single atoms of the elements itself, thus making each atom a microscopic version of the element.

2.3. Conceptual Change Teaching Strategies

Over the last twenty years, research program has been established in the area of children's conceptual understanding in science. Outcomes of this research include detailed information about children's conceptions, at various ages, in a wide range of science domains. Children's existing conceptions about natural phenomena is a common theme for research program. Learning is seen in terms of conceptual development or change rather than adding new information to existing knowledge. Various models of learning, based upon this viewpoint, have been proposed, some deriving from epistemological literatures (Posner, Strike, Hewson and Gertzog, 1982), others from cognitive psychology (Osborne and Wittrock, 1983). All of this work has strong implications for classroom practice.

Conceptual change does not imply that initial conceptions are extinguished. Initial conceptions, especially those that hold explanatory power in nonscientific contexts may be held concurrently with new conceptions. Successful students learn to utilize different conceptions in appropriate contexts. That is the status of one particular conception may change in differing contexts. (Tyson et al., 1997)

There are pedagogical decisions to be made at three levels. Firstly, the teacher needs to foster a *learning environment* which will be supportive of conceptual change learning. Such an environment would, for example, provide opportunities for discussion and consideration of alternative viewpoints and arguments. A second level of decision-making involves the selection of *teaching strategies. S*trategies in terms of overall plans will guide the sequencing of teaching within a particular topic. Finally, consideration must be given to the choice of specific *learning tasks*. The learning tasks fit into the framework provided by the selected strategy and must address the demands of the particular science domain under consideration.

In making decisions about appropriate teaching strategies, four factors may need to be taken into consideration: Students' prior conceptions and attitudes, the nature of the intended learning outcomes, an analysis of the intellectual demands involved for learners in developing or changing their conceptions, a consideration of the possible teaching strategies which might be used in helping pupils from their existing viewpoints towards the science view.

In order to identify strategies used by secondary science teachers to diagnose their students' preconceptions in the regular classroom environment and the ways that teachers might use the information gathered in such a diagnosis a study was designed by Morrison and Lederman (2003). This study involved intense observation of four teachers in their classrooms, interviews with these teachers about their classroom strategies, analysis of teachers' lesson plans, and analysis of their students' written work to determine whether any diagnosis of students' preconceptions occurred before and or during the teaching of a specific concept. A detailed profile of the teachers and their classroom practices was prepared. Coding categories provided a structure to outline the teachers' practices and particularly address their use of strategies to diagnose students' preconceptions. Although teachers had an intuitive feeling that they need to know students' ideas before teaching a concept, none of the teachers did not mention strategies such as pretests, concept maps, writing prompts, interviews, or journals that might be used to diagnose students' preconceptions in the classroom.

Posner et al (1982) believed learning like inquiry, is best viewed as a process of conceptual change. The basic question concerns how students' conceptions change under the impact of new ideas and new evidence. They proposed two types of conceptual change: *assimilation* which describes the process where students use existing concepts to deal with new phenomena and *accommodation* which describes when the student must replace or reorganize his central concepts.

Cognitive conflict has been used as the basis for developing a number of approaches to teaching for conceptual change. Nussbaum and Novick (1982) suggest a teaching sequence which draws upon the Piagetian notion of accommodation (Piaget, 1974) and includes four main elements:

- Initial exposure of students' preconceptions through their responses to an exposing event.
- Sharpening students' awareness of their own and other students' frameworks.
- Creating conceptual conflict by attempting to explain a discrepant event.
- Encouraging and guiding cognitive accommodation and the invention of a new conceptual model consistent with the accepted science view.

Cosgrove and Osborne (1985) have proposed a "Generative Learning Model of Teaching" which is organized into four phases: (1) *Preliminary Phase:* teacher needs to understand the scientist's view, the children's view, and his /her own view. (2) *Focus Phase:* opportunity for pupils to explore the context of the concept, preferably within a real everyday situation. (3) *Challenge Phase:* learners debate the pros and cons of their current views with each other and the teacher introduces the science view (where necessary). (4) *Application Phase:* opportunities for application of new ideas across a range of contexts.

According to Posner et al. (1982) there are four conditions for accommodation to occur: (1) Students don't explain an event with their existing concepts. (*Dissatisfaction*), (2) Students must be able to grasp how experience can be structured by a new concept sufficiently. (*Intelligibility*), (3) A new concept must be consistent with other knowledge. (*Plausibility*), (4) A new concept should have the potential to be extended to new areas of inquiry. (*Fruitfulness*)

The teacher has to ensure that students find new content to be intelligible, plausible and fruitful and this can only be done by taking account of prior knowledge since a conception presented by the teacher can be plausible to one student but not to another for whom it contradicts a firmly held conception. Therefore, the same ideas may require different teaching strategies for different students (Hewson and Hewson, 1983). Possible teaching strategies include:

1. Integration: The aim is to integrate new conceptions with existing conceptions, or different existing conceptions with each other. This is the dominant teaching strategy in science teaching today and is based on the assumption that the students' existing conceptions are those which the teacher has taught.

2. Differentiation: The aim is to differentiate existing conceptions into more clearly defined, separated but closely related conceptions. The student needs to see that what was plausible in the situation is no longer plausible in a different as more complex one.

3. Exchange: The aim is to exchange an existing conception for a new one because they contradict one another and cannot, therefore, both be plausible. Since a student is not going to exchange a plausible conception for one which is seen to be implausible, it becomes necessary to create dissatisfaction with the existing conception as well as showing that the new conception as more explanatory and predictive power than the old.

4. Conceptual Bridging: The aim is to establish an appropriate context in which important abstract concepts can be linked with meaningful common experiences. The choosing of a question which has to be answered in terms of the abstract concepts being taught creates a setting in which these concepts can be seen to be plausible and fruitful.

Some constructivist science educators used conceptual change approaches in science education and demonstrated the effectiveness of conceptual change approach to science learning. (Tyson et al. 1997, Hewson and Hewson, 1983; Stofflet & Stoddart, 1994; Hynd et al., 1994, Nieswandt, 2001)

Hynd et al. (1994) conducted a study to determine the effect of participating in viewing a demonstration, engaging in student-to-student discussion or reading a refutational text on conceptual change in physics. 310 ninth and tenth grade students were randomly assigned within classes to eight groups representing combinations of the three activities and participated in pretest, instruction and posttest. Posttest results showed that reading the refutational texts helped students change their intuitive ideas to scientific ones while seeing a demonstration or discussing ideas did not lead to significant learning of scientific notions.

Hewson and Hewson (1983) researched students' alternative conceptions and instructional strategies to effect the conceptual change from alternative to scientific conceptions. The scientific conceptions of mass, volume and density were taught to two groups of students using two different instructional strategies. The experimental instructional strategy was designed to lead students from their existing knowledge to the scientific knowledge. The traditional instructional strategy followed the presentation of concepts usually seen in textbooks on introductory physical science. The experimental strategy explicitly dealt with students alternative conceptions while the control strategy did not. The strategies of conceptual change were designed to promote the acquisition of new conceptions as a consequence of the exchange and differentiation of the existing conceptions, and the integration of new conceptions with existing conceptions. The instructional strategy and materials were developed for black high school students in South Africa. Pre- and post tests were used to assess the conceptual change that occurred in the experimental and control groups. The results showed a significantly larger improvement in the acquisition of scientific conceptions as a result of the instructional strategy and materials which explicitly dealt with student alternative conceptions.

Stofflet & Stoddart (1994) demonstrated that the theory of science conceptual change can be applied to elementary science teacher education and research. The elementary science methods course developed in this study was very different from the typical methods course because it is used the literature on scientific conceptual change to develop an intervention that would promote the accommodation of pedagogical preconceptions held by preservice teachers. The course then evaluated using the same criteria to determine whether the theoretical intentions were achieved.

Based on implications in the literature, the methodology of teaching is the underlying factor that influences chemistry achievement. Conceptual change strategy seems to be satisfactory approach that can be used to enhance students' understanding of chemistry concepts and it is important to test how successful it will be when compared to the other alternative teaching strategies.

2.4. Cooperative Learning

Cooperative learning is an old idea in education, which has experienced a substantial revival in educational research and practice in recent years. Cooperative learning is an approach to teaching in which groups of students work together to solve problems and complete learning assignments. (Johnson D. & Johnson R. 1989) Johnson and Johnson also assert that the research data on cooperative learning show that its use leads to students;

- Learning more material
- Feeling more confident and motivated o learn
- Exhibiting higher achievement
- Having greater competence in critical thinking
- Possessing more positive attitudes toward the subject studied
- Exhibiting greater competence in collaborative activities
- Having greater psychological health
- Accepting the differences among the peers

In cooperative groups, students share and compare their ideas to those of their peers, so that they take a different perspective than their own. This can give rise to the dissatisfaction that is proposed as a necessary condition for conceptual change. (Posner et al., 1982) Brandt (1987) identified a variety of outcomes of cooperative learning: achievement increases for all ability levels; higher-level thinking processes can result; a deeper level of understanding is possible; critical thinking is promoted; more positive peer relationships result; students exhibit better social skills and provide more social support for their peer; and a higher level of self esteem can result.

Slavin (1989) indicates that cooperative learning has been proposed as a solution to many problems in education. Since achievement is a frequently desired goal, Slavin stresses that two conditions must be present: a group goal and individual accountability. The success of the group must depend on the individual learning of all group members. Newmann and Thompson (1987) agree with Slavin that in addition to group goal and individual accountability, cooperative task structure and group reward are needed for effective cooperative learning. Because of the lack of these elements Jigsaw is less successful than other methods and STAD is the most successful method.

Slavin (1989) believed that group rewards based on individual achievement of each group member improves student achievement. On the other hand, Kohn (1991) thinks rewards undermine intrinsic motivation. He believes that a carefully structured cooperative environment that offers challenging learning tasks that allows students to make key decisions about how they will perform these tasks and that emphasizes the value of helping each other learn is a sufficient alternative to extrinsic motivators.

Johnsons (1992) outlined the essential components of a teaching and learning strategy that would focus on bringing small groups of students together in teams to work cooperatively. They proposed a model in which five elements were essential for cooperative learning groups to be successful:

1. Face to Face Interaction: The physical arrangements of students in small, heterogeneous groups encourage students to help, share and support each others learning.

2. Positive Interdependence: The teacher must structure the lesson either through a common goal, group reward or differentiated role assignments to achieve interdependence between students in a learning team. Assigning each person a role in the group is a way to achieve positive interdependence.

3. Individual Accountability: Each student in a learning team must be held accountable for learning and collaborating with other team members. Teachers can achieve individual accountability by focusing on (a) individual contributions of students (using roles, dividing the task, using experts, giving feedback) and (b) individual outcomes of students (using tests, quizzes, grading homework or giving group rewards for individual behavior.

4. Cooperative Social Skills: Students need to learn interpersonal skills such as active listening, staying on task, asking questions, making sure everyone contributed and using agreement for effective cooperative learning.

5. Group Processing: Students need to reflect on how well they worked together as a team to complete a task such as a laboratory activity. The teacher can structure to rate how well they did in the activity.

Many cooperative learning methods have been developed and tested over the last 30 years. The research has focused on four models: Student Teams – Achievement Divisions (Slavin R. E.), Teams – Games – Tournaments (Slavin R. E.), Jigsaw (Aronson E.) and Group Investigation (Sharan Y. & Sharan S.)

1. Student Teams – Achievement Divisions (STAD): Student team – achievement divisions (STAD) was originated by Robert Slavin and his colleagues at Johns Hopkins University. The STAD model is a very easy model to implement in the science classroom. STAD operates on the principle that students work together to learn and are responsible for their teammates' learning as well as their own. There are four phases of the STAD model: (i) Teaching (class presentation): The class presentation is a teacher-directed presentation of the material (concepts, skills and processes) that the students are to learn. (ii) Team study: In STAD, teams are composed of four students who represent a balance in terms of academic ability, gender and ethnicity. Team is the most important feature of STAD and it is important for the teacher to take the lead in identifying the members of each team. Each team would be composed of a high and a low ranking student and two near the average. Teams should also be formed with sex and ethnicity in mind. In short, each team should be more or less on average composite of the class.Team study consists of one or two periods in each team masters material that you provide. Team members work together with prepared worksheets and make sure that each member of the team can answer all the questions on the worksheet. Students should move their desks so that they face each other in each small team. Give each team two worksheets and two answer sheets. In the STAD model the following team rules are explained:

- Students have the responsibility to make sure that their teammates have learned the material.
- No one is finished studying until all teammates have mastered the subject
- Ask all teammates for help before asking the teacher
- Teammates may talk with each other softly

During small group sessions students will teach each other, and learn from each other. Teacher may circulate from group to group asking questions and encouraging students to explain their answers. (iii) Testing: After the team study is completed, the teacher administers a test to measure the knowledge that students have gained. Students take the tests individually and are not permitted to help each other. To encourage students to work harder, STAD uses an individual improvement score. Team averages are reported in the weekly recognition chart. (iv) Team Recognition. Teachers can use special words to describe the team's performance such as science stars, science geniuses and etc.

2. Teams – Games – Tournaments (TGT): Teams – Games – Tournaments (TGT) method was developed by Slavin (1989) and involves the same use of heterogeneous teams, instructional format and worksheets as does STAD for the learning of information. TGT is built around two major components: 4- to 5-member student teams and instructional tournaments. The teams are the cooperative element of TGT. The primary function of the team is to prepare its members to do well in the tournament. Following an initial class presentation by the teacher, the teams are given worksheet covering academic material similar to that to be included in the tournament. Teammates study together and quiz each other to be sure that all team members are prepared. For the tournament, students from different teams are placed in groups of three students of comparable ability. Students at the tournament tables are competing as representatives of their teams and the score each student earns at his or her tournament table is added into an overall team score. Students enjoy challenge of the tournament and because they compete with others of comparable ability, the competition is fair.

3. Jigsaw: This cooperative learning method was developed by Aronson (1978). In Aronson's method each student in a five member group is given information that comprises only one part of the lesson. Each student in the group has a different piece of information. All students need to know all information to be successful. Students leave their original group and form an expert group in which all persons with the same piece of information get together, study it, and decide how best to teach it to their peers in the original group. After this is accomplished, students return to their original groups, and each teaches his/her portion of the lesson to the others in the group. Students work cooperatively in two different groups, their group and the expert group. Grades are based on individual examination performance. There is no specific reward for achievement or for the use of cooperative skills. (Knight & Bohlmeyer, 1990)

There are now two additional versions: Jigsaw II and Jigsaw III.

a) Jigsaw II: The first step in the use of Jigsaw II is to select a chapter that contains material for two or three days. Divide the content in the chapter into chunks based on the number of team members. Each member of the team is assigned one of the topics and must read the chapter to find information about his or her assigned chunk. Expert groups should meet for about one class period to discuss their assigned topic. Then each experts returns to his or her learning team and teaches the topic to the other members. Teacher encourages members to use a variety of teaching methods. After the experts are finished reporting, he/she conducts a brief class discussion or a question and answer session. The test, which covers all the subtopics, should be administered immediately. Team recognition should follow the same procedures used in STAD.

b) Jigsaw III: This method developed by Spencer Kagan (1990), is for use in bilingual classrooms. Cooperative groups consist of one English speaker, one non-

English speaker, and one bilingual student. All materials are bilingual. (Knight & Bohlmeyer, 1990)

4. Group Investigation: Developed by Shlomo Sharan and Yael Sharan and their colleagues, the group investigation (GI) method is one of the most complex forms of cooperative learning. Students organize into groups of five or fewer and choose specific topics or problems in a general subject area of science. Teacher and his or her students in each learning team plan specific procedures, tasks, and goals consistent with the subtopics of the problem selected. Students carry out the plans formulated in the second step. Learning should involve a wide range of activities ad skills and should lead students to different kinds of sources, both inside and outside of school. Students might work in small groups or individually to gather data and information. Students meet to discuss the results of their subgroup or individual work. One of the attractive features of GI is that each team makes a presentation to the whole class. Students have to cooperate to prepare a presentation.

2.5. Cooperative Learning and Conceptual Change

A review of literature showed that one of the conceptual change strategies to remediate students' alternative conceptions is cooperative groups (Basili &

Sanford, 1991; Case & Fraser, 1999; Fraser & Case, 1999; Johnson & Johnson, 1992.)

Johnson & Johnson (1989) have reviewed the literature on cooperative learning and concluded that cooperative learning tends to promote higher achievement than does competition and or individual work for all age levels, all subject areas, and a variety of tasks.

Okebukola (1986) investigated the effect of cooperative work on students' attitudes toward the science laboratory. Ninth grade biology students in two schools participated in the study. Attitudes were measured using the Attitude toward Laboratory Work Scale. The scale was administered as both a pretest and a posttest. Posttest results indicated that students in the experimental treatment held significantly more favorable attitudes toward laboratory work than did students in the control group. Attitudes of male students were more favorable that those of females in the experimental group, but regardless of sex, attitudes of students in the experimental group were still more positive than those of control group students.

Lonning R. A. (1993) conducted a study in order to evaluate the effects of cooperative learning on students' verbal interaction patterns and achievement in a conceptual change instructional model in secondary science. Current conceptual change instructional model recognize the importance of student–student verbal interactions, but lack specific strategies to encourage these interactions. To provide necessary strategies for verbal interactions, cooperative learning was used. Two sections of 36 low ability 10th grade students were taken as experimental and control groups. Students in both sections received identical content instruction on the particle model of matter using conceptual change teaching strategies. The conceptual change teaching strategies were based on the instructional model Rosalind Driver. In these models instruction consists of four phases: (a) Orientation: A context for the instruction is presented and the relevance of the topic to the students established. (b) Elicitation: Students are given opportunities to make their personal conceptions explicit to other students, the teacher, and most importantly, to themselves. (c) Restructuring, modification and extension: Involves activities designated to allow students to exchange ideas with peers and construct and evaluate new ideas. (d) Application: Provides opportunities for students to try out their newly constructed concepts in familiar and new contexts. The experimental group used cooperative learning strategies involving instruction in collaborative skills and group evaluation of assignments. This instruction centered around five elements of cooperative learning: positive interdependence, face-to-face interaction, individual accountability, interpersonal and small group skills, and group processing. The control section received no collaborative skills training and students were evaluated individually on group work. Two measurement instruments were developed for this study. The test of conceptual understanding was developed to measure the students' achievement in understanding the concepts presented during instruction. The verbal interaction scheme was developed to categorize specific verbalizations that took place while the students engaged in group work. At the end of the study, it was found that the students using cooperative learning strategies showed greater achievement gains and made greater use of specific verbal patterns. The result of the study demonstrated that cooperative learning strategies enhance conceptual change instruction.

Barbosa, Jofili & Watts (2004) prepared three case studies within the teaching and learning of chemistry. Each case considers the effectiveness of group learning activities in terms of the ways in which they enhance cooperative learning. Group tasks are generally undertaken in order to encourage learners to develop their understanding of particular issues. These three cases were: (i) investigate the development of cooperative attitudes among students, looking for significant learning of scientific concepts, (ii) encourage the development of ethical attitudes, to motivate, and then (iii) empower the participants so that they can build upon the communal knowledge. For case study 1, 420 students at university level took part. In the Jigsaw method the academic material is divided into small parts and each member of the group is assigned just one part of the class work to study. Then they join with others who have read the same piece in order to discuss their materials. After the discussion each student returns to their original group and teaches their part to other members. For case study 2, 69 science students participated from eight grade classes. One class used the jigsaw method and the other carried out its work individually. In the latter the teacher explained the subject matter, performed experiments as demonstrations and solved numerical problems. Then students at this class were given a sheet similar to that of jigsaw group to be answered individually. Case study 3 based on Communicare Nelle Science project, a European-funded project between France, Italy and the UK. The groups in each school have communicated their work to schools in other countries by means of a project website. Some key elements to be drawn from three case studies:

- Group work must be considered as a means for the intellectual, personal, social and ethical development of learners.
- Group work is important in raising students' self-esteem as they actively contribute to the construction of knowledge.
- Student awareness that they studying with a particular audience in mind enhance motivation and add a real-world dimension to the classroom.

Basili et al. (1991) conducted a study at a suburban community college tested a method of conceptual change in which treatment students worked in small cooperative groups on tasks aimed at eliciting their misconceptions so that they could be discussed in contrast to the specific conceptions that had been taught in direct instruction. Categorizations of student understanding of the target concepts of the laws of conservation of matter and energy and aspects of the particulate nature of gases, liquids and solids were ascertained by pre- and post testing. 62

students were enrolled in four sections that were heterogeneous. Both instructors were taught one treatment group. At the beginning of the study, treatment students instructed by using concept maps and informed of the nature and requirements of the group sessions. Regular instruction consisting of the lecture/discussion proceeded for five class periods. During the last class period students worked in groups of three to five. Both instructors were taught one control group. Lecture/discussion paralleled that in the treatment group. During the last class period control group students were given a demonstration related to the course content. Student conception test was used to assess and categorize concept understanding. Verbal interaction coding scheme was use to assess the effects of the tasks from the perspective of the resulting process in small groups. Chi-square analysis of posttests indicated that students in the treatment group had significantly lower proportion of misconceptions than control students on four or five target concepts. Students who exhibited no change in concept state had a higher frequency of verbal behaviors suggestive of impeding conceptual change when compared to students who did change.

Chang and Mao (1999) investigated the effects of cooperative learning instruction versus traditional teaching methods on students' earth science achievement in secondary school. 770 secondary school students and 8 teachers from ninth-grade earth science classrooms took part in the study. Ten classes receiving the cooperative-learning instruction were randomly assigned to experimental groups; the other ten classes taught by a more traditional lecture instruction were randomly assigned to the control groups. In the experimental group, class presentation of group discussion and teacher discussions with students were followed by the teacher's explanation of the weather system in Taiwan. For the control groups, the traditional instructional method included lectures by the teacher, assigned textbook readings, whole class discussion, and a review of textbook topics at the end of each teaching unit. After treatment both control group and experimental group received meteorology achievement test. An analysis of covariance on posttest scores with pretest scores as the covariates was applied to the achievement data. ANCOVA tests performed on posttest scores revealed that no statistically significant differences were found with regard to student overall earth science achievement ($F=0.13$ $p>0.05$). There were no significant differences between subjects who used cooperative and individual learning strategies on knowledge-level scores ($F=0.12$, $p>0.05$), on comprehension-level scores ($F=0.34$, $p>0.05$). However, the cooperative learning group had significantly higher achievement scores on the application test items than those exposed to the more traditional approach ($F=4.63$, $p<0.05$)

Lazarowitz & Lazarowitz (1994) used jigsaw-group mastery learning approach in order to teach a unit in earth science. A sample of 120 eleventh and twelfth grade students were randomly assigned to five sections and two treatments. The experimental group included three sections who studied the topic energy in a group mastery learning (GML) approach while the control group consisted of two sections who studies the same topic in an individualized mastery learning (IML) approach. Since the importance of both academic and nonacademic outcomes in assessing the effectiveness of the cooperative learning experience, two sets of measures were used in this study. The same achievement test was administered to all of the students by using two forms of scoring: the objective score reflecting the number of subunits on which the students achieved 2/3 level of mastery and a mean score reflecting a normative measure. Nonacademic assessment involved; (a) self esteem: items were adapted from the work of Aronson et al. (1978) (b) friendship: were assessed through a sociometric measure (c) classroom learning environment: measured based on a questionnaire. An analysis of covariance was conducted using the pretest scores as covariates to test for the effect of methods and gender on the posttest scores. The results of the study show that when a cooperative mode of learning is incorporated within the mastery learning approach, students gains in both academic and nonacademic ways.

Based on implications in the literature, the methodology of teaching is the underlying factor that influences science achievement. Conceptual change strategy seems to be satisfactory approach that can be used to enhance students' understanding of science concepts and it is important to test how successful it will be when compared to the other alternative teaching strategies. However, the effectiveness of using cooperative learning based on conceptual change conditions in instruction is questionable. Some studies showed that cooperative learning based on conceptual change conditions provided a better acquisition of scientific conceptions and removing alternative conceptions. But this approach did not provide an excellent understanding of scientific conceptions after instruction. Therefore further researches are needed to investigate the effects of cooperative learning based on conceptual change conditions on different science subjects.

It can be said that the main difference of the present study when compared to the other studies is due to the treatment factor on understanding of chemical and physical changes and classification of matter concepts. There is no study comparing the effectiveness of cooperative learning based on conceptual change conditions over traditionally designed chemistry instruction in terms of chemical and physical changes and classification of matter concepts.

CHAPTER 3

PROBLEMS AND HYPOTHESES

In this chapter, the main problem, sub-problems and associated hypotheses were presented.

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 cooperative learning based on conceptual change conditions over traditionally designed science instruction on 7^{th} grade students' understanding of physical and chemical changes, classification of matter concepts and attitudes towards science as a school subject.

3.1.2. The Sub-Problems

1. Is there a significant difference between the effects of traditionally designed science instruction and cooperative learning based on conceptual change

conditions on students' understanding of physical and chemical changes, classification of matter concepts, when the effects of students' science process skills are controlled as a covariate?

2. Is there a significant difference between the means of males and females with respect to understanding of chemical and physical changes and classification of matter concepts?

3. Is there a significant effect of interaction between treatment and gender difference on understanding of chemical and physical changes and classification of matter concepts?

4. What is the effect of students' science process skills on understanding of chemical and physical changes and classification of matter concepts?

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

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

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

3.2. Hypotheses

In this study, the following hypotheses were developed in order to find solutions to main problems and sub-problems stated above. All hypotheses were stated in null form.

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 conditions with respect to achievement related to physical and chemical changes, classification of matter concepts when the students' science process skills are controlled.

H_0 2. There is no significant difference between the means of males and females with respect to understanding of chemical and physical changes and classification of matter concepts.

H_0 3. There is no significant effect of interaction between treatment and gender difference on understanding of chemical and physical changes and classification of matter concepts.

H_0 4. There is no effect of students' science process skills on understanding of chemical and physical changes and classification of matter concepts.

H_0 5. There is no significant difference between the effects of traditionally designed science instruction and cooperative learning based on conceptual change conditions on students' attitudes toward science as a school subject.

H_0 6. There is no significant difference between the means of males and females' attitudes toward science as a school subject.

H_0 7. 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

The cooperative learning based on conceptual change conditions was used in this study in order to change 7^{th} grade students' alternative ideas about physical and chemical changes and classification of matter concepts to scientifically accepted ideas. This chapter explains the experimental design, subjects of the study, variables, instruments, treatment and analysis of data.

4.1. The Experimental Design

In this study, the Non Equivalent Control Group Design as a type of Quasi-Experimental Design was used. This design does not involve random assignment of subjects to groups, but already formed groups are used. Therefore, each class was assigned as control or experimental group randomly.

Table 4.1. The Experimental Design

Groups	Pre-test	Treatment	Post-test
EG	CCMT,ASTS, SPST	CLCC	CCMT, ASTS
CG	CCMT,ASTS, SPST	TDSI	CCMT, ASTS

In this table, EG represents the Experimental Group instructed by cooperative learning based on conceptual change conditions (CLCC). CG represents the Control Group instructed by traditionally designed science instruction (TDSI). CCMT is the Classification and Changes of Matter Test involving physical and chemical changes and classification of matter as elements, compounds and mixtures concepts. ASTS is the Attitude toward Science as a School Subject. SPST is the Science Process Skills Test.

102 seventh grade students were participated in this study and treatment was completed with four weeks. The experimental group consisting of two classes (n=50) were taught by cooperative learning based on conceptual change conditions. The control group consisting of two classes (n=52) were taught by traditional method. The experimental group engaged in cooperative small groups while the control group participated in whole class discussions. Both of the groups completed the study at the same time. The equivalence of the groups was ascertained by the results of science process skills test.

At the beginning of the study CCMT, ASTS and SPST tests were given to students in both groups. At the end of the treatment, to examine the effect of the treatment on dependent variables two tests CCMT and ASTS were given to students in both groups.

4.2. Subjects of the Study

In this study 102 seventh grade students from four classes of a Science Course instructed by two teachers from ODTÜ G.V. ÖZEL İLKÖĞRETİM OKULU took part. This study was conducted during the 2004-2005 fall semester.

One class of each teacher was assigned as control group; the other classes were assigned as experimental group randomly. The experimental group who received CLCC consisted of 50 students while the control group who received TDSI consisted of 52 students.

4.3. Variables

In this study two types of variables were mentioned. Independent variables are the variables the researcher chooses to study and often manipulate in order to asses their possible effects on one or more other variables. Independent variable is presumed to have an effect on or to influence another variable called dependent variable.

4.3.1. Independent Variables

The independent variable in this study was treatment, (Cooperative Learning Based on Conceptual Change Conditions vs. Traditionally Designed Science Instruction). In addition, students' science process skills as measured by SPST were taken to control their integrated process skills at the beginning of the treatment and also to identify its effects on achievement. Moreover, gender of students was taken as independent variable in order to compare understanding the classification and changes of matter concepts and attitudes toward science as a school subject of males and females.

4.3.2 Dependent Variables

Dependent variables were the students' understanding of physical and chemical changes and classification of matter concepts measured by CCMT and their attitudes toward science as a school subject measured by ASTS. Table 4.2. summarizes the dependent and independent variables of the study.

Table 4.2. Types of Variables

Variables	**Type**
CCMT Scores	Dependent
ASTS Scores	Dependent
Treatment (CLCC vs. TDSI)	Independent
SPST Scores	Independent
Gender	Independent

4.4. Instruments

In order to test the hypotheses in this study, students in both groups were given: (1) Classification and Changes of Matter Test as pre- and post-test to identify students' misconceptions and conceptual understanding on physical and chemical changes and classification of matter concepts; (2) Science Process Skills Test as pre-test to control its effect as covariate; (3) Attitude Scale toward Science as a School Subject as both pre-test and post-test in order to understand the effect of treatment on students' attitudes toward science.

4.4.1. Classification and Changes of Matter Test (CCMT)

This test was developed by the researcher. It consisted of two parts: Part A is about physical and chemical changes, Part B is about classification of matter as elements, compounds and mixtures. In Part A, first two questions include eight simple experiments. Students were asked to classify these changes in the experiments as physical and chemical changes and wrote their reasoning. In second question students wrote the differences between some changes given in the first question. Third and fourth questions are multiple choice questions. In Part B, four diagrams are given in the first question. Students are asked to classify these diagrams as elements, compounds or mixtures and write their reasoning. Second question is an open ended question. Third question contains four changes. Students are required to classify each matter in these changes as elements, compounds or mixtures and classify each change as physical or chemical change.

The Turkish version of the test was prepared because the language of instruction in science course was Turkish in ODTÜ G.V. Özel İlköğretim Okulu. In order to eliminate factors that might prevent the pupils from responding, a simple grammar structure and vocabulary were used in the construction of this test. This test contained conceptual questions which need conceptual knowledge in science. These questions required students to make a qualitative conceptual prediction about a situation in which there is a possibility to make wrong response caused by the misconceptions of students.

The students' level of understanding for open ended questions was assessed by employing a concept evaluation technique used by Abraham et al. (1992). In their technique, for tabulation of responses, students' partial and sound understandings were placed under an "understanding" category, students' specific misunderstanding and partial understanding with specific misunderstanding were put under a "misunderstanding" category, and no responses and no understanding categories were placed under "no understanding" category. These categories are indicated in Table 4.3.

Table 4.3. Categories of Students Responses

Level of understanding	Criteria for the classification of students' responses
Sound understanding	Responses that include all components of the scientific conceptions
Partial understanding	Responses that include at least one of the components of the scientific conceptions, but not all of the components
Partial understanding with specific misconception	Responses that show an understanding of the concept but used together with statements that demonstrate a misunderstanding
Alternative Conceptions	Responses that attempt to describe the phenomenon, but do not necessarily match the scientific conception
No understanding	Repeat a part or full of question; Irrelevant or unclear responses; Blank; I don't know; I don't understand

In order to facilitate the use of comparative statistics students' answers were lie on an ordinal scale. The following scale, which was used in a previous study (Renner et al., 1987) was applied: "No understanding" (NU) = 0, "Alternative Conceptions" (AC) = 1, "Partial Understanding with Specific Misconception" (PUSM) = 2, "Partial Understanding" (PU) = 3, "Sound Understanding" (SU) =4. The acceptable responses were developed by the researcher from the currently used science textbooks. The test was assessed out of 133 points.

During the development stage of the test; firstly, the instructional objectives were stated. (See Appendix A) Secondly, the literature related to students' misconceptions with respect to physical and chemical changes and classification of matter concepts were carefully examined (e.g. Solsona & Izquerdo, 2003; Liu & Leisniak, 2005; Nakhleh et al. 2005; Anderson, 1986, 1990; Hesse, 1988; Basili, 1989; Nieswandt, 2001; Abraham & Williamson, 1994; BouJaoude, 1991; Barker, 1995) and a taxonomy was constructed. (See Table 4.4.) Items were prepared by considering the instructional objectives and students' misconceptions related to classification and changes of matter.

Table 4.4. A classification of students' misconceptions probed by CCMT items.

Misconception	CCMT Item
Phase changes are examples of chemical reactions	Part A 1.g.
Physical changes are reversible while chemical changes are not	Part A 1. a, b, c, d, e, f, g, h Part B. 2. a
The original substance vanishes completely and forever in a chemical reaction	Part A 1. b, e, f, h Part B. 2. a
When reversibility of a chemical reaction is observed it can be explained as phase changes which occur as the temperature fluctuate	Part A 4. b
Phenomena during chemical reactions are the result of mixing and separating substances	3. d
The substance changes in color, mass and state it is obvious that a chemical change has taken place	Part A 1. a, g, 2. b
Solutions are compounds because it is made up of two elements together	Part A 1. c , 2. a
Iron and sulfur powders in the same flask is a compound because they have affected each other	Part A 4
Burning was a physical change	Part A 1. b, e, 2. b
A new substance was actually modified form of original substances and it continued to be the same substance, although it looked different	Part A 1. b, e, f, h Part B. 2. b

Table 4.4. continued

When gold rod was heated by burning candle, black film on the gold was oxygen from air, gas from the flame, or burning of the rod.	Part A 1 d
Transmutation occurs: Students viewed that atoms changed into a new kind of atom.	Part A 1. b, e, f, h Part B. 2.b
During burning the burnt substance change its status (e.g. melting of plastic)	Part A 1 e
Substances have properties and these properties can change without the substance itself undergoing any drastic change	Part A 1 b, f, h
Using the visible aspects of changes instead of the atomic molecular level	Part B 3 a, b, c, d
A static representation of chemical change	Part A 1. b, e, f, h
Do not discriminate between particulate representations of compounds, mixtures and elements	Part B 1,a, b, c, d
Compounds are formed by simply sticking fragments together rather than as being created by the breaking and reforming of bonds	Part B 3 b, d
Confusion of compounds, elements and mixtures	Part B 1.a, b, c, d 3 a, b, c, d

The items were evaluated by a group of classroom teachers and experts in science education and chemistry for the appropriateness of the items and the content validation.

Reliability coefficient of the test was found to be 0.8. An analysis of the responses indicated widespread misconceptions which were in the agreement with the studies in literature.

This test was given as a pre-test and post-test to determine the effects of treatment on understanding of chemical and physical changes and classification of matter concepts and remediation of misconceptions. A copy of the test was given in Appendix B.

4.4.2. Attitude Scale Toward Science (ASTS)

This scale was developed by Geban and Ertepınar (Geban et al., 1994) to measure students' attitudes toward science as a school subject. This instrument contains 15 items in a point likert type scale (fully agree, agree, undecided, partially agree, and fully disagree) in Turkish. There are both positive and negative statements. The reliability was found to be 0.83. It was given as both pre-test and post-test to all students in this study. (See Appendix C)

4.4.3. Science Process Skills Test (SPST)

The test was originally developed by Okey, Wise and Burns (1982). It was translated and adapted into Turkish by Özkan, Aşkar and Geban (1991). This instrument contains 36 four-alternative multiple choice questions. It is useful to bring out analysis ability of students in solving complex problems. This test is given to all students at the beginning of the study. The reliability of the test was found to be 0.85. It measures the intellectual abilities of students including the items related to identifying variables, identifying and stating the hypotheses, operationally defining, designing investigations and graphing and interpreting data. (See Appendix D)

4.4.4. Interview Questions

Interview questions were prepared in Turkish after related literature about students' misconceptions on physical and chemical changes and classification of matter concepts was investigated and interview conducted by the researcher after the treatment. (See Appendix E) Six students from experimental group and six students from control group were selected based on achievement on post-CCMT scores. Two students from each group were randomly selected from higher achievers, two students from middle achievers and two students from lower achievers. All interview data was recorded on audiotape and used to find out students' understanding of physical and chemical changes and classification of matter concepts. Interviews showed that some students even from experimental group still hold some misconceptions after treatment. Interview results are given in results and conclusions chapter.

4.5. Treatment (CLCC vs. TDSI)

This study was conducted over four weeks during the 2004-2005 fall semesters. 102 seventh grade students in four science classes of two teachers in ODTÜ G.V. Özel İlköğretim Okulu were enrolled in the study.

There were two groups in the study. The experimental group was instructed by cooperative learning based on conceptual change conditions while the control group was instructed by traditionally designed science instruction. Both experimental group and control group were given CCMT and ASTS as pre- and post-test, and SPST as pre-test to determine whether there would be a significant difference between two groups.

During the treatment, the physical and chemical changes and classification of matter concepts were covered as part of the regular classroom curriculum in the science course. The classroom instruction was four 40-minute sessions per week.

In the traditionally designed chemistry instruction, the teacher used lecture and discussion methods. Teacher did not consider students' misconceptions. On the other hand, the students were provided with the worksheets. They were required to respond to assigned conceptual questions. Then worksheets were corrected and scored and the students reviewed their responses after correction.

The treatment in the experimental group involves four parts: i. The class presentation: This involved a teacher-directed presentation of the material (concepts, skills and processes) that the students were to learn. ii. Team study: Teams were composed of four students such that each team was more or less on average composite of the class. Teams studied the given worksheets and make sure that each member of the team can answer all the questions on the worksheet. Students should move their desks so that they face each other in each small team. iii. Testing: After the team study was completed, CCMT was administered. Students took the tests individually and were not permitted to help each other. To encourage students to work harder individual improvement scores were used. iv. Team Recognition: Team averages were announced in the class and the members of the group that had the highest average score took rewards.

In this study, the cooperative learning method used was STAD (Standard teams' achievement divisions) which was developed by Slavin (1989).

The physical arrangements of students in small, heterogeneous groups encourage students to help, share and support each others learning. Each student in a learning team must be held accountable for learning and collaborating with other team members. During small group sessions students taught each other, and learned from each other. Teachers circulated from group to group asking questions and encouraging students to explain their answers.

The students in the experimental group worked the given worksheets which were designed according to conceptual change conditions in small cooperative learning groups. Each group contained four students, one from higher achievers, one from lower achievers and two from middle achievers. Students' achievement levels were assured by their general science exam results. In this instruction student-student and teacher-student interaction in small groups were essential.

There were two parts in conceptual change worksheets: (1) Physical and chemical changes; (2) Classification of matter as elements, compounds and mixtures. During the construction of conceptual change worksheets difficult vocabulary was avoided. They identified misconceptions about subject matter and directly informed students that may posses such kind of misconceptions.

In the first part, there were four different stations containing experiments about physical and chemical changes. Each group visited all of these stations, read the instructions, performed the experiments and wrote their observations including physical properties of each matter before changes and observed changes on the matter, on their worksheets. After that each group decided whether each change was physical and chemical change and answered the discussion questions. (See Appendix F)

The second part is about classification of matter as compounds, elements and mixtures. Review of literature showed that students seemed to understand the macroscopic nature of an element but did not use particle ideas. About half of the students regarded any diagram that contained different symbols for atoms as a representation of a mixture. In addition, students were asked to identify an element from a list of four substances; each described using basic chemical terminology instead of using particle ideas in making their choice. Thus, this part contains diagrams about particulate nature of matter in understanding differences between elements, compounds and mixtures. These diagrams involve different symbols to represent different atoms in diagrams of a mixture of two elements, a compound and an element alone. Students were given six different particles. By these particles six diagrams were made[*]. Students discussed whether given diagrams were compounds, mixtures and elements and wrote their reasoning. (See Appendix G) In the second question students selected the two diagrams of the same matter. In the third question students classified each diagram as pure substance and impure substance. In the fourth question, they decided whether the given diagram was

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[*] RC.S Elements, Compounds and Mixtures
http://www.chemsoc.org/pdf/LearnNet/miscon2/Elements_compounds_or_mixtures.pdf
Access date: 1st September 2004

element molecule or compound molecule. In the fifth question, they drawn diagrams for the mixture of iron and sulfur and for the compound of iron sulfide by using the given symbols for iron and sulfur atoms. They wrote their reasons for their drawings and answer the questions.

This part also contains clay modeling in order to students learn the differences between mixtures and compounds. Students were given yellow and blue play dough and they make small balls. Yellow balls were representing sulfur atoms and blue balls were representing iron atoms. After that students were asked to make a mixture of iron and sulfur using these small balls and write three characteristics of this mixture e.g. random proportion, physically separated into components. Then students made a new chemical compound by mixing yellow and blue balls in 1:1 portion and wrote the characteristics of this new compound e.g. fixed proportions, cannot be physically separated into components. Some conceptual challenge questions also directed to students for example "place some balls on a sheet of white paper to represent a mixture of the element sulfur and the compound iron sulfide."

The design of the instruction was based on the conceptual change conditions in which alternative conceptions could be replaced into scientific conceptions. The teachers used worksheets in order to activate students' misconceptions. By this way, common misconceptions about subject matter were identified. Then the teachers presented the evidence that typical misconception was incorrect and provided a scientifically correct explanation of the situation.

The teaching strategies used in this study were constructed so that to address conceptual change conditions described by Posner et al. (1982) and summarized in Table 4.5. (Piquette and Heikkinen, 2005)

Table 4.5. Correspondence of Strategies Used and Conceptual Change Conditions

Strategies Used	Posner et al. (1982) Conceptual Change Conditions Addressed
Peer discussions in small groups	Dissatisfaction
Simple explanations of correct answer	Intelligibility, Plausibility
Describing correct answer in greater detail	Intelligibility, Plausibility
Assessing students' preconceptions	Intelligibility
Generalizations for other problems	Fruitfulness
Using diagrams and clay modeling	Dissatisfaction, Intelligibility, Plausibility

In cooperative groups, students shared and compared their ideas to those of their peers, so that they took a different perspective than their own. This could give rise to the dissatisfaction that is proposed as a necessary condition for conceptual change.

After student discussions on worksheets in small groups, teacher provided a simple explanation of correct answer and then describing the correct answer in greater detail. These strategies helped students to comprehend the material and to think that the concept was reasonable and addressed intelligibility and plausibility.

Since the teacher had knowledge of students' alternative conceptions she could devise explanations that are understood by students. This was congruent with the conceptual change condition of intelligibility. When answering some questions on the worksheet, students could generalize their knowledge to other situations and recognized the usefulness of new concept. This strategy met the fruitfulness condition.

Use of diagrams and clay modeling made abstract concepts more concrete. These approaches corresponded to conceptual change conditions of dissatisfaction, intelligibility and plausibility.

4.6. Analysis of Data

ANCOVA was used to determine and compare the effectiveness of two different instructional methods on the achievement related to physical and chemical changes, classification of matter as elements, compounds and mixtures concepts by controlling the effect of students' science process skills as a covariant. For this reason Classification and Changes of Matter Test scores and Science Process Skills Test scores were used. So that we could equate groups on one or more independent variables by controlling unwanted inflation of experimental wise Type I error rate. In addition analysis of covariance revealed the contribution of science process skills to the variation in achievement.

ANOVA statistics was used to determine the effect of treatment and gender difference on students' attitudes toward science as a school subject.

4.7. Assumptions and Limitations

4.7.1. Assumptions

1. The teachers were not biased during the treatment.
2. All the subjects in both groups were accurate and sincere in answering the questions of measuring instruments.

3. Students in the experimental group did not interact with the students in the control group.

4. There were no other reasons than use of cooperative learning based on conceptual change conditions that modify the post-test results of students in the experimental group.

4.7.2. Limitations

1. The subjects of the study were limited to 102 seventh grade students from ODTÜ G.V. Özel İlköğretim Okulu.

2. The study was limited to physical and chemical changes, and elements, compounds and mixtures concepts.

CHAPTER 5

RESULTS AND CONCLUSIONS

The hypotheses stated in Chapter 3 were tested at a significant level of α=0.05. ANOVA and ANCOVA models were used to test hypotheses. Statistical analyses were carried out by SPSS, Statistical Package for Social Sciences for Personal Computers.

5.1. Results

In order to find out students' prior knowledge about classification and changes of matter concepts, prior attitudes toward science as a school subject and their science process skills, CCMT, ASTS and SPST were given to students before the treatment.

The analysis showed that there was no significant difference between the mean scores of experimental group and control group with respect to previous concept understanding measured by pre-CCMT ($t = 0.42$, $p > 0.05$), students' attitudes toward science as a school subject ($t = 0.52$, $p > 0.05$) and science process skills ($t = 0.004$, $p > 0.05$).

Hypothesis 1:

To answer the questions posed by hypothesis 1 stating 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 conditions with respect to achievement related to physical and chemical changes, classification of matter concepts when the students' science process skills are controlled" analysis of covariance was used. The analysis of the data is summarized in Table 5.1.

Table 5.1. ANCOVA Summary (Achievement)

Source	DF	SS	MS	F	p
Covariate (Science process skills)	1	9658.870	9658.870	32.759	0.000
Treatment	1	1256.833	1256.833	4.263	0.042
Gender	1	120.528	120.528	0.409	0.524
Interaction of treatment and gender	1	266.062	266.062	0.902	0.345
Error	97	28600.223	294.848		

The analysis results showed that the post-test mean scores of CLCC group and TDSI group with respect to the achievement related to physical and chemical changes and classification of matter concepts were significantly different. ($F = 4.26$, $p < 0.05$) CLCC group scored significantly higher than the TDSI group. ($\overline{X}$(CLCC) = 88.52, $\overline{X}$(TDSI) = 80.56)

The analysis of results indicated that the students in CLCC group had a significantly lower proportion of misconceptions on the CCMT than students in the TDSI group. Table 5.2. summarized the level of understanding of students' in control group on CCMT items.

Table 5.2. Level of understanding of students' in control group on some CCMT items

CCMT Item	No understanding (%)	Misconceptions (%)	Understanding (%)
Part A. 1.a.	17	31	52
Part A. 1.b.	13	33	54
Part A. 1.c.	19	39	42
Part A. 1.d.	21	30	49
Part A. 1.e.	13	48	39
Part A. 1.f.	26	37	37

Table 5.2. continued

Part A. 1.g.	9	35	56
Part A. 1.h.	22	26	52
Part A. 2.a.	25	22	53
Part A. 2.b.	14	42	44
Part B. 1.a.	4	13	83
Part B. 1.b.	4	20	76
Part B. 1.c.	4	16	80
Part B. 1.d.	3	14	83
Part B. 2.a.	20	24	56
Part B. 2.b.	23	25	52

Table 5.3. summarized the level of understanding of students' in experimental group on CCMT items.

Table 5.3. Level of understanding of students' in experimental group on some CCMT items

CCMT Item	No understanding (%)	Misconceptions (%)	Understanding (%)
Part A. 1.a.	2	17	81
Part A. 1.b.	3	29	68
Part A. 1.c.	23	31	46
Part A. 1.d.	28	20	52
Part A. 1.e.	15	38	47
Part A. 1.f.	21	33	46
Part A. 1.g.	5	28	67
Part A. 1.h.	4	20	76
Part A. 2.a.	9	18	73
Part A. 2.b.	12	35	53
Part B. 1.a.	5	11	84
Part B. 1.b.	4	9	87

Table 5.3. continued

Part B. 1.c.	4	10	86
Part B. 1.d.	5	5	90
Part B. 2.a.	17	17	66
Part B. 2.b.	20	20	60

Table 5.4. summarized correct proportions of some questions on CCMT for both experimental and control groups.

Table 5.4. Correct proportions of some questions for experimental and control groups.

Item on CCMT	Correct proportions for control group	Correct proportions for experimental group
Part A 3	36	64
Part A 4	20	44
Part B 3.a.	71	81
Part B 3.b.	72	84

Table 5.4. continued

Part B 3.c.	64	71
Part B 3.d.	62	78

As we indicated CCMT was administered to all students before and after the treatment to identify broad range of misconceptions about the physical and chemical changes and classification of matter as elements, compounds and mixtures concepts. Percentages of some responses as “no understanding”, “misconception” and “understanding” were given for control group in Table 5.2. and for experimental group in Table 5.3. In addition, correct responses of some questions for both control and experimental groups were given in Table 5.4.

Part A of CCMT was about physical and chemical changes. First question includes eight experiments and students had to decide whether the change in each experiment was physical and chemical and wrote their reasoning. The CLCC caused a significantly better elimination of misconceptions than the TDSI. But even experimental group students still have higher percentages of misconceptions on some questions. Because many students have had great difficulty in changing their thinking when they were jump from the phenomenogical level of chemistry i.e. observable changes in substances, to the atomic-molecular level which explains observable changes in terms of the interactions between individual atom and molecules. For question 1.a. 31% of students from control group and 17% of students from experimental group showed misconceptions since they thought that only physical changes were reversible. (Stavridou and Solomonidou, 1989) For question 1.b. 33% of students from control group and 29% of students from experimental group showed misconceptions. They said that chemical changes were always irreversible. Some of them explained combustion as melting. Some students said that the heated sugar was burned sugar" or "brown sugar". These responses showed that the students' understanding of burning was based on their observable everyday experiences. 39% of students from control group and 31% of students from experimental group had misconceptions for question 1.c. Many of the students classified this change as physical correctly. But they thought that when a substance was mixed with water its molecular structure was changed. Some students classify this example as chemical change since they thought that when two substances were mixed always a new substance was formed. 30% of students from control group and 20% of students from experimental group had misconceptions for question 1.d. Students tended to classify "heating of gold rod" as a chemical change because they thought that the gold was burned and seen this change as irreversible. For question 1.e. 48% of students from control group and 38% of students from experimental group showed misconceptions. Some students tended to classify "heating plastic rod" as a physical change. Because of their everyday experiences they thought that during burning the burnt substance change its status (e.g. melting of plastic) and the idea that "A new substance was actually modified form of original substances and it continued to be the same substance, although it looked different". For question 1.f. 37% of students from control group and 33% of students from experimental group had misconceptions. In this experiment phenolphthalein was added to soap solution. Some of the students named this change as physical because of the idea that "Substances have properties and these properties can change without the substance itself undergoing any drastic change". Some of the students defined the change as chemical but the reasoned that "the change was irreversible" and "The original substance vanishes completely and forever in a chemical reaction". For question 1.g. 35% of students from control group and 28% of students from experimental group had misconceptions. Many of the students classify melting of ice as physical change and they showed right reasoning for example "ice took heat and changes its phase. The water had the same chemical properties with ice". Although many students gave the correct answer, some of them also thought that "water was a new substance". 26% of students from control group and 20% of students from experimental group had misconceptions on question 1.h. Many of the students named this change as chemical correctly. But some of the students showed the reason that "The original substance vanishes completely and forever in a chemical reaction and chemical reactions were always irreversible".

For question 2.a. and 2.b. on Part A students had to differentiate between physical and chemical change. Percentages of misconceptions for these questions were 22% and 42% for control group and 18% and 35% for experimental group respectively.

For question 3 and 4 on Part A correct proportions were 36% and 20% for control group and 64% ad 44% for experimental group respectively. Question 3 gave the reaction of oxygen and hydrogen gases to form water. Some of the students thought that “the reaction was irreversible. In other words, oxygen and hydrogen gases could not be obtained from water”. Some of them realized that “water could be formed by mixing oxygen and hydrogen gases or water was formed by phase changes of oxygen and hydrogen”. Question 4 gave the heating of iron and sulfur mixture. Some of the students showed the reason that “A chemical reaction could be reversible and it could be explained as phase changes which occur as the temperature fluctuates” or “The reaction was irreversible” or “Iron and sulfur melted by heat”.

Part B of CCMT was about classification of matter as elements, compounds, and mixtures. Four diagrams were given for the first question. Students had to classify each diagram as elements, compounds or mixtures and wrote their reasoning. Although, many of them made the classification correctly their explanations included some alternative ideas. 13, 20, 16 and 14% of control group students and 11, 9, 10 and 5% of experimental group students had some misconception on these four diagrams respectively. Some of the students did not use the particulate ideas instead they said “this is made of same stuff or matter or substance”. They indicated ideas according to common features of substances such as “hydrogen is a gas and gases are elements or iron powder is a mixture” or “Solutions are compounds because it is made up of two elements together” or “Compounds are formed by simply sticking fragments together rather than as being created by the breaking and reforming of bonds”.

Questions 2.a. and 2.b. on Part B asked whether we could obtain elements from a compound and whether a compound could have the properties of elements that were combined. Some students thought that “we could not obtain elements from compounds because the chemical changes were irreversibl”e or viewed that atoms changed into a new kind of atom. Some of the students also said that “a compound could show the properties of elements”.

Question 3 on Part B included diagrams. Students had to classify each diagram as elements, compounds and mixtures and each change as physical or chemical. For questions 3.a., 3.b., 3.c. and 3.d. correct proportions were 71, 72, 64 and 62% for control group and 81, 84, 71 and 74% for experimental group respectively.

Table 5.5. gives examples of students responses from misunderstanding and understanding levels for selected items on CCMT.

Table 5.5 Selected student responses for some CCMT items

CCMT Item	Misunderstanding	Understanding
Part A 1e	• It is physical change, because its phase is changed. • It is chemical change, because it is irreversible.	It is chemical change. Plastic rod is burned and a new substance is formed. The properties of this new substance are different from that of plastic.
Part A 1g	• It is chemical change, a new substance is formed. • It is chemical change a new substance is formed by taking heat; it can be reversed by giving heat.	It is a physical change, because ice changes its phase. Water and ice have the same chemical properties. No new substance is formed.
Part A 2b	• There is no change on gold rod but plastic rod is melted. • The gold is oxidized while the plastic rod is melted.	Heating gold rod is a physical change, because no new substance is formed. The gold has the same chemical properties after heating. But heating of plastic rod is a chemical change, it burns.
Part B 2b	• Yes they have same properties • No, when Na and Cl elements are mixed, they have new properties.	NaCl compound do not have the same properties with Na or Cl elements. These elements combine chemically and formed a new substance NaCl with new properties.

Hypotheses 2:

To answer the questions posed by hypothesis 2 stating that "There is no significant difference between the means of males and females with respect to understanding of chemical and physical changes and classification of matter concepts" analysis of covariance was used. The analysis of the data is summarized in Table 5.1.

The results showed that there was no significant difference between the means of males and females with respect to understanding of chemical and physical changes and classification of matter concepts. ($F = 0.409$, $p > 0.05$)

Hypotheses 3:

To answer the questions posed by hypothesis 3 stating that "There is no significant effect of interaction between treatment and gender difference on understanding of chemical and physical changes and classification of matter concepts" analysis of covariance was used. The analysis of the data is summarized in Table 5.1.

The results showed that there is no significant effect of interaction between treatment and gender difference on understanding of chemical and physical changes and classification of matter concepts. ($F = 0.902$, $p > 0.05$)

Hypotheses 4:

To answer the questions posed by hypothesis 4 stating that "There is no effect of students' science process skills on understanding of chemical and physical changes and classification of matter concepts" analysis of covariance was used. The analysis of the data is summarized in Table 5.1.

The results showed that there is an effect of students' science process skills on understanding of chemical and physical changes and classification of matter concepts. ($F = 32.759$. $p < 0.05$)

Hypotheses 5:

To answer the questions posed by hypothesis 5 stating that "There is no significant difference between the effects of traditionally designed science instruction and cooperative learning based on conceptual change conditions on students' attitudes toward science as a school subject" analysis of variance was used.

The results showed that there is no significant difference between the effects of traditionally designed science instruction and cooperative learning based on conceptual change conditions on students' attitudes toward science as a school subject. ($F = 0.336$, $p > 0.05$) The analysis of the data is summarized in Table 5.4. On the other hand, post-mean scores of students in experimental group on attitudes toward science as a school subject test were slightly higher than mean scores of students in control group. ($\overline{X}_{control} = 51.9$, $\overline{X}_{experimental} = 53.6$)

Table 5.6. ANOVA Summary (Attitudes toward science as a school subject)

Source	DF	SS	MS	F	p
Treatment	1	40.719	40.719	0.336	0.563
Gender	1	81.247	81.247	0.671	0.415
Interaction of treatment and gender	1	0.616	0.616	0.005	0.943
Error	98	11869.968	121.122		

Hypotheses 6:

To answer the questions posed by hypothesis 6 stating that "There is no significant difference between the means of males and females' attitudes toward science as a school subject" analysis of variance was used.

The results showed that there is no significant difference between the means of males and females' attitudes toward science as a school subject. ($F = 0.671$, $p > 0.05$) The analysis of the data is summarized in Table 5.4.

Hypotheses 7:

To answer the questions posed by hypothesis 7 stating that "There is no significant effect of interaction between treatment and gender difference on students' attitudes toward science as a school subject" analysis of variance was used.

The results showed there is no significant effect of interaction between treatment and gender difference on students' attitudes toward science as a school subject. ($F = 0.005$, $p > 0.05$) The analysis of the data is summarized in Table 5.4.

5.2. Interview Results

In this study, interview was conducted with 7^{th} grade students to understand students' reasoning and retention on physical and chemical changes and classification of matter concepts after treatment. Students 1 to 6 from experimental group and 7 to 12 from control group were selected based on their CCMT scores. Two students from each group were randomly selected who were higher achievers, two students from middle achievers and two students from lower achievers. Interviews are given below:

The first part of the interview questions were about physical and chemical changes.

Interviewer: What is the type of change when ice is heating? Why? Which properties of ice are changed?

Students 1: Physical. There is no change in molecular structure of matter. The change is reversible.

Students 2: Physical. Ice is actually water. The chemical properties of ice don't change.

Students 3: Since there is no change in the structure of the ice it is physical change.

Students 4: Physical. It isn't change the structure of ice.

Student 5: It is physical change. Ice changes its phase. There is no change in its atoms.

Students 6: It is physical change. Ice is the same substance when it melts. No new substance is formed.

Student 7: Melting of ice is a physical change. It changes its phase and becomes water.

Student 8: Physical, it is recycled.

Student 9: It is physical change. Ice melts, changes its phase and its appearance is changed.

Student 10: It is physical, because ice is frozen water.

Student 11: Physical. No new substance is formed. Its appearance is changed but it does not change itself.

Student 12: Physical. When ice melts, we can freeze it again.

Many students understand that the melting of ice is a physical change, because it is a phase change. Some of the students from experimental group mention that there is no change in atomic structure or in the structure of the ice. But some students from control group give the reversibility as a reason for physical change.

Interviewer: As a candle burns it gives off light and heat. When a glass rod is hold in the yellow part of the flame, a black film forms on the rod. What is the source of black film on the rod? Give your reasons.

Student 1: It is related with the combustion of candle. When the candle is burning it is combined with oxygen.

Student 2: Flame affected the glass rod.

Student 3: The soot that is formed because of burning candle is collected on the rod.

Student 5: It is aroused from fire.

Student 8: The molecules in the glass rod undergo a chemical change.

Student 9: It originates from the glass rod.

Student 10: Its source is glass rod.

Student 11: It comes from the candle.

Student 12: Its resource is the structure of glass rod. .

Interviewer: Is the rod undergoes a chemical or physical change?

Student 1: It is physical. If the color, the shape or the structure is changed it is chemical change.

Student 2: Since the change is sourced from heat it is chemical change.

Student 3: Since the basic structure of the glass rod does not change, it is physical change.

Student 4: Since the black film can be cleaned on the glass rod it is physical change.

Student 6: It is chemical. A new substance is formed.

Student 7: Because it is changed easily, it is physical.

Student 8: Glass rod is burned so it is chemical.

Student 10: Because a new is formed it is chemical change.

Student 11: Chemical change. The black film on the rod comes from a different substance.

Student 12: The change is sourced from the heat. For this reason it is a chemical change.

Many students understand that when a candle burns it combine with oxygen and a new substance is formed. However, some students even from experimental group think that the black layer is formed because of heat or burning of glass rod or the glass rod undergoes a chemical change.

Interviewer: When you hold piece of iron and a piece of plastic for some time, there is no difference on plastic while the iron is coated by rust. What is the source of rust on the iron?

Student 1: It is sourced from iron combining a different substance i.e. oxygen.

Student 3: Iron and oxygen in the air affected each other and rust is formed.

Student 5: It is formed because of the place that is present.

Student 6: Oxidation occurs because of iron contacting with air.

Student 7: It happens because of the gases in the air.

Student 9: It is formed from matter in the iron.

Student 10: Iron and air affected each other.

Student 11: Because of matter in the iron…

Student 12: Because of the structure of iron and moisture.

Interviewer: If the coating is removed from the iron, is the remaining iron will weight less? Explain your answer.

Student 1: Yes. Because its part that belongs to its mass rusts.

Student 2: There is no change.

Student 3: Since a piece of iron forms the rust, the mass of iron decreases.

Student 4: It decreases. The particles of iron undergo a chemical change so when coating is removed the mass of iron is decreased.

Student 5: Decreases. A pieces of iron affected and rust forms.

Student 6: It decreases because iron forms the rust.

Student 7: Its mass is changed.

Student 8: The mass does not change.

Student 9: It decreases. A part of iron is converted to rust.

Student 10: The mass of iron is decreases. Iron is transformed to a new substance.

Student 11: It decreases. Because, when we removed rust, a piece of iron is also removed.

Student 12: The mass is different. A new thing is formed on the iron because of its structure.

Some students understand that rusting of iron is chemical change and a new substance is formed because of the effect of oxygen. But some students don't relate this example with conservation of matter. Some of them think that when some rust is removed the mass doesn't change.

The second part of the interview questions were about the classification of matter as elements, compounds and mixtures.

Interviewer: Define element. List the properties of elements and give examples.

Student 1: It is not divided into simpler substances. It is pure. It is showed by symbols. E.g. Oxygen, hydrogen, nitrogen.

Student 3: It contains one type of atoms. It is pure. E.g. Iron, copper

Student 4: They are pure substances. E.g. Iron

Student 5: It is formed by only one type of atom. It is homogeneous. It is showed by symbols. E.g. Iron

Student 6: It is pure. It is showed by symbols. It consists of one type of atom. E.g. Oxygen

Student 7: It is simple. It is showed by symbols. It is one substance.

Student 8: They are pure substances. It contains one type of atom. It is showed by symbols. It is not divided. E.g. Iron

Student 9: It occurs from one type of atom. E.g. chrome

Student 10: It contains one type of atom. E.g. mercury

Student 11: It happens from one type of atom. E.g. water

Student 12: It is made up of one atom. E.g. Iron

Interviewer: Define compound. List the properties of compounds and give examples.

Student 1: It is not pure. It is formed by combination of two substances by chemical ways and it is decomposed by chemical ways. It is showed by formulas.

Student 3: They are pure substances. It is formed by combination of two substances by chemical ways. It is decomposed by chemical ways. E.g. Sugar

Student 4: It composed of two substances. E.g. Water

Student 5: It is formed by combination of atoms more than one type. It is homogeneous. E.g. Water.

Student 6: They are pure substances. It consists of atoms more than one type. It is showed by symbols. It is decomposed by chemical ways. E.g. Water

Student 7: Two different substances unite and combine and a new substance is formed. It is homogeneous. It is showed by symbols. E.g. Water

Student 8: It is comprised of more than one substance. It is showed by formulas. It can be decomposed. For example when iron and sulfur are mixed and heated iron sulfur is formed. We can take iron by a magnet from iron sulfur.

Student 9: Different substances are united to form compounds. When two substances come together they form a compound.

Student 10: They are formed from two different kinds of atoms by chemical ways. They are decomposed by chemical ways such as acids.

Student 11: They are formed by the same kind of atoms.

Student 12: Compounds are formed by combination of two different kinds of atoms by chemical ways.

Interviewer: Define mixture. List the properties of mixtures and give examples.

Student 1: Different substances are combined by physical ways. Its components properties and freezing point do not change. They are decomposed by physical ways. Symbols do not use.

Student 3: They are formed by combination of two or more substance by physical means. The substances that form the mixture do not lose their properties and they are decomposed from the mixture by physical means. We can mix the substances in any ratio.

Student 4: It is something that two substances are mixed such as sugar in water.

Student 5: More than one different type of atoms comes together by physical means to form mixtures. They can be heterogeneous or homogeneous. E.g. Air

Student 6: It is formed by more than one type of substances. It is not pure. They have no symbols. They can be decomposed by physical ways. E.g. Sugar in water.

Student 7: It is something two substances are combined. We can not see and decompose the substance.

Student 8: They are formed from more than one element. They can be homogeneous and heterogeneous. E.g. Salty water.

Student 9: It consists of one type of substance.

Student 10: Two different substances come together without combining by physical ways.

Student 11: It is formed from two or more atoms.

Student 12: It is mixed and decomposed like salty water.

Interviewer: Classify the given substances as element, compound or mixture.

Water, Sugar in water, Iron, Sugar, Hydrogen gas, Iron powder

Student 1:

Element	**Compound**	**Mixture**
Iron, Hydrogen gas	Water, Sugar	Sugar in water, iron powder

Student 2:

Element	Compound	Mixture
Water	Iron, iron powder, hydrogen gas, sugar	Sugar in water

Student 3:

Element	Compound	Mixture
Iron, hydrogen gas, iron powder	Water, sugar	Sugar in water

Student 4:

Element	Compound	Mixture
Iron, hydrogen gas, iron powder	Water, sugar	Sugar in water

Student 5:

Element	Compound	Mixture
Iron, hydrogen gas, iron powder	Water, sugar	Sugar in water

Student 6:

Element	**Compound**	**Mixture**
Sugar, hydrogen gas	Water, iron, iron powder	Sugar in water

Student 7:

Element	**Compound**	**Mixture**
Iron, iron powder	Water, sugar	Sugar in water, hydrogen gas

Student 8:

Element	**Compound**	**Mixture**
Iron, hydrogen gas, iron powder	Water	Sugar in water, sugar

Student 9:

Element	**Compound**	**Mixture**
Iron, water, iron powder	Sugar	Sugar in water, hydrogen gas

Student 10:

Element	**Compound**	**Mixture**
Iron, hydrogen gas, iron powder	Water, sugar	Sugar in water

Student 11:

Element	**Compound**	**Mixture**
Water, hydrogen gas	Iron, sugar, iron powder	Sugar in water

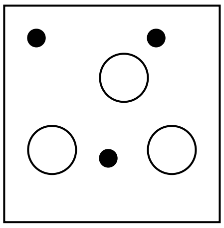
Student 12:

Element	**Compound**	**Mixture**
Water, sugar, iron powder	Iron, hydrogen gas	Sugar in water

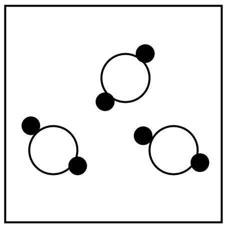
Almost all students learn the properties of elements, compounds or mixtures. But some of them use particle ideas. Many students easily classified given examples as elements, compounds or mixtures. But some of them make the classification since they learn from their teacher or read from their book like that.

Interviewer: Classify the given diagrams as elements, compounds and mixtures. Give your reasons.

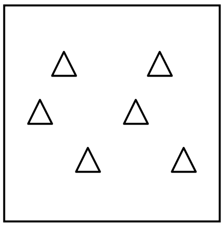
a)



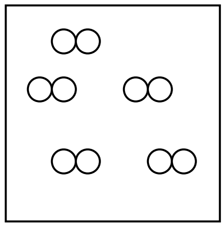
b)



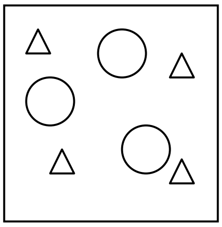
c)



d)



e)



Student 1:

a) Mixture: There are different particles.

b) Compound: They are combined. The chemical ways are necessary to decompose them.

c) Element: There is only one type of atom.

d) Element: There is only one type of atom.

e) Mixture: There are two different substances and they are not combined.

Student 2:

a) Mixture: There are different substances.

b) Compound: They are combined.

c) Element: Because it is unmixed.

d) Compound: They are combined.

e) Mixture: There are different substances.

Student 3:

a) Mixture: There are two different particles.

b) Compound: Two different atoms are combined to form a new particle.

c) Element: There is one type of particles.

d) Element: There is one type of particles.

e) Mixture: There are two different particles.

Student 4:

a) Compound: There are two substances.

b) Compound: There are two substances. Different particles…

c) Element: It is comprised of one substance. Same substance…

e) Compound: Two different substances.

Student 5:

a) Mixture: It consists of more than on kind of atom.

b) Compound: Two different kinds of atoms are combined by chemical means.

c) Element: There is one type of atom.

d) Element: There is one type of atom.

e) Mixture: It consists of more than on kind of atom.

Student 6:

a) Mixture: It consists of more than one substance.

b) Compound: Two kinds of atoms are combined to form one substance.

c) Element: There is one type of atom.

d) Element: There is one type of atom.

e) Mixture: It consists of more than one substance.

Student 7:

a) Mixture: Two different substances do not united completely.

b) Compound: Two different substances united completely.

c) Element: One substance…

d) Element: One substance…

e) Mixture: Two different substances do not united completely.

Student 8:

a) Mixture: Atoms do not unite; there are different types of atoms.

b) Compound: Atoms are combined.

c) Element: There is one kind of atom.

d) Element: There is one kind of atom.

e) Mixture: Atoms do not unite; there are different types of atoms.

Student 9:

a) Mixture: They are far away.

b) Compound: They are close together.

c) Element: There is only one atom.

d) Compound: They are close together.

e) Mixture: Different substances come together.

Student 10:

a) Mixture: two different kinds of atoms do not combine. It is formed by physical means.

b) Compound: They are combined by chemical means.

c) Element: It consists of one type of atom.

d) Element: There is same kind of atoms, no different type of atom.

e) Mixtures: Two different kinds of atoms do not combine. It is formed by physical means.

Student 11:

a) Element: Particles are not combined, they are far away.

b) Mixture: different kinds of atoms are combined.

c) Element: It contains one kind of atom.

d) Compound: Same kinds of atoms are combined.

e) Mixture: Different kinds of atoms are combined.

Student 12:

a) Mixture: There are two different types of particles.

b) Compound: There are two different types of particles and they are stick together.

c) Element: There is one type of particle.

d) Compound: There are two different types of particles and they are stick together.
e) Mixture: There are two different types of particles.

5.4. Conclusions

The following conclusions can be deducted from the results:

1. The CLCC caused a significantly better acquisition of scientific conceptions related to physical and chemical changes, and elements, compounds and mixtures and elimination of misconceptions than the TDSI.

2. Students in CLCC group had a lower proportion of misconceptions on CCMT than students in TDSI group.

3. There was no effect of gender on students' understanding of physical and chemical changes and classification of matter concepts.

4. Student-student interactions in cooperative learning group evoked by the task questions included behaviors suggestive of conditions associated with the conceptual change process.

5. There is no significant effect of interaction between treatment and gender difference on students' understanding of chemical and physical changes and classification of matter concepts.

6. Science process skills were strong predictor for the achievement related to physical and chemical changes, and classification of matter concepts.

7. There is no significant effect of treatment on students' attitudes toward science as a school subject. However, post-mean scores of students in experimental group on attitudes toward science as a school subject test were slightly higher than mean scores of students in control group.

8. Students' attitudes toward science as a school subject were not affected from gender differences in both experimental and control groups.

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

CHAPTER 6

DISCUSSIONS, IMPLICATIONS, AND RECOMMENDATIONS

This chapter involves discussion of results and implications and recommendations for further research.

6.1. Discussion

The main purpose of this study was to compare the effectiveness of the cooperative learning based on conceptual change conditions and traditionally designed science instruction on 7^{th} grade students' understanding of physical and chemical changes and classification of matter concepts and attitudes toward science as a school subject.

As mentioned before, the Classification and Changes of Matter Test was administered to all subjects in order to assess students' conceptual understanding of physical and chemical changes and classification of matter concepts before and after the treatment.

In addition, science process skills test was also administered to students in both experimental and control groups to determine whether there was a significant mean difference between the experimental and control groups. This test measures the rational and logical thinking skills that have great influence on students' understanding of science. So there was a need to control this variable for students in experimental and control groups.

The results showed that experimental group who instructed by cooperative learning based on conceptual change conditions had significantly higher post-test mean scores on the Classification and Changes of Matter Test than the traditionally designed science instruction group after treatment. The difference between learning activities provided in cooperative learning based on conceptual change conditions and traditionally designed science instruction may lead to difference in achievement of students in both groups. The traditionally designed science instruction was apparently less effective on understanding of physical and chemical changes and classification of matter concepts while the cooperative learning based on conceptual change conditions showed more improvement. The traditional instructional strategy followed the logical presentation of concepts usually seen in textbooks on science. However, the cooperative learning based on conceptual change conditions was designed to deal with students' prior knowledge or alternative concepts. The main difference between traditionally designed chemistry instruction and cooperative learning approach based on conceptual change conditions was that the latter dealt with students' misconceptions while the former did not.

This study examined the use of cooperative learning strategies to enhance conceptual change learning. The instruction in the experimental group was based on the conceptual change conditions in which alternative conceptions could be replaced into scientific conceptions. The teachers used worksheets in order to activate students' misconceptions. By this way, common misconceptions about subject matter were identified. Then the teachers presented the evidence that typical misconception was incorrect and provided a scientifically correct explanation of the situation.

In traditional classrooms, students are seldom given an opportunity to talk about their ideas, explore their conceptions and to test them. Thus, any misconceptions that students have are seldom exposed. This study provides evidence that cooperative learning based on conceptual change conditions can provide an environment for learners to overcome misconceptions in science. Furthermore, interaction evoked by the discussion questions did include behaviors suggestive of conditions associated with the conceptual change process. Students who engaged in a high frequency of verbal behavior were not likely to undergo any sort of alteration in concept understanding. In addition, carefully structured small-group tasks encouraged students to take more responsibility. Self-esteem of the students was increased by using heterogeneous groups that structured by the teacher to include both boys and girls with different levels of academic achievement and varying cognitive abilities.

In cooperative groups, students share and compare their ideas to those of their peers, so that they take a different perspective than their own. This can give rise to the dissatisfaction that is proposed as a necessary condition for conceptual change. (Posner et al., 1982) In addition, cooperative learning give rise to a variety of outcomes for example achievement increases for all ability levels, higher-level thinking processes can result, a deeper level of understanding is possible, critical thinking is promoted, more positive peer relationships result, students exhibit better social skills and provide more social support for their peers, and a higher level of self esteem can result. (Johnson & Johnson, 1990; Brandt, 1987)

The teachers used worksheets in order to activate students' misconceptions. These worksheets included activities and discussion questions that help students revise their prior knowledge. The activities and discussion questions were prepared by the researcher by considering the review of related literature. By this way, common misconceptions about subject matter were identified. Then the teachers presented the evidence that typical misconception was incorrect and provided a scientifically correct explanation of the situation. In cooperative groups, students shared and compared their ideas to those of their peers, so that they took a different perspective than their own. This could give rise to the dissatisfaction that is proposed as a necessary condition for conceptual change. Student- teacher and student-student discussions of the concepts could facilitate students' understanding and encourage their conceptual restructuring. As a result students thought that scientific conception was more adequate and meaningful.

In short, cooperative learning based on conceptual change conditions promoted the acquisition of new conceptions as a consequence of the exchange and differentiation of the existing conception and integration of new conceptions with existing conceptions. As a result, it was confirmed that the cooperative learning based on conceptual change conditions did lead to a better conceptual understanding of physical and chemical changes and classification of matter concepts.

Moreover, this study has shown that the physical and chemical changes and classification of matter concepts were much more complex than most teachers acknowledge. Also, the concepts associated with atoms are used in explanation of almost all chemical phenomena. Since the atomic model is a central concept, it is not possible to understand and explain the chemical phenomena scientifically. Misconceptions of subjects in this study in physical and chemical changes and classification of matter concepts were bound to this reason. Many of the students did not use the terms "atom" and "molecule" to explain their answers in written questions as well as during the interviews. They used commonsense thinking instead of scientific concepts and explain chemical phenomena by everyday analogies. In addition they memorized facts rather than understanding concepts. For example they could classify the given examples as elements, compounds or mixtures by recalling from the lesson but could not explain the reason behind it. (Nakhleh et. al, 2005; Hesse & Andeson, 1992; Solsona & Izquerdo, 2003; Barker, 1995)

One of the characteristics of chemistry is its microscopic nature. However, students tend to see chemical phenomena at macroscopic level. For this reason, in this study the learning materials were prepared in a way that promotes connections between students' macroscopic experiences obtained through experiments and their scientific microscopic explanations.

The most valuable result of this study might be the construction of a taxonomy of students misconceptions associated with strategies to induce conceptual change. The test questions developed in this study can be used by teachers to find out whether the misconceptions described in this study appear in their learning group. Because, it is unfair to leave students with their problems, hoping that they will understand them on their own. Students might never arrive at scientific principles lonely. Also, the teacher as clarifier of ideas and presenter of information is clearly not adequate for helping students accommodate new conceptions. Therefore, the development of strategies of how to proceed in helping students construct scientific principles is an important issue.

Also, the degree of science process skills accounted for a significant portion of variation in science achievement. It is useful to bring out analysis ability of students in solving complex problems that requires students' conceptual understanding, because it measures the intellectual abilities of students including the items related to identifying variables, identifying and stating the hypotheses, operationally defining, designing investigations and graphing and interpreting data. To understand complex concepts and problems in science, students should be able to apply fundamental facts and principles, use appropriate conceptual and theoretical frameworks, and perform calculations. It can be expected that mastery of these performances in science courses requires a range of science process skills such as interpreting data, controlling variables, formulating hypotheses, and experimenting, in addition to a sound previous knowledge in science. In summary, science process skill achievement is a significant predictor of the science achievement.

Moreover, the attitude scale toward chemistry as a school subject was administered to all subjects of the study both before and after the treatment. The analysis of the data showed that there was no significant difference between the pretest and posttest means scores of the CLCC group and TDSI group. But, posttest mean scores of students in experimental group on Attitudes toward Science as a School Subject test were slightly higher than post test mean scores of students in control group. Cooperative learning based on conceptual change conditions caused a better acquisition of scientific concepts related to physical and chemical changes and classification of matter concepts and elimination of alternative conceptions. More interaction between the teacher and the students was created, and conceptual change conditions made students dissatisfied with their existing alternative conceptions and find new concepts intelligible, fruitful and plausible. These may have produced more positive attitudes toward science as a school subject.

6.2. Implications

The findings of this study have the following implications:

1. The traditional teaching methods are ineffective in helping students learn physical and chemical changes and classification of matter concepts. Teachers needed to devise teaching methods and materials that can address specific alternative conceptions.

2. It is very difficult to remove misconceptions from the minds of the learners. Cooperative learning based on conceptual change conditions helped

students to consider their prior knowledge and make the scientific explanations understandable and useful satisfying the idea advanced by Posner et al. (1982) that to cause conceptual change, the new information must be plausible, useful in helping students explain the current problems and fruitful for solving future problems.

3. Well designed cooperative learning based on conceptual change conditions can cause a significantly better acquisition of scientific concepts and elimination of alternative conceptions.

4. Conceptual change teaching strategies do not imply that alternative conceptions are extinguished. Alternative conceptions that hold explanatory power in nonscientific contexts may be held concurrently with new conceptions.

5. Science teachers and textbook authors should be aware of students' prior knowledge and misconceptions. They should examine why misconceptions occur. They should use learning activities to eliminate misconceptions.

6. It is helpful to include questions on examinations that specifically probe for misconceptions. By this way teachers can be aware of the students' conceptions and students would then have more chance of becoming meaningful learners of science.

7. Teachers must be informed about the usage and importance of cooperative learning based on conceptual change conditions. In presenting scientific concepts in class possible preconceptions should be analyzed and considered in the planning and teaching process.

8. Cooperative learning based on conceptual change conditions increases the secondary school students' achievement in the science course. This may occur because students using this technique have active and reinforced practice.

9. Instruction on physical and chemical changes and classification of matter concepts should involve discrepant events, open-ended discussions of how these events can be interpreted and student writing about observations and explanations.

10. Science process skills are a strong predictor of science achievement. Since physical and chemical changes and classification of matter concepts are so abstract, teachers must realize that non-formal operational students will probably have difficulty in comprehending these concepts. This realization will require teachers to adjust their teaching strategies to develop students' science process skills.

11. Most teachers and textbook authors have treated the physical and chemical changes and classification of matter concepts as elementary and simple

for students. But this has not been true for the students in this study. Analogies and metaphors that focus upon surface similarities lead the students away from the underlying scientific theory or law.

12. Students should be reminded that if they can not explain chemistry concepts in molecular terms then they do not really understand it.

13. Misconception can occur when students come for instruction holding meanings for everyday words that differ from the scientific meaning. Thus, teachers should introduce scientific terms by emphasizing the differences between the everyday meaning and scientific meaning.

6.3. Recommendations

On the basis of the findings from this study, the researcher recommends that:

1. A similar study can be conducted for different grade levels and for different concepts.

2. Further studies can be conducted with a larger sample from different schools to increase the accuracy and for the generalization to Turkish student population.

3. Other instructional methods such as computer assisted instruction, problem solving, demonstration, use of analogies etc. can be used for further studies to compare the effectiveness of cooperative learning based on conceptual change conditions with these instructional methods.

4. For further studies, different science concepts can be chosen for teaching with cooperative learning based on conceptual change conditions.

5. Although the atomic model is a central concept in chemistry, most students do not use atom and molecule concepts in their explanations of chemical phenomena. This seems to be a general problem rather than misconception which need further consideration by further researches.

6. Wider implementations of cooperative methods of learning are recommended in the light of possible contribution to students' academic and affective outcomes.

7. Further research studies can be conducted to investigate the effect of cooperative learning based on conceptual change conditions on retention related to conceptual understanding of physical and chemical changes and classification of matter concepts.

8. Traditional teaching techniques are not capable of promoting conceptual change in most students. Schools of education will need to include this approach as part of their methods courses for prospective science teachers.

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Yarroch, W. L. (1985). Student understanding of chemical equation balancing. *Journal of Research in Science Teaching*, 22, 449-559.

APPENDIX A

INSTRUCTIONAL OBJECTIVES

- Define physical change and list examples.
- Define chemical change and list examples.
- Examine physical changes of matter (i.e. water, wood, and paper).
- Examine chemical changes of matter (i.e. water, wood, and paper).
- Identify properties of materials as they undergo physical changes, such as size, form, shape, heated, expanded, cooled, or contracted.
- Identify properties of a material as they undergo chemical changes.
- Given a list and description of changes of matter, students differentiate between physical changes and chemical changes.
- Differentiate evidence for physical and chemical changes.
- Observe chemical reactions.
- Observe physical changes.
- Conduct experiments with various substances to observe physical properties.
- Conduct experiments with various substances to demonstrate chemical properties.
- Determine that chemical reactions form new substances with different properties.

- Recognize that chemical reactions may release or consume energy.
- Define elements, compounds and mixtures.
- Create examples of elements, compounds and mixtures.
- Identify examples of elements, compounds, and mixtures.
- Demonstrate the ability to classify matter into elements, compounds and mixtures.
- Explore and describe the differences between elements, compounds, and mixtures.
- Compare and contrast elements, compounds, and mixtures.
- Students are able to distinguish between properties of matter and identify which ones are elements and compounds.
- Predict or explain ways to separate mixtures.
- Predict ways to separate compounds.

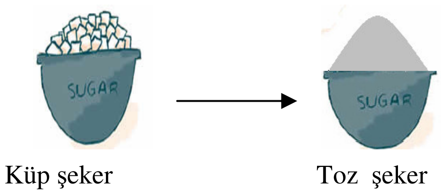
APPENDIX B

Maddedeki Değişim ve Maddenin Sınıflandırılması Kavramları Testi

A. Fiziksel ve Kimyasal Değişim

1. Şekilde verilen değişimleri fiziksel ya da kimyasal değişim olarak sınıflandırınız ve düşüncenizin nedenini açıklayınız.

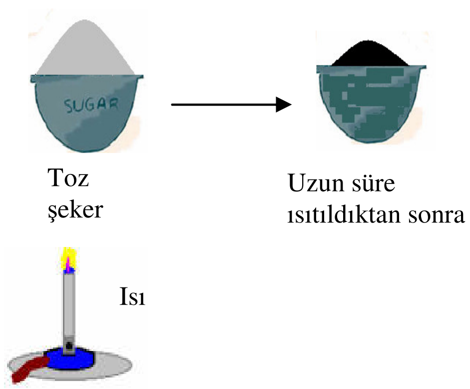
a.



………………………Değişim

Nedeni: --

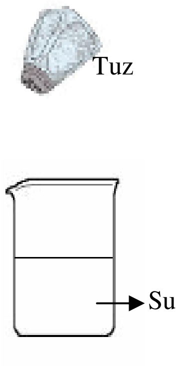
b.



………………………Değişim

Nedeni: --

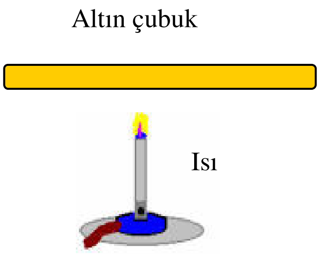
c.



………………………Değişim

Nedeni: ---

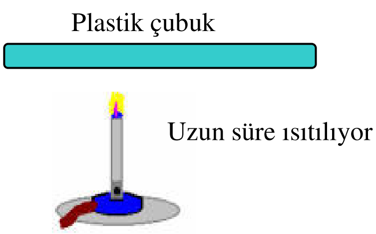
d.



………………………Değişim

Nedeni: ---

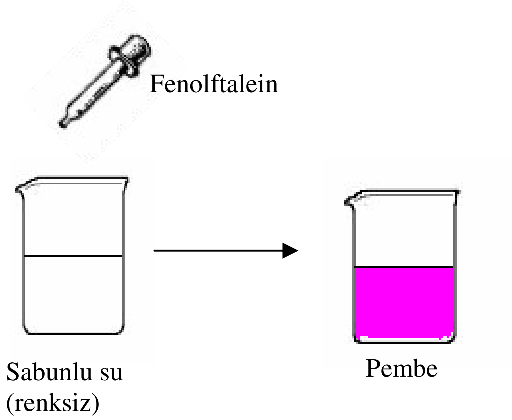
e.



………………………Değişim

Nedeni: ---

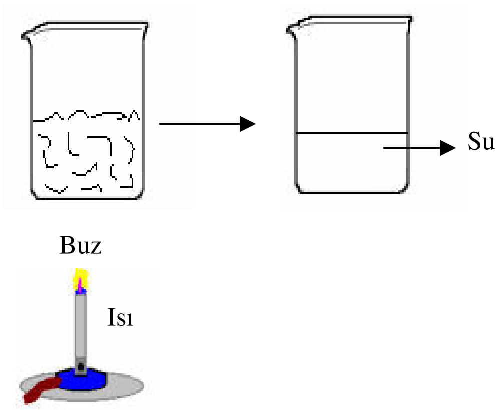
f.



………………………Değişim

Nedeni: --

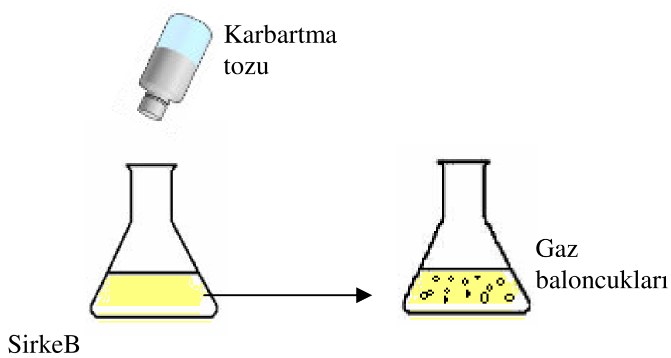
g.



………………………Değişim

Nedeni: --

h.



………………………Değişim

Nedeni: --

2. Yukarıdaki deneylerde;

a) c. ve h.

b) d. ve e.

arasındaki farkı bir cümle ile açıklayınız.

3. Hidrojen ve oksijen gazları aşağıda verilen denkleme göre tepkimeye girerek su oluştururlar.

$$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$$

Bu değişim için aşağıdakilerden hangisi doğrudur?

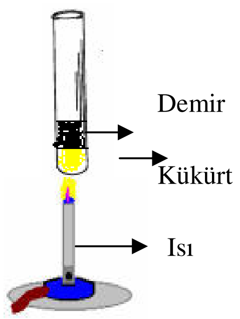
a) Su, hidrojen ve oksijenden farklı özelliklere sahiptir.

b) Sudan tekrar hidrojen ve oksijen gazları elde edilemez.

c) Hidrojen ve oksijen gazları hal değiştirerek suyu oluşturur.

d) Hidrojen ve oksijen gazları karıştırılarak su elde edilebilir.

4.



Yukarıda verilen değişim için aşağıdakilerden hangisi doğrudur?

a) Demir ve kükürt ısı alarak erir.

b) Oluşan madde tekrar ısı verirse demir ve kükürt oluşur.

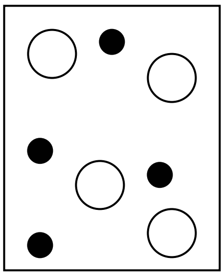
c) Oluşan madde tekrar eski haline dönüştürülemez.

d) Oluşan madde mıknatıs ile bileşenlerine ayrılamaz.

B. Element - Bileşik – Karışım

1. Aşağıda tanecikleri verilen maddeleri element, bileşik ya da karışım olarak sınıflandırınız ve cevabınızın nedenini açıklayınız.

a.



Nedeni: ----------------------------

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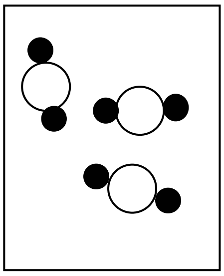
b.



Nedeni: -----------------------------

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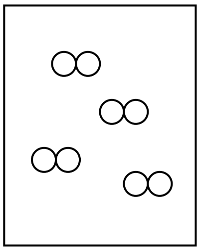
c.



Nedeni: ---------------------------

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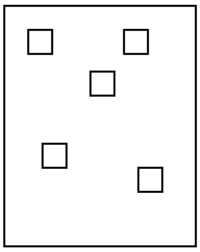
d.



Nedeni: ---------------------------

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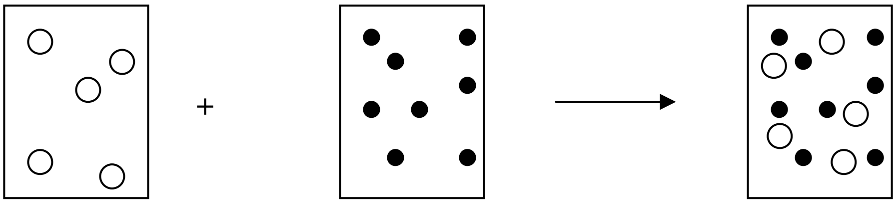
2. Na ve Cl atomları birleşerek NaCl (Sodyum klorür) bileşiğini oluşturur.

a) NaCl bileşiğinden tekrar Na ve Cl elementlerini elde etmek mümkün müdür? Nasıl? Açıklayınız.

b) Na elementi elektrik akımını iletir. Cl elementi oda sıcaklığında gaz haldedir ve zehirlidir. NaCl bileşiğinin bu özellikleri gösterdiğini söyleyebilir miyiz? Neden? Açıklayınız.

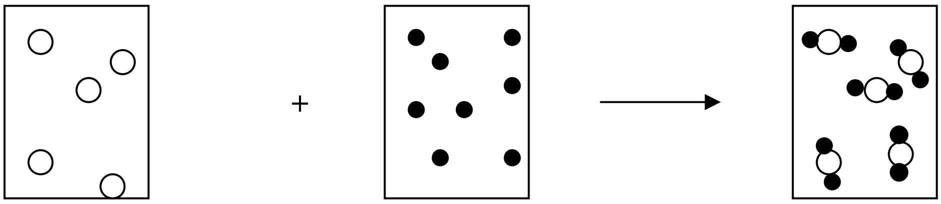
3. Aşağıda verilen değişimlerde değişimden önce ve sonra tanecikleri verilen maddeleri element, bileşik ya da karışım olarak, değişimi de fiziksel ya da kimyasal olarak gruplandırınız.

a)



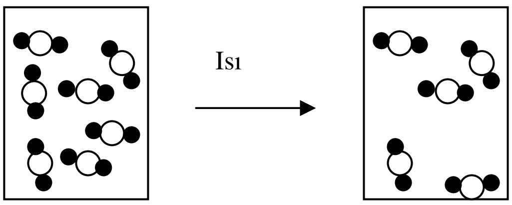
Değişim:

b)



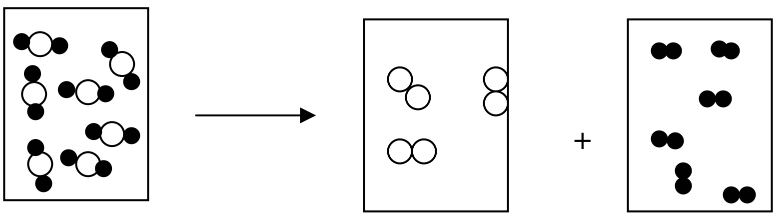
Değişim:

c)



Değişim:

d)



Değişim:

APPENDIX C

FEN BİLGİSİ DERSİ TUTUM ÖLÇEĞİ

Açıklama: Bu ölçek, Fen Bilgisi dersine ilişkin tutum cümleleri ile her cümlenin karşısında TAMAMEN KATILIYORUM, KATILIYORUM, KARARSIZIM, KATILMIYORUM VE HİÇ KATILMIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatlice okuduktan sonra kendinize uygun seçeneği √ işareti ile belirleyiniz.

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

APPENDIX D

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 yalnızca cevap kâğıdına işaretleyiniz.

Bu testin orijinali James R. Okey, Kevin C. Wise ve Joseph C. Burns tarafından geliştirilmiştir. Türkçeye çevrisi ve uyarlaması ise Prof. Dr. İlker Özkan, Prof. Dr. Petek Aşkar ve Prof. Dr. Ömer Geban tarafından yapılmıştır.

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 konulur. 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 <u>değildir</u>?

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.

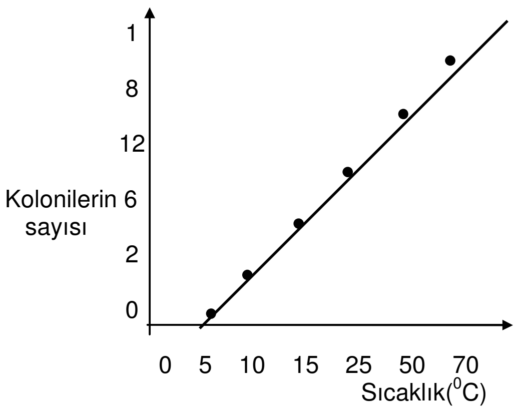
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

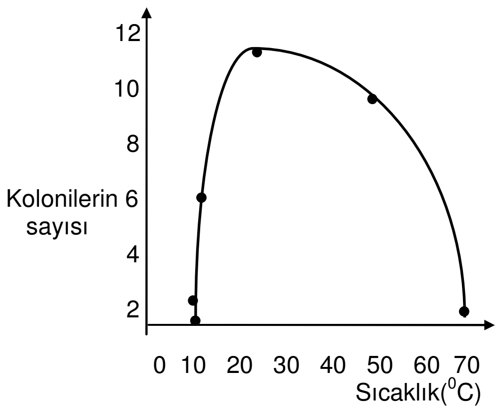
Deney odasının sıcaklığı (^0C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

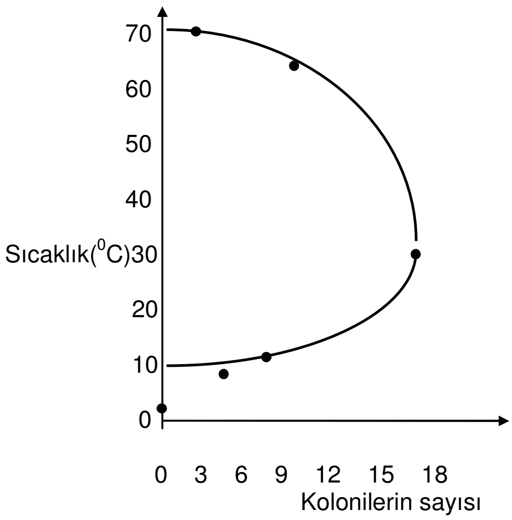
a.



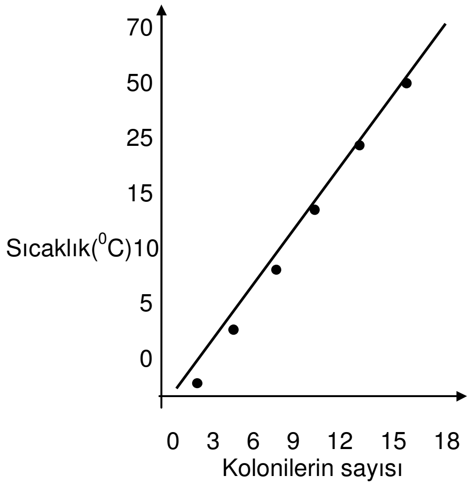
b.



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?

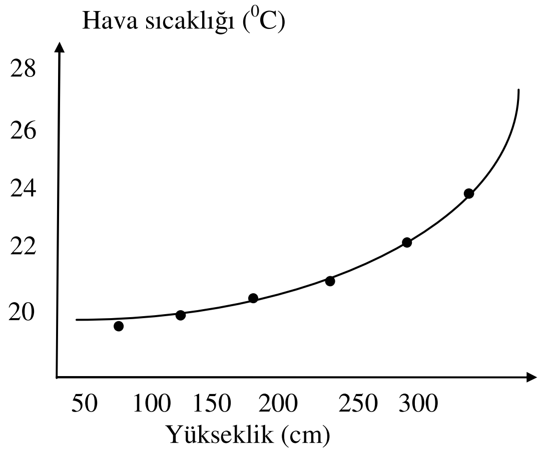
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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 sıcaklıklarla 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 ilşki 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?

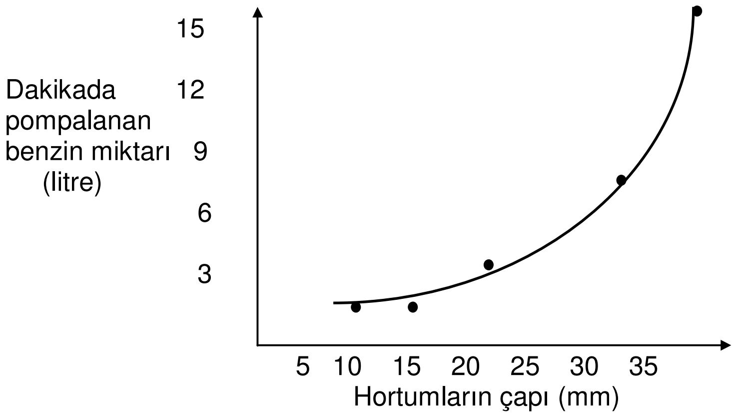
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

b. İçlerinde farklı 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 gübrenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

d. Bahçe ne kadar engebeliyse çimenleri kesmek de o kadar zor olur.

17, 18, 19 ve 20'nci 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 ya da spreyin miktarı ölçülür.
b. Toz ya da 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.

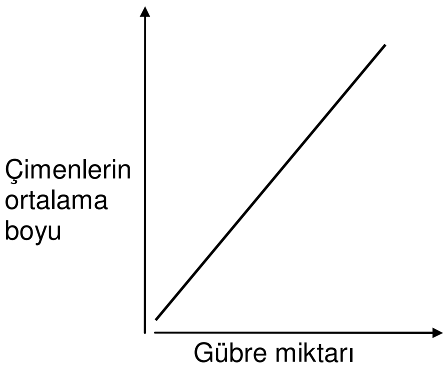
d. Her biri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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.

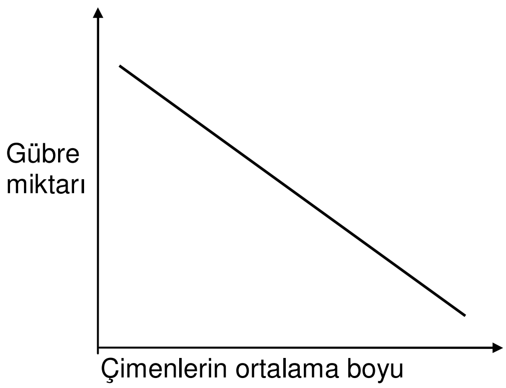
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

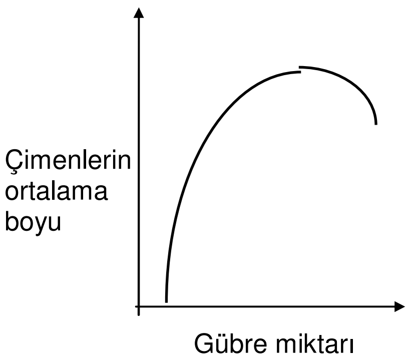
a.



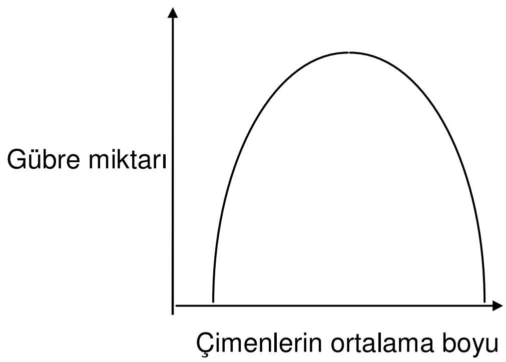
b.



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?

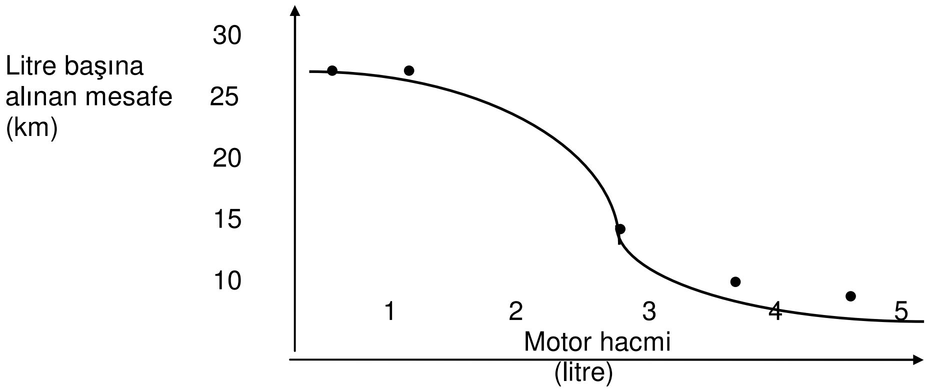
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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'nci 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 yapak 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 yapak 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 yapak 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.

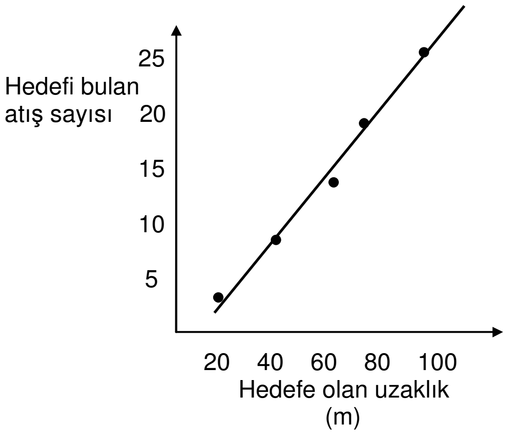
d. Çekilen demir tozlarının ağırlığı ile.

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

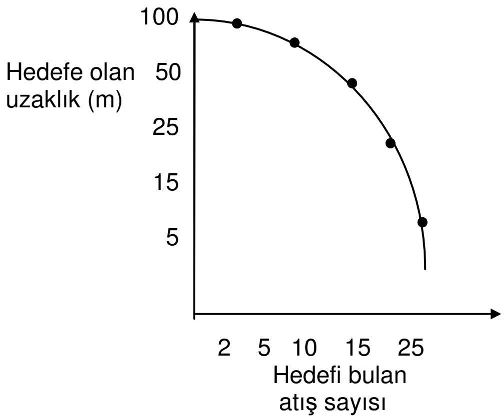
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

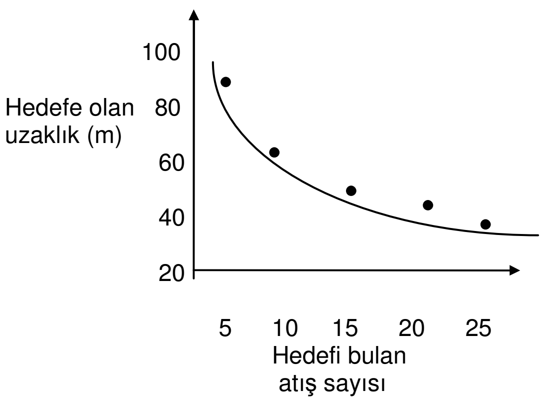
a.



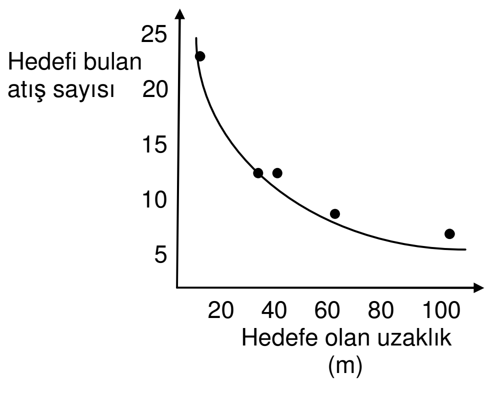
b.



c.



d.



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 makinesinin kullanma sıklığı.

d. a ve c.

APPENDIX E

INTERVIEW QUESTIONS

A. Physical and Chemical Changes

1. What is the type of change when ice is heating? Why? Which properties of ice are changed?

2. As a candle burns it gives off light and heat. When a glass rod is held in the yellow part of the flame a black film forms on the rod.

a) What is the source of black film on the rod?

b) Is the rod undergoes a chemical or physical change?

c) Give your reasons.

3. When you hold piece of iron and a piece of plastic for some time, there is no difference on plastic while the iron is coated by rust.

a) What is the source of rust on the iron?

b) In your opinion is rusting of iron physical or chemical change? Why?

c) If the coating is removed from the iron, is the remaining iron will weight less? Explain your answer.

B. Elements, Compounds and Mixtures

1. a) Define element. List the properties of elements and give examples.

b) Define compound. List the properties of compounds and give examples.

c) Define mixture. List the properties of mixtures and give examples.

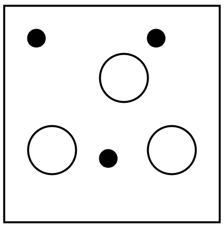
2. Classify the given substances as element, compound or mixture.

Water, Sugar in water, Iron, Sugar, Hydrogen gas, Iron powder

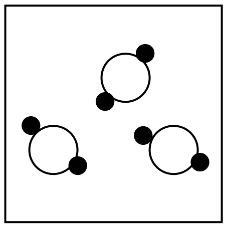
Element	Compound	Mixture

3. Classify the given diagrams as elements, compounds and mixtures. Give your reasons.

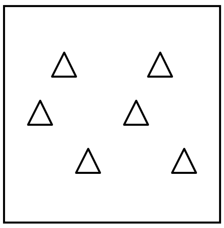
a)



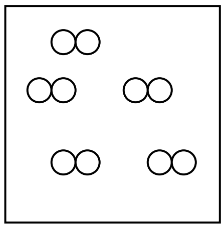
b)



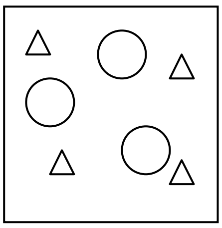
c)



d)



e)



APPENDIX F

FİZİKSEL VE KİMYASAL DEĞİŞİMLER

Deneyin Adı: Fiziksel ve Kimyasal Değişimler

Amaç: Fiziksel ve Kimyasal değişimler arasındaki farklar

Araç ve Gereçler:

Kabartma tozu Kalsiyum klorür Potasyum nitrat Çıra

Cam çubuk Deney tüpleri

İşlem Basamakları:

Laboratuarda sizin için dört farklı istasyon hazırlanmıştır. Her bir istasyona giderek orada bulunan görev kartlarını dikkatlice okuyunuz ve aşağıda verilen gözlem tablolarını doldurunuz.

Tablo 1.

Madde	**Fiziksel özellikler**	**Gözlenen Değişim**
Kabartma tozu		
Kalsiyum klorür		
Su		

Tablo 2.

Madde	Fiziksel özellikler	Gözlenen Değişim
Potasyum nitrat		
Su		

Tablo 3.

Madde	Fiziksel özellikler	Gözlenen Değişim
Çıra		

Tablo 4.

Madde	Fiziksel özellikler	Gözlenen Değişim
Cam çubuk		

İSTASYON 1

Kabartma tozu, Su ve Kalsiyum klorürün fiziksel özelliklerini yazdıktan sonra beher içine 1 spatül kabartma tozu, 1 spatül kalsiyum klorür alınız ve üzerine 50 ml su ekleyiniz. Değişimleri gözlemleyerek kâğıdınıza not ediniz.

İSTASYON 2

Potasyum nitrat ve suyun fiziksel özelliklerini kaydettikten sonra beher içine 1 spatül potasyum nitrat alınız ve 50 ml su ekleyiniz ve değişimleri gözlemleyerek yazınız.

İSTASYON 3

Çıranın fiziksel özelliklerini yazdıktan sonra çırayı bir süre mum alevine tutunuz ve değişimleri gözlemleyerek kaydediniz.

İSTASYON 4

Cam çubuğun fiziksel özeliklerini yazdıktan sonra bir süre mum alevine tutunuz ve değişimleri gözlemleyerek tabloya kaydediniz.

Sorular:

1. Gözlemlediğiniz değişimlerden hangileri kimyasal değişimdir?

2. Gözlemlediğiniz değişimlerden hangileri fiziksel değişimdir?

3. I. deneyde kabartma tozunda gözlemlediğiniz değişimle, II. deneyde potasyum nitratta gözlemlediğiniz değişim arasındaki fark nedir?

4. Çırayı ateşe tuttuğunuzda çıra küçüldü mü? Neden?

5. Çırayı ateşe tuttuğunuzda çıkan duman nereden gelmektedir?

6. Cam çubuğu ateşe tuttuğunuzda üzerinde oluşan siyah tabaka ne idi?

7. Cam çubuğun üzerindeki siyah tabakayı silince, ateşe tutmadan önceki haline göre kütlesinde bir değişim oldu mu? Neden?

8. Evdeki kararan gümüşleri silerek parlattığınızda, kararmadan önceki kütlesine göre değişim olur mu? Neden?

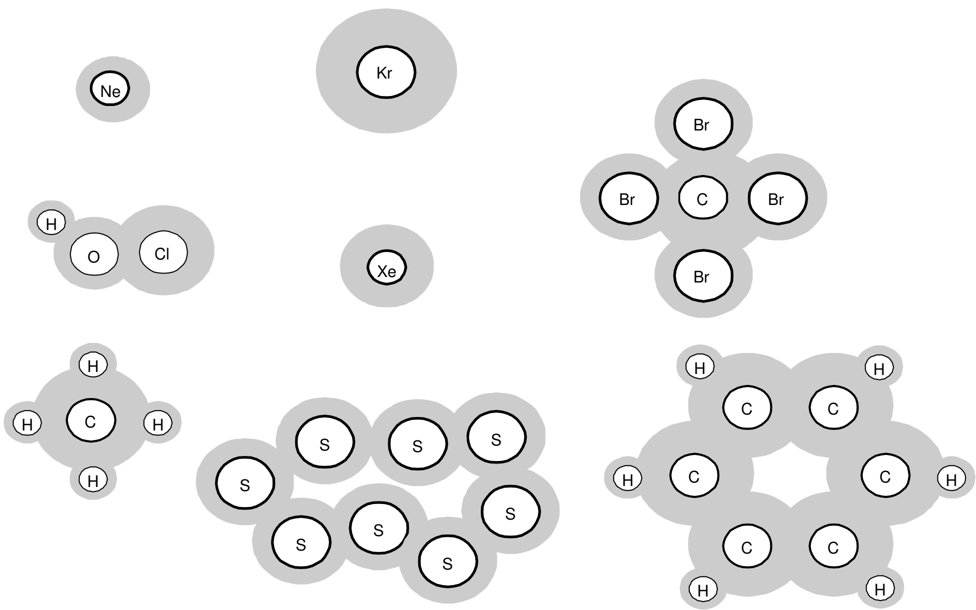
9. a) Bir parça demir ve bir parça plastik bir süre bekletildiğinde, plastikte bir değişim olmazken, demir paslanır. Bunun nedenini açıklayınız.

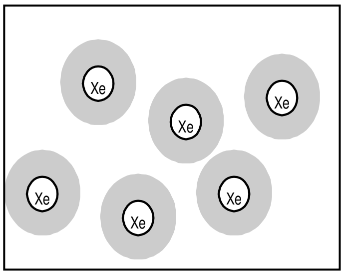
b) Demir üzerindeki pasın bir kısmı kazınırsa, demirin paslanmadan önceki kütlesine göre bir değişim olur mu? Neden?

APPENDIX G

ELEMENT, BİLEŞİK VE KARIŞIM

1. Aşağıda 8 farklı tanecik verilmiştir. Bu taneciklerin oluşturduğu 6 maddeyi element, bileşik ya da karışım olarak sınıflandırınız. Nedenini belirtiniz.



a) 

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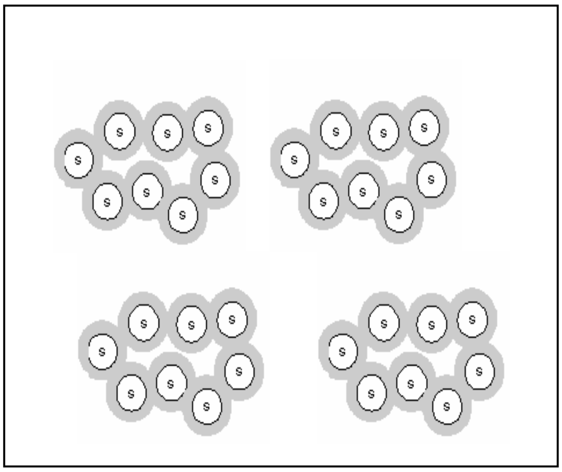
b) 

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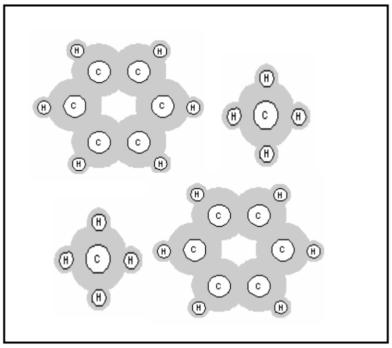
c) 

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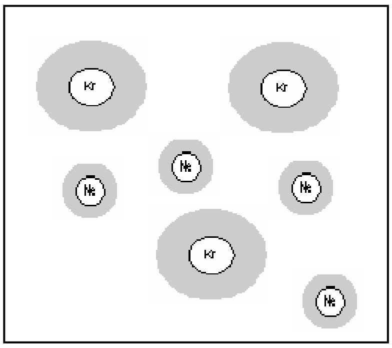
d)



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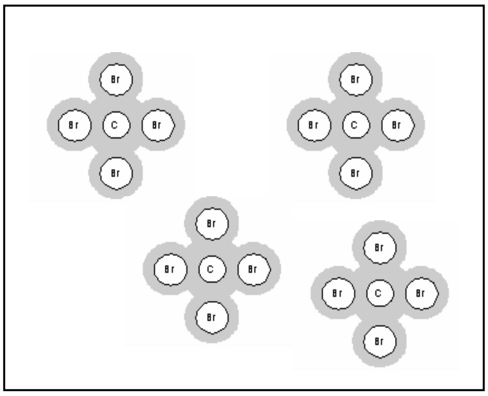
e)



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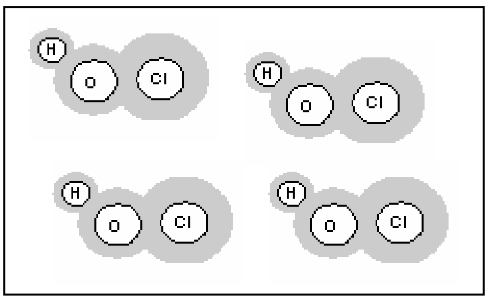
Çünkü …………………………………………………………………..

f)



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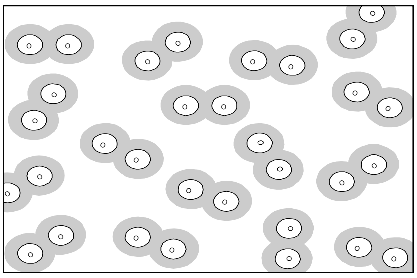
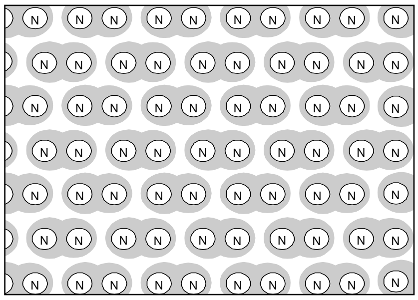
Çünkü …………………………………………………………………..

2. Aşağıda verilen şekillerden hangi ikisi aynı maddeye aittir? Nedenini açıklayınız.

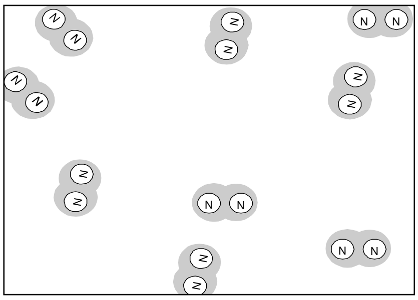
A)



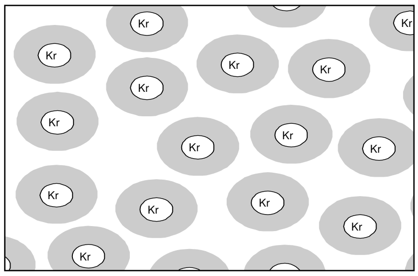
C)



B)



D)



Nedeni: ……………………………………………………………………………

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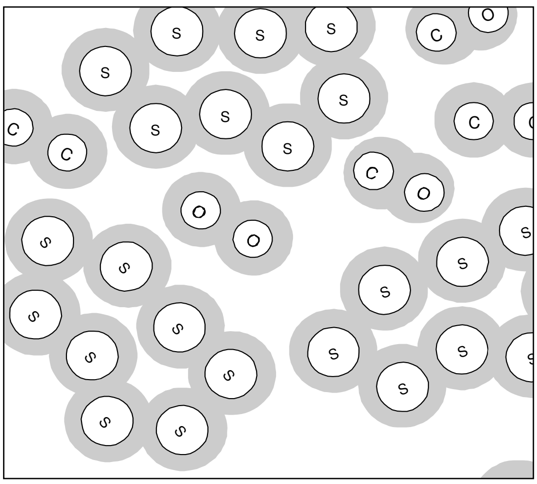
3. Aşağıda şekilleri verilen maddeleri saf madde ya da saf olmayan madde olarak sınıflandırınız ve nedenini açıklayınız.

a)



Nedeni: ………………………………………………………………………….

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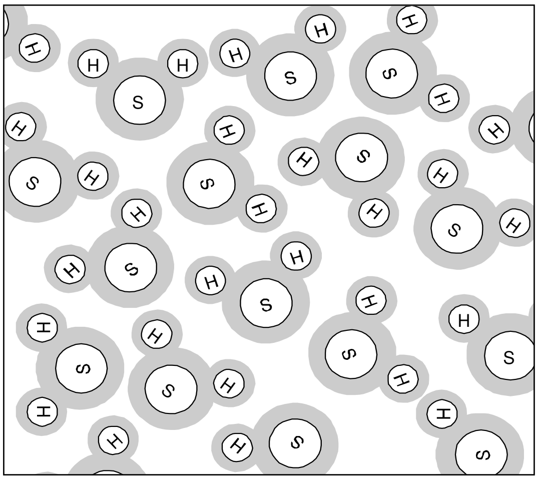
b)



Nedeni: …………………………………………………………………………

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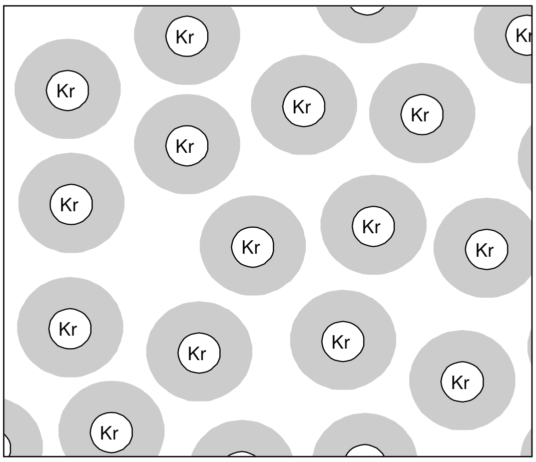
c)



Nedeni: …………………………………………………………………………

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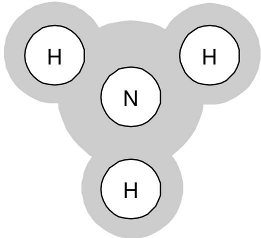
4. Aşağıda verilen molekülleri element molekülü ya da bileşik molekülü olarak sınıflandırınız ve nedenini açıklayınız.

a)



Nedeni: …………………………………………………………………………

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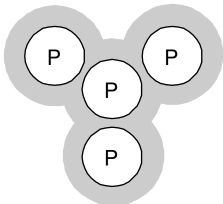
b)



Nedeni: …………………………………………………………………………

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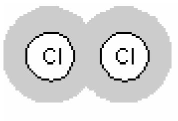
c)



Nedeni: …………………………………………………………………………

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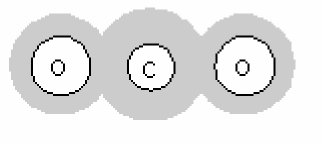
d)



Nedeni: …………………………………………………………………………

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5. Aşağıda verilen şekiller demir ve kükürt atomlarını temsil etmektedir.

a) Size 5 tane demir ve 6 tane kükürt atomu verildiğini düşününüz. Aşağıdaki kutuya bu demir ve kükürt atomlarından oluşan karışımın şeklini çiziniz.

b) Çiziminizi bu şekilde oluşturmanızın üç nedenini yazınız.

c) Demir ve kükürt atomlarının tamamı karışımı oluşturmada kullanıldı mı? Neden?

d) Size verilen 5 tane demir ve 6 tane kükürt atomunun FeS (demir sülfür) bileşiğini oluşturmak için ısıtıldığını düşününüz. Aşağıdaki kutuya oluşan son durumun şeklini çiziniz.

e) Çiziminizi bu şekilde oluşturmanızın üç nedenini yazınız.

f) Demir ve kükürt atomlarının tamamı karışımı oluşturmada kullanıldı mı? Neden?

6. Size verilen sarı oyun hamurlarını kullanarak 6 tane kükürt atomu oluşturunuz.

Mavi oyun hamurlarından ise 7 tane demir atomu oluşturunuz.

Şimdi demir ve kükürt atomlarından oluşan bir karışım oluşturunuz.

a) Tüm demir ve kükürt atomlarını karışımı oluşturmada kullandınız mı? Neden?

b) Karışımı bileşenlerine hangi yöntemle ayırt edebilirsiniz?

c) Karışım içindeki demir ve kükürt atomlarının özelliklerinde bir değişim oldu mu? Oldu ise açıklayınız.

Şimdi de demir ve kükürt atomlarından FeS (demir sülfür) bileşiği oluşturunuz.

d) Tüm demir ve kükürt atomlarını bileşiği oluşturmada kullandınız mı? Neden?

e) Bileşiği kendisini oluşturan bileşenlerine hangi yöntemle ayırt edebilirsiniz?

f) Demir ve kükürt atomları bileşiği oluşturduklarında özelliklerinde bir değişim oldu mu? Olduysa açıklayınız.

VITA

Name & Surname: Arzu (Özdemir) Erdemir

Date of birth: June 20, 1974

Place of birth: Kırıkkale

Collegiate Institution	Dates	Degree	Date of Degree
Middle East Technical University Faculty of Education	1991-1996	B.S.	January, 1996
Middle East Technical University Faculty of Education	1996-1998	M.S.	July, 1998
Middle East Technical University Faculty of Education	1998-2006	Ph.D.	March, 2006

Major: Chemistry

Professional Positions held.	Dates	Places
Research Assistant	1996-1999	Middle East Technical University in Ankara
Science Teacher	1999-continue	ODTÜ G.V. Özel İlköğretim Okulu in Ankara

Main Areas of Interest: Students' alternative conceptions and cooperative learning and conceptual change approach in chemistry