EFFECT OF COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE CONDITIONS ON MOTIVATION AND UNDERSTANDING OF REACTION RATE

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ABSTRACT

EFFECT OF COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE CONDITIONS ON MOTIVATION AND UNDERSTANDING OF REACTION RATE

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The present study mainly focuses on the effect of cooperative learning based on conceptual change conditions to remedy 11th grade students' misconceptions related to reaction rate. Also, effect of this method on their motivation was investigated.

A total of 110 eleventh grade students participated in the study. Two schools in Ankara and two classes being instructed by the same teacher in each school were included in the sample. One of the classes was randomly assigned as a control group instructed by traditional way and the other as an experimental group instructed by cooperative learning based on conceptual change conditions. This study was conducted on 2008-2009 first semester over six weeks. Reaction Rate Concept Test and Motivated Strategies for Learning Questionnaire were administered as pre-test and post-test to measure students' understanding of reaction rate, and their motivation. Moreover, Science Process Skill Test was given before instruction to decide whether there was a significant difference between two groups in their science process skills.

ANCOVA was used to evaluate the effect of cooperative learning on students' understanding of reaction rate. The results indicated that cooperative learning based on conceptual change conditions removed most of students' misconceptions about reaction rate concept and resulted in a significantly better understanding of reaction rate than traditional instruction. Furthermore, data reflecting the effect of conceptual change based cooperative learning on students' motivation was analyzed by MANOVA. According to the results, cooperative learning based on conceptual change conditions improved intrinsic goal orientation, and self-efficacy for learning and performance.

Keywords: Cooperative Learning, Conceptual Change, Reaction Rate, Misconception, Motivation

ÖZ

KAVRAMSAL DEĞİŞİM KOŞULLARINA DAYALI İŞBİRLİKÇİ ÖĞRENME YÖNTEMİNİN MOTİVASYONA VE TEPKİME HIZI KONUSUNU ANLAMAYA ETKİSİ

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Bu çalışma, başlıca kavramsal değişim koşullarına dayalı işbirlikçi öğrenme yönteminin, 11. sınıf öğrencilerinin tepkime hızı konusundaki kavram yanılgılarını gidermedeki etkisi üzerine odaklanmıştır. Ayrıca, bu yöntemin öğrencilerin güdülenmelerine etkisi incelenmiştir.

Çalışmaya toplam olarak 110 öğrenci katılmıştır. Ankara'dan iki okul ve her okuldan aynı öğretmenin ders verdiği iki sınıf seçilmiştir. Sınıflar deney ve kontrol grubu olarak rastgele seçilmiş; deney grubunda kavram değişim koşullarına dayalı işbirlikçi öğrenme yöntemi, kontrol grubunda ise geleneksel yöntem kullanılmıştır. Çalışma, 2008–2009 öğretim yılının ilk döneminde, 6 hafta süreyle uygulanmıştır. Tepkime Hızı Kavram Testi ve Öğrenmede Güdüsel Stratejiler Anketi, öğrencilerin tepkime hızını anlamalarını ve güdülenmelerini ölçmek amacıyla, öntest ve sontest olarak verilmiştir. Buna ek olarak, çalışmanın başlangıcında iki grubun bilimsel işlem becerilerinde fark olup olmadığını ölçmek için Bilimsel İşlem Beceri Testi uygulanmıştır.

İşbirlikçi öğrenme yönteminin öğrencilerin tepkime hızı konusunu anlamalarına etkisine ilişkin veriler ANCOVA ile analiz edilmiştir. Sonuçlara göre, tepkime hızı konusunda işbirlikçi öğrenme grubu geleneksel gruptan daha başarılı olmuştur. Geleneksel grupla kıyaslandığında, işbirlikçi öğrenme grubundaki öğrencilerin kavram yanılgılarının çoğu ortadan kaldırılmış ve tepkime hızını daha iyi anladıkları ortaya çıkmıştır. Ayrıca kavram değişimine dayalı işbirlikçi öğrenme yönteminin güdülenmeye etkisini yansıtan veriler MANOVA kullanılarak analiz edilmiştir. Sonuçlar göstermiştir ki, kavram değişimine dayalı işbirlikçi öğrenme yöntemi öğrencilerin içsel hedef yönelimi ve öğrenme ve performansa yönelik özyeterliliğini geliştirmiştir.

Anahtar Kelimeler: İşbirlikçi Öğrenme, Kavram Değişimi, Tepkime Hızı, Kavram Yanılgısı, Güdülenme

To My Parents

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RRCT	: Reaction Rate Concept Test
MSLQ	: Motivated Strategies for Learning Questionnaire
SPST	: Science Process Skill Test
CLCC	: Cooperative Learning based on Conceptual Change
TI	: Traditional Instruction
EG	: Experimental Group
CG	: Control Group
IGO	: Intrinsic Goal Orientation
EGO	: Extrinsic Goal Orientation
TV	: Task Value
CLB	: Control of Learning Beliefs
SELP	: Self-efficacy for Learning and Performance
TA	: Test Anxiety
SD	: Standard Deviation
p	: Significance level
F	: F statistic
df	: Degrees of freedom
N	: Sample size
MANOVA	: Multivariate Analysis of Variance
ANCOVA	: Analysis of Covariance

CHAPTER 1

INTRODUCTION

Students come to the classroom with a range of pre-knowledge. This existing knowledge has a great influence on their learning. The constructivist view of learning attaches importance to students' prior knowledge. This view emphasizes the requirement of linking their prior knowledge with the new concepts to be taught to encourage meaningful learning. Correspondingly, Ausubel (1968) stated that "If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (p.iv). Similarly, Alexander (1996) drew attention to the significant role of students' base knowledge in learning: "Truly, one's knowledge base is a scaffold that supports the construction of all future learning" (p. 89). Hence, teachers should take students' existing knowledge into account. Some research studies indicated that the role of students' pre-knowledge, "misconceptions" (Driver & Easley, 1978), "preconceptions" (Driver & Easley, 1978), "alternative frameworks" (Driver & Erickson, 1983), or "children's science" (Osborne & Freyberg, 1985) limited their understanding in science. These terms are used interchangeably by researchers and they are generally different from normally accepted scientific ideas (Carmichael et al., 1990; Pfundt & Duit, 1994). Research findings supported that students often have misconceptions constructed before or even after the science instruction (Wandersee, Mintzes & Novak, 1994). When the learner incorporates misconceptions into his/her cognitive structure, they impede learning. Therefore, new information cannot be attached to his/her cognitive structure and misapprehension arises (Nakleh, 1992). The research studies revealed that misconceptions are persistent and resistant to change by traditional ways (Clement, 1982; Tsai, 1999).

When the research studies are examined, it will be observed that researchers generally worked on matter and particulate nature of it, solubility, gases, heat and temperature, chemical change, electrochemistry, mole concept, acids and bases, stoechiometry and chemical equilibrium (Hackling, & Garnett,1985; Yarroch 1985; Hines 1990; Renstrom, Anderson, & Morton,1990; Haidar & Abraham 1991; Garnett, 1992; Hesse & Anderson, 1992; Staver & Lumpe 1995; Quilez-Pardo, & Solaz-Portoles, 1995 ; Tyson, Treagust & Bucat, 1999; Voska, & Heikkinen, 2000; Uzuntiryaki & Geban, 2005). Among these, chemical equilibrium is one of the most studied topics. Although there are so many research studies on chemical equilibrium, more studies are necessary to be conducted on reaction mechanisms and reaction rate concepts that play an important role on understanding chemical equilibrium. These concepts were generally examined under the heading of chemical equilibrium in a limited extent (Johnstone, MacDonald & Webb, 1977; Wheeler & Kass, 1978; Hackling, & Garnett, 1985; BouJaoude, 1993; Garnett, Garnett & Hackling, 1995; Huddle & Pillay, 1996). Nevermore, there have been still some research studies on students' conceptions about reaction rate (Haim, 1989; Garnett et al., 1995; Nakiboğlu, Benlikaya & Kalın, 2002; İcik, 2003; Bozkoyun, 2004; Çakmakçı, 2005; Balcı, 2006; Çakmakçı, Leach & Donnelly, 2006; Kıngır & Geban, 2006) but, some of them are not reachable because of their language or being unpublished. Moreover, the research studies suggesting a teaching strategy to enhance understanding of reaction rate are very limited (Bozkoyun, 2004; Balcı, 2006) and these are very similar. At this point, it is important to work on an appropriate teaching strategy providing meaningful learning and remedy of most of the misconceptions.

To promote meaningful learning, conceptual change approach is an alternative way to overcome students' misconceptions (Hewson and Hewson, 1983; Smith, Blakessie & Anderson, 1993; Treagust, Harrison & Venville, 1996; Beeth, 1998; Tsai, 2000; Vosniadou, Ioannides, Dimitrakopoulou & Papademetriou, 2001). Conceptual change means that a learner actively substitutes existing scientific knowledge with scientifically accepted ideas (Posner, Strike, Hewson, & Gertzog, 1982; Dole & Sinatra, 1998; Tsai, 1998). During learning process, learners should make an effort and be attentive, and so they should be supported to be actively involved in the course of action instead of being passive. This is possible by encouraging students to plan and conduct experiments, listen to others' ideas, engage in projects, make connections between scientific phenomena and daily life experiences and solve complex problems (Vosniadou et al., 2001). Posner et al. (1982) claimed that for conceptual change to occur successfully learners should be dissatisfied with their existing ideas and the new knowledge has to be intelligible, plausible, and fruitful. That means, old conception needs to meet difficulties in order for new conception to replace, and a new intelligible and plausible notion resolves these difficulties. The interaction between learner's pre-knowledge and scientifically accepted ideas assists the construction of new personal meanings from existing knowledge. The teaching strategy planned by these principles has proven to assist students to remove their misconceptions (Chambers & Andre, 1997).

Conceptual change theory is based on Piaget (1950)'s idea of disequilibrium, assimilation and accommodation. Assimilation takes place when the learner fits new conception with his/her existing cognitive structure or schema which is composed of mental images that are formed as we experience the world. When new conception doesn't match with existing cognitive structures, disequilibrium occurs and the learner attempts to balance between experienced environment and existing structures. As a result, existing structures are changed or new ones are created. This is called accommodation. Assimilation and accommodation influence each other. Disequilibration provides conceptual change. Hence, learning environments should intend to create disequilibrium in students' minds for conceptual change (Dykstra 1992).

Vosniadou et al., (2001) stated that learning occurs not only in the head but also in a social or cultural environment. If learning activities are designed based on the real world conditions, remembering the related concepts will be much easier. Therefore, problem solving skills would be adapted to the social context that the learner lives in. Learning is a social event and so the students should be provided learning environments to work with their peers so that they could allow for their individual differences. Among the conceptual change based strategies, cooperative learning was found to be effective to enhance students' understandings (Slavin, 1987c; Roschelle, 1992; Cohen, 1994; Hogan, Nastasi & Pressley, 1999; Barron, 2000; Van Boxtel, Van der Linden & Kanselaar, 2000; Mori, 2002; Barbosa, J´ofili & Watts, 2004; Gijlers & de Jong, 2005; Graham, 2005; Doymuş, 2007; Acar & Tarhan, 2008).

Cooperative learning requires students to work together in small groups to support each others' learning and understanding and to accomplish shared goals. According to Vygotsky (1981), children learn through their interactions with other people. They internalize skills and knowledge experienced during these interactions and ultimately they use those internalized skills and knowledge to lead their own behavior. The tasks given to the groups need to be structured to ensure that students are independent and individually accountable. Only putting pupils into groups doesn't mean that they will work cooperatively. Just copying others' work is not cooperation in the group. Cooperative learning has also been used successfully as a teaching strategy to help students learn to manage conflict (Stevahn, Johnson, Johnson, Gren & Laginski, 1997) and to build appropriate interpersonal skills (Cowie & Berdondini, 2001). The major gains of cooperative learning that teachers have recognized for students with special needs include improved self-esteem, a safe learning environment, increased motivation and better classroom success rates and products (Jenkins, Antil, Wayne & Vadasy, 2003). Moreover, cooperative learning positively affects motivation when the high-achievers and the low-achievers work together in a small group for group rewards (Gage & Berliner, 1992). Students feel good about making contribution to the welfare of others. Furthermore, Johnson and Johnson (1987a) found out that when cooperative learning approach was used more in the classroom, students would learn science better, they would tolerate the differences more and they would value themselves more as science students. Moreover, Slavin (1999) offered that it is one of the greatest educational innovations of recent times. To Ormrod (1995), the success of cooperative learning may be because (a) learners get assistance and support from many sources such as teachers and peers, (b) cooperative group members mostly support achievement socially, not "freeloaders", (c) cooperative learning promotes discussion and social interaction which eventually encourages meaningful learning and elaboration that is a process assisting long term memory encoding.

Studies conducted at primary and secondary level indicated that cooperative learning brought about higher achievement, improved relationships among students and better psychological adaptation than did competitive (students work against each other to attain a goal) or individualistic strategies (students work by themselves to reach the goal) (Johnson & Johnson, 1989, 1998; Johnson, Johnson, & Smith, 1991; Slavin, 1995; Johnson, Johnson, & Stanne, 2000). Likewise, studies on college level and adults detected that cooperative learning produced higher achievement than did competitive or individualistic learning (Johnson & Johnson, 1987b, 1989; Johnson et al., 1991).When students work cooperatively, they learn to listen to the others, share thoughts, give and receive help, try to find ways to solve difficulties and actively construct new learning and understanding. Founded on these ideas, present study aims to investigate the effect of cooperative learning based on conceptual change conditions on 11th grade students' understanding of reaction rate concept and their motivation.

1.1 Significance of the Study

There are several studies about the effect of cooperative learning compared to traditional instruction on students' understanding, achievement and motivation (e.g. Klein & Schnackenberg, 2000; Barbosa et al., 2004; Gillies, 2004; Zakaria & Iksan, 2007) but this is the only one that intended to explore the effect off cooperative learning strategy on removing students' misconceptions related to rate of reaction and on their motivation.

Turkish education system at secondary level is being adapted to constructivist approach. Curriculum of 9th grade level has already been modified accordingly. The pilot studies for other grades at secondary education continue and the researchers work on an appropriate curriculum. At 9th grade, there are some activities on the textbooks requiring students to work in cooperative groups. Obviously, putting these activities into practice depends on the teacher. When the studies are completed, similar activities or teaching materials will take place in the curriculum and lesson plans at other grades of secondary education. This study is expected to contribute chemistry education at high schools and be helpful for chemistry teachers since it provides detailed information about cooperative learning, useful teaching materials which were prepared based on cooperative learning approach, related instruments to evaluate students, and directions and procedures to apply those instruments and materials according to cooperative learning strategy which has been found to be helpful to improve students' understanding in science and their motivation (e.g. Slavin, 1987c; Sisovic & Bojovic, 2000; Eilks, 2005; Gillies, 2008).

CHAPTER 2

REVIEW OF RELATED LITERATURE

How educators should teach has been the central issue of the most research studies for decades. Major goal of science teaching is to make students capable of understanding the nature of the world by enabling them to gain knowledge (Hodson, 1992). Herron (1996) suggested that knowledge cannot directly be transmitted from one person to another. Knowledge is constructed by the individual based on existing experiences and understandings. However, in most of the schools, lecturing is the indispensable method to teach science (Cooper, 1995; Kolz & Synder, 1982). In the classroom, students listen to the teacher and take notes or generally copy the board. Teacher does not have to consider what each student needs. Students are like spectators in the classroom and they passively get information. This may be suitable for some students but some of them may be bored or cannot keep pace with the teacher. It is a teacher-centered technique. Therefore, this method is out-of-date and must be exchanged with more student-centered strategies. Contemporary educators have to modify their teaching methods because "… teaching of higher level reasoning and critical thinking does not depend on *what* is taught, but rather than on *how* it is taught" (Ruggiero, as cited in Johnson & Johnson, 1994, p.57). At this point, we ask this question as science educators: "what is the best teaching method for my students?" According to Dressel and Marcus (1982) and Heron (1996), learning depends on characteristics of learners, teachers, and the nature of the materials. Teachers can guide learning of students having different backgrounds by creating an environment in which they are actively involved in their learning. Cooperative learning which is founded on constructivism is one of the appropriate methods satisfying this goal. When students work in cooperative groups, they more frequently use higher levels of reasoning and critical thinking skills to create new ideas and solutions compared to competitive and individualistic situations (Johnson & Johnson, 1999a).

According to constructivism, students learn by constructing knowledge, not by automatically receiving information from outside. It doesn't imply that lecturing is ineffective but, other student-centered strategies are more efficient (Huba & Freed, 2000; Shulman, 2002). Constructivism supports keeping students being actively involved in their learning, investigating their existing knowledge and later exploring how new information matches with internal constructions in their minds (Huba & Freed, 2000). Students come to the learning environment with a lot of experiences and the teacher has to consider them during the instruction. This experiences, understandings, or conceptions play a critical role in students' learning. That is why educators or researchers have been conducting a lot of studies concerning students' conceptions about various topics in science, mathematics, and social areas. Constructivist approach necessitates students to integrate pre and new knowledge and participate in conversations or dialogues with others in the classroom in order for internalization and deep understanding (Richardson, 1997). Based on this argument, this study provides information about the effectiveness of a student-centered strategy, cooperative learning, on students' understanding of reaction rate concept. In this chapter, related literature about misconceptions, conceptual change, and cooperative learning is presented.

2.1 Misconceptions in Reaction Rate

Students may have built up thoughts about some events or concepts before formal instruction in the classroom (Amir & Tamir, 1994). Students' conceptions or ideas that do not match or are not in accordance with the scientific explanations are called *misconceptions* (Fisher, 1983, Gabel & Bunce, 1994, p. 305; Griffiths, 1994; Nakleh, 1992; Wandersee et al., 1994, p. 179). Misconceptions are persistent. Once the misinformation is located in person's knowledge structure, new information is often distorted or disregarded, that causes to reinforce or retain the incorrect idea (Otero, 1998; Vosniadou, 2001). If a scientific concept is not clearly expressed and explained, students are most likely to hold on a misconception that makes sense to them. As a result, every new term or theory will be incorporated into that flawed framework. For this reason, educators or researchers investigate students' conceptions related to science or other disciplines. It is necessary to say that misconceptions are different from "mistakes". Mistakes can be distinguished by the students when they are given the correct explanation (Abimbola, 1988).

The sources of misconceptions are limited personal experiences and observations, social interactions, incorrect and imprecise prior instruction (Dole, 2000; Quian & Guzetti, 2000), imprecise use of language by teachers and students (Jacobs, 1989; Veiga, Costa Pereira & Maskil; 1989), imprecisely formulated analogies (Feltovich, Spiro & Coulson, 1989), and the "cartoon" figures or visual representations found in textbooks (Ebenezer & Erickson, 1996). Schoon (1995) proposed that several misconceptions are formed in the classroom and teachers cannot assist students to overcome them if the teachers have these misconceptions. In his study which included 122 preservice elementary teachers, he revealed that most of them had the same misconceptions with their students. Sadler (1987) also found similar results that many of the misconceptions had been taught to them in the classroom.

There are different methods to obtain students' conceptions. Haslam and Treagust (1987) stated that individual student interviews are helpful for researchers to detect students' misconceptions in science. On the other hand, it is difficult to conduct interviews sometime and interviewing is not enough singly. Odom and Barrow (1995) claimed that it is necessary to develop paper-and-pencil tests to facilitate classroom teachers to identify misconceptions. Moreover, concept maps (Novak & Gowin, 1984) and word-association tests (Sutton, 1980) are other useful methods for the same purpose. Through using the combination of these methods, researchers identified numerous misconceptions in chemistry including the topics of various matter concepts (Liu & Lesniak, 2005), particulate nature of matter (De Vos & Verdonk, 1996), atoms and molecules (Griffiths & Preston, 1992), gases (Furio Mas, Perez & Haris, 1987; Nurrenbern, & Pickering, 1987; Pickering, 1990; Stavy, 1988), phase changes (Anderson, 1986; Ben-Zvi, Eylon, & Silberstein, 1987, 1988; Bodner, 1991; Osborne & Cosgrove, 1983; Stavridou & Solomonidou, 1989), chemical and physical changes (Anderson, 1986; Ben-Zvi et al., 1987; Stavridou & Solomonidou, 1989), chemical equations (Ben-Zvi et al., 1987, 1988; Yarroch, 1985), acids and bases (Pınarbaşı, 2007), chemical equilibrium (Gussaryky & Gorodetsky, 1990; Hackling & Garnett, 1985; Piquette & Heikkinen, 2005) and reaction rate (Balcı, 2006; Bozkoyun, 2004; Çakmakçı, 2005; Çakmakçı et al., 2006; Garnett et al., 1995; Haim, 1989; İcik, 2003; Kıngır & Geban, 2006; Nakiboğlu et al., 2002). Chemistry is full of abstract concepts and difficult to grasp for students most of the time. Reaction rate is one of those topics including many abstract notions. Researches indicated that students have great difficulties in understanding reaction rate. Therefore, it is necessary to find out students' misconceptions and proper strategies to overcome them. For example, BouJaoude (1993) examined first year science and engineering major university students to identify students' conceptual chemical errors and systematical mathematical errors when solving chemical equilibrium problems and the relationship between students' logical thinking ability and their performance on the kinetics and chemical equilibrium problems. He concluded that students did not understand the relationship between experimental results and rate of reaction and students were dependent on using learned algorithms to solve problems. Numerous students were not able to control variables and many others couldn't use the given experimental results to write the rate law.

In another study, Garnett et al. (1995) detected 17-19 years old students' understanding of chemical kinetics and found the following misconceptions:

- "The forward reaction rate increases as the reaction 'gets going'" (p. 81).
- "The forward reaction rate always equals the reverse reaction rate" (p. 81).
- "The forward reaction is completed before the reverse reaction commences" (p. 81).

Most of the studies on students' conceptions of chemical equilibrium presented students' understanding in chemical kinetics also. For example, Kousathana and Tsaparlis (2002) argued 17-18 aged students' errors while solving numerical-chemical equilibrium problems in an elective course. There were 120-148 students participating in the study depending on the questions. They investigated two types of errors: (1) random errors resulted from hastiness or by burden of working memory or by field dependence or combination of all. (2) "systematic errors" resulted from misconceptions or a difficulty in understanding a concept. They found that many students in their sample were unable to understand that reaction rate and reaction yield are different concepts and they are not directly related to each other. Many students stated the following misconception: "*Rate of reaction means the same as extent of reaction*", that it is also supported by Griffiths (1994). Kousathana and Tsaparlis (2002) also concluded that students applied Le Chatelier's principle to rate of reaction concept. Several students thought that if the reaction is thermoneutral (neither endothermic nor exothermic) the rate of reaction is not influenced by a change in temperature in line with Le Chatelier's principle. There is a hidden misconception here: "*heat is evolved or absorbed only in the cases that heat is explicitly involved (that is, shown) in the chemical equation ("thermochemical" equation*) (p. 14).

Moreover, Nakiboğlu et al., (2002) examined 61 undergraduate students' misconceptions about reaction rate, reaction rate-temperature relation, reaction rate-pressure relation and other factors affecting reaction rate by using V-diagrams prepared by the students. They listed the misconceptions below:

- "Reaction rate equals to the product of reactant concentrations" (p. 810).
- "Reaction rate is the time required for reactants to form products" (p. 810).
- "Reaction rate is amount of substance forming products at in unit period of time at constant concentration and temperature" (p. 810).
- "When the concentration is increased, time necessary for a reaction to occur increases" (p. 810).
- "When the concentration of the reaction increases, percentage of compounds increases and as a result the reaction rate increases" (p. 810).

- "In chemical reactions, reaction rate increases by increasing the concentration of one of the reactants" (p. 810).
- "Temperature changes reaction rate by changing the interaction between the molecules" (p. 810).

In another study, İcik (2003) investigated 10^{th} grade students' preconceptions and misconceptions about chemical reactions, reaction rate and factors affecting reaction rate instructed through traditional way and relationship between levels of students' understanding and their interests and attitudes towards chemistry, levels of cognition, spatial ability and algorithmic problem solving ability. He conducted interviews with 10 students before instruction to identify their preconceptions and misconceptions caused by these preconceptions. After the instruction, he administered paper-pencil tests and interviews to understand students' conceptions of reaction rate and detect their misconceptions. Sample was 190 tenth grade students from four different schools. He concluded that students instructed by traditional method had many misconceptions about chemical reactions, reaction rate and factors affecting reaction rate and students' preconceptions caused misconceptions. The misconceptions identified by this study were:

- "Two different substances are necessary in order for a reaction occur" (p. 48).
- "All particles have equal speeds" (p. 48).
- "Some of particles are moving some of them are not in a solution" (p. 48).
- "Particles do not move before the reaction" (p. 48).
- "Particles of solid substances do not have motion" (p. 48).
- "Collision of particles at appropriate geometries means reacting at appropriate conditions" (p. 48).

- “Potential energy of particles depends on height” (p. 48).
- “Energy of particles is not important during chemical reactions” (p. 49).
- “Activation energy is the highest point on the energy vs. reaction coordinate graph” (p. 49).
- “When the solutions are lifted, their potential energy increases” (p. 49).
- “Reaction rate is the time period between the beginning and the end of the reaction” (p. 49).
- "Reaction rate of exothermic reactions decreases by increasing temperature” (p. 49).
- “Temperature increase reaction rate since it emits heat” (p. 49).
- “Since collision and energy are necessary for a reaction to occur, temperature does not affect reaction rate” (p. 49).
- “Concentration does not affect reaction rate” (p. 50).
- “Pressure does not affect reaction rate” (p. 50).
- “Volume does not affect reaction rate” (p. 50).
- “Rates of all reactions increase with increasing pressure and volume” (p. 50).
- “Catalyst does not enter into reaction” (p. 50).
- “When catalyst is used, more substances react” (p. 50).
- “Surface area does not affect reaction rate” (p. 50).
- “Cube sugar has a greater surface area than powdered sugar” (p. 50).
- “Mixing the reaction vessel decreases activation energy and so increases the reaction rate” (p. 50).

Different from the above studies, Bozkoyun (2004) investigated the effectiveness of conceptual change texts oriented instruction accompanied with analogies compared to traditionally designed chemistry instruction to overcome 56 10th grade students' misconceptions, their understanding of rate of reaction concepts and attitude towards chemistry as a school subject in Ankara. According to the results, students in conceptual change text oriented instruction accompanied with analogies had better understanding in rate of reaction than the ones in traditional group. Also, students in experimental group indicated a higher positive attitude toward chemistry as a school subject. In addition, science process skill was a strong predictor for the achievement related to rate of reaction concepts. He used the misconceptions found from literature while preparing Rate of Reaction Concepts Test. At the end of intervention, though most of the misconceptions of students instructed by conceptual change texts oriented instruction accompanied with analogies were remedied, the students were still found to have the misconceptions mostly below:

- "Students confused reaction intermediate and catalyst in the reaction mechanism" (p. 34).
- "Rate equation is written according to fast step or net reaction equation" (p. 34).
- "Catalyst does not participate in the reaction and it only affects reaction by increasing rate" (p. 34).
- "To increase the rate of any reaction, you can increase the surface area of the reactants" (p. 34).

A similar study conducted by Balcı (2006) supports the findings of Bozkoyun (2004). She examined the effectiveness of conceptual change text oriented instruction accompanied with analogies over traditionally designed chemistry instruction on overcoming 10th grade students' misconceptions, their understanding of rate of reaction concepts, and their attitude towards chemistry as a school subject.

She implemented her research in Çanakkale. Like Bozkoyun (2004)'s findings, the results of the study indicated that students instructed with conceptual change texts oriented instruction accompanied with analogies gained higher average scores in Rate of Reaction Concepts Test than the students instructed with traditionally designed chemistry instruction.

Another study related to students' conceptions about reaction rate topic was conducted by Çakmakçı (2005), who examined secondary school and undergraduate students' conceptual understandings of chemical kinetics. This study is the most comprehensive research among others in the context of reaction rate. He used open-ended diagnostic questions and conducted interviews with students and teachers to investigate students' understanding of chemical kinetics. His study showed that though most of the school students knew the factors affecting reaction rate (e.g. temperature, concentration, catalysts), many of them did not agree that volume or pressure are factors affecting gaseous reaction rates. Some students used the terms of concentration and number of moles interchangeably. A misconception held by students is the rate of a reaction is directly proportional to the concentration of reactants. They did not consider the order of the reaction. Other results indicated that students could not interpret the graphs related to the factors affecting reaction rate. Also, they had difficulty in understanding the fact that the rate of a reaction must be determined experimentally. Other misconceptions revealed by Çakmakçı (2005) are:

- "Students have difficulties in interpreting the concentration vs. time graph. They can not see the slope of the concentration vs. time graph as the reaction rate" (p. 80).
- "Students had limited knowledge on the nature of the catalysis process. When it was asked how a catalyst affects on a reaction, they said that it lowers the activation energy of

the reaction. They could not relate it with the mechanism of the reaction” (p. 81).

- “Reaction rate is the time required for a reaction to be completed” (p. 91).
- “A catalyst increases or decreases the reaction rate without entering into a reaction” (p. 91).
- “Reaction rate= ΔH products – ΔH reactants. If rate of products is greater than reactants, reaction rate (ΔH) will be $\Delta H>0$. If rate of reactants is greater than products, reaction rate will be $\Delta H<0$” (p. 92).
- “Reaction rate is the amount of energy needed to initiate a reaction” (p. 93).
- “Reaction rate is equal to the formation energy of products (p. 93).
- “Reaction rate is the ratio of the concentrations of products to the concentrations of reactants. Reaction rate=[C]/[[A].[B]” (p. 93).
- “Elements are formed slowly at the beginning of a reaction. During reaction time the formation of them rises and as a result the rate of the reaction increases (confusion of reaction rate and the amount of product)” (p. 96).
- “Many of the students assumed that as long as certain factors (e.g. temperature, concentration or catalysts) were not altered, the reaction rate would remain constant or remain the same during a reaction” (p. 98).
- “The students made a general statement (i.e. rate of reactions decreases as reactions progress). Students tended to make over-generalizations of principles and ignoring some variables (i.e. the order of the reaction)” (p. 100).
- “Exothermic reactions occur faster than endothermic reactions” (p. 100).

- “They were not aware of the differences between the instantaneous rate and the average rate for a reaction. What they meant by the reaction rate was actually the overall reaction rate” (p. 100-101).
- “The reaction rate is zero at the beginning. During time interaction of molecules increases and as a result the reaction rate increases” (p. 103).
- “The rate of the reaction increases at the beginning of the reaction. When reactants are used up the reaction rate drops and at the end of the reaction, the rate is zero” (p. 106).
- “An increase in concentration increases the *speed of particles*” (p. 114).
- “Students argued that pressure and the volume of a container do not affect reaction rates. They only recalled temperature, concentration, and catalyst as factors affecting rates of reactions, but not the pressure for gaseous reactions” (p. 120).
- “Heat/energy is needed to initiate an endothermic reaction, but it is not needed for an exothermic reaction. In other words, they may have thought an endothermic reaction cannot be spontaneous” (p. 137).
- “An increase in temperature (temperature change) does not affect (change) the rate of exothermic reactions… exothermic reactions release energy; therefore they do not need energy to proceed and a rise in temperature would not affect the reaction rate” (p. 145).
- “A rise in temperature would not affect the reaction rate, because the reaction rate is independent of temperature. Reaction rate only depends on the rate constant and molarities” (p. 146).

- “An increase in temperature increases the rate of exothermic reactions” (p. 148).
- “An increase in temperature decreases reaction rate” (p. 148).
- “In order to enter into a reaction, solid substances need to dissolve” (p. 159).
- “Molecules” of granulated MgO were more strongly bonded to each other than those of powdered ones” (p. 162).
- “Because the same amount of substances has been used the reaction rate is the same for both reactions” (for using granulated MgO and powdered MgO situations) (p. 163).
- “Bigger the activation energy, the faster a reaction occurs” (p. 170).

“Activation energy is the maximum energy that substances could have…they interpreted activation energy as the highest point on the energy vs. reaction coordinate graph” (p. 172). (See Figure 2.1)

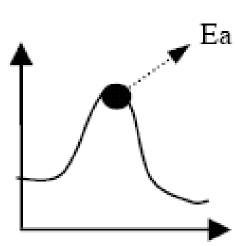


Figure 2.1 Potential Energy vs Reaction Coordinate graph

- “Activation energy does not affect a reaction rate” (p. 173).
- “Activation energy is the kinetic energy of product molecules” (p. 174).
- “Exothermic reaction would occur faster, because exothermic reactions had lower activation energy” (p. 178).
- “Endothermic reactions have lower activation energy” (p. 179).
- “At the same temperature, rates of both exothermic and endothermic reactions would be equal” (p. 179).
- “If two different reactions take place at the same temperature, kinetic energy of reacting molecules would be equal” (p. 179).
- “We do not write liquids or solids in a rate equation, therefore usage of a catalyst will not affect the reaction rate” (p. 186).
- “A catalyst would increase the yield of the products” (p. 187).
- “A catalyst does not affect/change the mechanisms of the reaction” (p. 188).
- “A catalyst does not affect zero order reactions” (p. 191).
- “The reaction order is the difference between the number of reactants and products moles” (p. 203).

Furthermore, Kıngır and Geban (2006) studied 49 tenth grade students’ misconceptions about reaction rate by using a multiple choice test. They concluded that students had problems in understanding the factors affecting reaction rate. Most of the students had the misconception that *“temperature affects activation energy”*. Other misconceptions detected by the concept test they used were:

- “Increasing the concentration of reactants always increases the rate of reaction (p. 435).

- "Rate of reaction equals to the number of collisions per unit time" (p. 435).
- "Catalyst is always used to increase rate of reaction" (p. 435).
- "Catalyst is needed to initiate the reaction" (p. 435).
- "Catalyst increases the average speed of molecules" (p. 435).
- "Increasing the temperature increases the activation energy" (p. 435).
- "Average kinetic energy of the molecules increases when the pressure of the reactants increases" (p. 435).
- "Increasing the temperature does not increase the number of collisions (p. 435).

As a conclusion, based on the studies about students' conceptions of reaction rate, which are given above, students had mostly difficulties in understanding what reaction rate is, how reaction rate changes with time and the factors affecting reaction rate. As a result, they had many misconceptions in these concepts. To remove them, constructivism and conceptual change based teaching strategies can be implemented in classrooms. In the below section, constructivism and conceptual change approach are explained in detail.

2.2 Constructivism and Conceptual Change Approach

The constructivist view of learning focuses on students' prior knowledge. One of the main ideas of this view is the need of connecting students' prior knowledge with the new contents to be taught. Therefore, teachers should take students' prior knowledge into account to promote learning. Also, constructivists agree that learner is the active builder of his/her knowledge. What the prior knowledge students bring to the classroom and how this prior knowledge can be connected to the new topics to be learned are strongly associated with conceptual change. Conceptual change approach is based on constructivism that all learning is a course of individual construction and the students construct a scientific conception if they perceive that new coming information is superior to their pre-instruction conception (Posner et al., 1982). Superior conception is “more powerful and useful in explaining and predicting phenomena" (Hewson, 1981, p. 384). Conceptual change concentrates on knowledge gaining in specific domains and explains learning as a process that necessitates the significant reorganization of existing knowledge structures and not just increasing their amount (Vosniadou & Brewer, 1987). The conceptual change approach forces the creation of new, qualitatively different representations. The old representations may continue or may disappear. This perspective emphasizes knowledge refinement and reorganization rather than replacement. Some researchers have criticized the conceptual change model because of the fact that early conceptions do not disappear when new ones are understood. On the other hand, disappearance of old representations is not necessary. Conceptual change model forces the formation of new and qualitatively different knowledge (Vosniadou et al., 2001).

Posner et al., (1982) denoted that four conditions are needed for conceptual change:

1) *Dissatisfaction:* Students should be dissatisfied with their existing knowledge. To change something, learner needs to realize that he/she has to change something and to be willing to do it. A conflict can create such a disequilibrium state in students’ minds.

2) *Intelligibility:* New coming information should be intelligible; that means learners should be able to understand new content. He/she should be able to construct a meaningful representation of a theory.

3) *Plausibility:* New knowledge should be plausible. It needs to be reasonable or believable for the learner. Moreover, it should be consistent with other theories.

4) *Fruitfulness:* New concept should be useful to solve problems in other areas or in the future. It directs to new discoveries and insights.

Tytler (2002) stated that to provide conceptual change in the classroom, the first stage is to explore students' existing ideas and misconceptions. Students are exposed to experiences creating conceptual conflicts, in which their prior ideas are challenged by purposefully providing situations in which their predictions about these ideas are likely be incorrect. These conflicts can be created by using their misconceptions. Through discussions, students reevaluate their ideas and compare their incorrect ideas with scientific view. The conflicts and discussions provide dissatisfaction. Teacher joins, stimulates, and contributes to the discussions. Different teaching strategies can be designed for students to actively involve in their learning process. During the instruction, when connection between daily life and the current content is made, fruitfulness condition can be met. The important point is to provide a supportive learning environment encouraging students to present their ideas and listen to each other and to give opportunities for them to try out new ideas by allowing them to be confident while experiencing new ideas in different contexts, both familiar and new.

There are many instructional strategies providing these conditions for conceptual change established by Posner et al. (1982). Some of them are cooperative learning (e.g. Slavin, 1987a), refutational texts (e.g. Palmer, 2002), analogies (e.g. Dagher, 1994; Smith & Abell, 2008), conceptual change texts (e.g. Özmen, Demircioğlu & Demircioğlu, 2009; Roth, 1985) and learning cycle (e.g. Musheno & Lawson, 1999; Niederberger, 2009). In this study, effectiveness of cooperative learning based on conceptual change conditions was examined. Detailed information about cooperative learning is provided in the next section.

2.3 Cooperative Learning

Before getting deeper into cooperative learning, it would be useful to see the connection between *goal structures* in the classroom: competitive, individualistic, and cooperative learning. The goal structure implies the means that students interact with each other and the teacher to accomplish the learning goal (Johnson & Johnson, 1999a).

Competitive Environment: In a competitive learning environment, students work against each other to attain a goal that only a few students can reach. Students look for outcomes or results useful for themselves and disadvantageous to others. Students concentrate on completing or doing faster and more correctly than classmates. Students recognize that they can reach their goals if and only if their peers in the class fall through to achieve their goals (Deutsch; Johnson & Johnson, as cited in Johnson & Johnson, 1999a). They impede each other's success, work alone, conceal their work from each other, reject to assist others, and may obstruct and lower each other's endeavors to learn. The evaluation system of competitive learning is based on norm-referenced technique. Students are ranked based on their academic achievements from top to bottom (Johnson & Johnson, 1999a). Following sentences suit for competitive learning, according to Johnson and Johnson (1999a):

> The more you gain, the less for me; the more I gain, the less for you… I can defeat you… My winning means you lose… Only a few of us will get As… Your failure makes it easier for me to win… Winners always win, losers always lose (p. 7).

Individualistic Environment: People sometimes do not interact with each other and want to be alone in their work. In an individualistic environment, individuals work alone to reach goals unconnected to and independent from other's goals (Deutsch; Johnson

& Johnson, as cited in Johnson & Johnson, 1999a). Individuals have no influence on each others' goal attainments. In this environment, students look for outcomes that are helpful to themselves. Individualistic learning is working alone to make sure one's own learning satisfies a predetermined criterion independently from other's efforts. There is no interaction among individuals. To evaluate students, criterion-referenced ways are used in the classroom. The important thing is whether an individual's performance meets a preset criterion (Johnson & Johnson, 1999a). Following sentences suit for competitive learning, according to Johnson and Johnson (1999a): "How well can I do?... What is in it for me?... If I am able, I will receive a high grade... I did it!.. Whether my classmates achieve or not does not affect me" (p. 8).

Cooperative Learning Environment: In the society, people need to and search for opportunities to cooperate mutually with each others to achieve mutual goals. From the birth, we cooperate with family, people at work and society. Cooperation is working together to reach collective goals (Johnson & Johnson, 1999a). "Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning" (Johnson & Johnson, 1999a, p. 5). Performing cooperative activities is important for students. Major problem of most adults fired from their first jobs is their lack of interpersonal skills like managing relationships with others (Rottier & Ogan, 1991). Cooperative learning supplies the ways of interacting together to students so they listen what and how others say, challenge their own perspectives, and improve new or alternative arguments that are reasonable and others will accept as suitable. When students interact with others in this way, they learn to develop their ability to use language as a tool so thinking and reasoning and so to construct new understandings and learning (Mercer, Wegerif & Dawes ,1999). On the other hand, unless students are helped dialogue together, they only rarely give rich and detailed help to each other or engage in cognitively sophisticated talk (Meloth & Deering, 1999). Students must be taught the skills required to dialogue together to enrich their discourse and enhance their learning.

2.3.1 Basic Elements of Cooperative Learning

The research studies in the literature propose that successful cooperative learning needs to provide following elements to increase students' efforts to achieve, and to improve their interpersonal relationships:

1. Positive Interdependence (Johnson & Johnson, 1975): This involves all members working together to complete the group's goal. Johnson, Johnson, Holubec, & Roy (1990) stated that when positive interdependence is established, students will understand that each member's contributions are crucial and each member has a unique contribution to help the group achieve its goals. They learn that "they sink or swim together" and they must complete their assigned task to attain the group's goal. Johnson & Johnson (1999a) noted that "members have two responsibilities: to learn the assigned material and to ensure that all members of their group learn the assigned material" (p. 75). They also stated that:

> Structuring positive interdependence involves three steps. "*The first is assigning the group a clear, measurable task.* Members have to know what they are supposed to do. *The second step is to structure positive goal interdependence* so members believe that they can attain their goals if and only if their group mates attain their goals. In other words, members know that they cannot succeed unless all other members of their group succeed.…*The third step is to supplement positive goal interdependence with other types of positive interdependence.* Reward/celebration interdependence is structured when (a) each group member receives the same tangible reward for successfully completing a joint task…or (b) group members jointly celebrate their success… A long-term commitment to achieve is largely based on feeling recognized and respected for what one is doing (p. 75-76).

Moreover, positive interdependence can also be structured by assigning interconnected roles (such as reader, checker of understanding, recorder, and encourager of participation) to each member of the group in order to complete the mutual task (Johnson & Johnson, 1999a).

2. Face to Face Promotive Interaction (Johnson & Johnson, 1975): This condition exists when students work in small groups where they can see each other so that they can engage in face-to-face discussions about their tasks. It provides opportunities to develop personal rapport that encourages students to be more willing to listen what others say, to reach out others and actively work to include other's ideas in the group discussions. Promotive interaction is gained when group members provide each other with efficient assistance, exchange necessary resources like information or materials, giving feedback to each other to make their performance better and acting in trustworthy ways (Johnson & Johnson, 1999a).

3. Individual Accountability (Johnson & Johnson, 1975): Individual accountability exists when students understand that they will be responsible for their individual contributions to the group, free-loading will not be tolerated, and everyone must contribute. When they contribute and receive acknowledgement for their work, their sense of self-efficacy enhanced and they are motivated to continue to work on the task. All group members are strengthened by working cooperatively. Teachers can accomplish individual accountability by making small groups since smaller group size provide greater individual accountability. Also giving tests to each student and giving random oral examinations provides individual accountability. Students are randomly selected to present his/her group's work to the teacher or whole class. Furthermore, assigning a student as a checker in every group is another way of structuring individual accountability. The checker requests the reasoning of their group's answers from other group members. In addition, teacher may ask students for teaching what they learned to someone in his/her group. When all students perform this responsibility, it is called simultaneous explaining (Johnson & Johnson, 1999a).

4. Social Skills (Johnson & Johnson, 1975): Students should be taught how to communicate efficiently with each other in order to know how to express their ideas, acknowledge contributions of others, deal with discrepancies, and manage conflicts. Moreover, they need to learn how to share resources fairly, take turns, and engage in democratic decision making. Forming a group from socially unskilled individuals and saying them to cooperate does not ensure that they will be able to do so efficiently (Johnson & Johnson, 1989).

5. Group Processing (Johnson et al., 1990): This is a kind of formative assessment involving students' reflections on how they are managing the process of learning and what they may still need to do to reach their goal. Group members discuss how well they are reaching their goals and maintaining effective working relationships with each other. Gillies (2007) argued that it involves students asking such questions as: *How are we doing? Is there anything else that we should be doing? What could be done differently?* Teacher assesses the quality of interaction between group members while they are working to improve each other's learning by observing cooperative groups as they work. The teacher systematically moves from group to group and uses a checklist to obtain data. This provides the teacher with an opportunity to see the students' minds and listen to students during group works while they are discussing about the assignment. By this way, teacher can have more information about what students understand compared to by checking their answers on tests or homework assignments. Therefore, he or she can give feedback on the effectiveness of the group members' work to each group or to whole class at the end of the lesson. Group processing makes group members more responsible and skillful group members. A lack of contribution of even one member of a group demoralizes the whole group. When groups process, they discuss the actions and behaviors of each group member and the ways to improve or change them in order to increase each other's learning (Johnson & Johnson, 1999a).

The above are the characteristics and basic elements of cooperative learning. However, to attain a successful cooperative learning environment, teachers should undertake great responsibilities. The role of the teacher in cooperative learning is presented in the next section.

2.3.2 The Role of the Teacher in Cooperative Learning

Teachers play a critical role in cooperative learning environment. They should ensure that the groups are well structured so students will cooperate and promote each other's learning. Also the teacher should present a well structured group task so that students find it interesting and relevant to their learning and that all group members understand how they will operate and contribute. Cohen (1994) stated that when the procedure for completing the task is fairly straightforward in that students are only required to exchange information, request assistance or provide an explanation, it promotes only low-level cooperation among students because students need to engage in only minimal interactions with each other as they work on solving problem. On the contrary, when the students work on tasks that are open and discovery based and there are no clear answers, they must discuss how to carry on as well as the content of the task. Cohen (1994) refers to this type of task as one promoting high-level cooperation since interaction is crucial to be productive. Gillies (2007) argued that effective teachers have several pedagogical practices in a cooperative learning environment, which are:

- Preparing students complex and interesting tasks
- Using numerous sources to stimulate students' interests

- Modeling the types of discussion they want students to use
- Supporting students to dialogue together
- Promoting higher-order thinking
- Ensuring learning as student-centered
- Encouraging students to take responsibility of their own learning
- Providing students with feedback.

Johnson and Johnson (1999a) reported the following steps for teachers to establish cooperative learning in the classroom:

1. Make preinstructional decisions: Teacher should formulate objectives, determine the group size, decide on a method for assigning students to groups, assign roles of the students in their groups, organize the room and arrange the materials that the students need to complete the assignment. The Roman philosopher Seneca said that "When you do not know to which port you are sailing, no wind is favorable". It is important to determine academic objectives and social skills (interpersonal and small group skills) you expect from your students as a teacher. Moreover, the teacher must decide on group size and how students should be assigned to the groups. Lou et al. (1996) reported that small groups (e.g. 3-4 members) are more desirable to larger groups, because if group size is too large, the groups attend to be less personal and students will not contribute. Furthermore, small group guarantees that everyone is included in the activity. In terms of the composition of the groups, Lou et al. (1996) stated that low-achievers learned significantly more in mixed-ability groups while high-achievers learned equally well in mixed-ability or homogeneous groups. It seems that low-achievers profit from the tutoring they get from their high-achiever peers, who tend to be relatively active with the assistance they provide in mixed-ability groups. On the other hand, medium-achievers do significantly better in homogeneous groups in which they are more verbally active and benefit from comprehensive and elaborative help they give and take from each other. Related to the gender composition of the groups, Webb (1984) revealed that in gender-balanced groups, males and females were equally interactive and exhibit similar levels of achievement. In addition, the arrangement of classroom space and furniture depends on learning activities taking place during lesson and appropriate behaviors that the students are expected to do.

2. Explain the task and cooperative structure: The teacher should explain the academic assignment or task to students, clarify the criteria for success, make sure that positive interdependence is established in groups, explain individual accountability and the behaviors expected during the lesson. While explaining academic task, the teacher must specify and communicate the level of performance expected. Cooperative learning necessitates criterion-based evaluation. It is made by implementing a fixed set of standards and judging the achievement or performance of each student based on these standards. For example, you may grade students by assigning letter grades on the basis of the percentage of test items answered correctly. Or you might state that: "The group is not completed until each member has mastered the task." In some situations, improvement (doing better this week than the previous week) may be decided as criterion. Moreover, structuring positive interdependence in groups is important. Positive interdependence exists when a shared goal is established so that each member understands that they can reach their goals if and only if their group mates reach their goals (Johnson & Johnson, 1992). In unstructured groups where there is no positive interdependence, students are less motivated to support each other's learning, take responsibility of one's own and other's learning, show the social skills promoting good relationships among group members since they are mainly concentrated on attaining their own goals rather than the group's (Johnson, as cited in Gillies, 2007). In cooperative groups, every individual has to fulfill his/her share of work. Individual accountability can be provided by keeping groups small, testing each student individually, providing individual oral examinations, having students teach what they learned to their peers and having students apply what they have learned to different problems. Furthermore, you must specify desired behaviors during group activities. You must teach small group and interpersonal skills they need to work cooperatively with each other. To achieve mutual goals, the students must get to know and rely on each other, and resolve conflicts constructively (Johnson & Johnson, 1995).

3. Monitor and intervene: During the lesson, the teacher should observe each learning group, interfere when necessary to improve teamwork and bring closure to the lesson. Teachers need to monitor group work in terms of interaction among group members actively and based on these observations, teacher can intervene and provide feedback on group's progress and each individual's efforts. The observations should focus on positive behaviors. By carefully listening to students' talk among their groups, teachers can determine what students do or do not understand. By this way, teacher can intervene to make instructions clear, review important points and strategies to complete the task, and answer questions. At the end of the lesson, teacher closes the session by having students sum up the major points and remember ideas. Students should be able to summarize what they have learned and to know how these skills will be used in forthcoming lessons.

4. Evaluate and Process: Teacher should assess and evaluate the student achievement, have students plan their improvement and have students celebrate the hard work of group members. Quality and quantity of student learning must be assessed regularly and evaluated by criterion-referenced technique from time to time. Cooperative learning provides opportunities for performance-based assessment (students show what they can do with what they know by performing a skill) and authentic assessment (students demonstrate the desired procedure in a real life context). Both standardized and teacher-made tests may be used to assess students. They may be multiple-choice, true-false, matching, short answers or essay type. When students have finished their work, or at the end of each class session, they illustrate what member actions were helpful and not helpful in completing the task and decide on the behaviors to continue or change. Group processing arises at two levels: in each group and in the whole class. In small group processing, every group members argues how effective the group work was and how it could be improved. In whole-class processing, teacher gives feedback to the class and have students share incidents occurred in their groups. Teacher must be sure that students analyze and reflect on the feedback they receive. Finally, teacher should support the celebration of groups' hard work and success.

2.3.3 Cooperative Learning Methods

Several cooperative learning methods have been developed and tested over the last 30 years. Most of the research studies have focused on four models: Student Teams – Achievement Divisions (Slavin, 1989), Teams – Games – Tournaments (Slavin, 1989), Jigsaw techniques (Aronson, 1978; Slavin, 1987a; Stahl, 1994) and Group Investigation (Sharan & Sharan, 1987).

Student Teams-Achievement Divisions (STAD): STAD is a simple and a good method to start for teachers who are new to the cooperative learning. Slavin (1995) suggested five main components for STAD: *class presentation, teams, quizzes, individual improvement scores, and team recognition.* Materials in STAD are first introduced in a *class presentation.* It is a direct instruction or lecture-discussion performed by the teacher. It could involve audiovisual presentations also. The only difference of class presentations from traditional teacher-centered instruction is students should understand that they must carefully concentrate on the class presentation of the teacher since it will help them during their group work, quizzes, and team scores which are determined by quiz scores. After the class presentation, the working groups are formed. *Teams* are composed of four or five students and they represent the position of the classroom in terms of academic achievement, gender, and ethnicity. The main purpose of the group work is to ensure that all members learn or master the material. Another function of teams' work is to prepare group members for the quizzes. After the teacher presents the related content, teams are formed and they are given some worksheets or other material. Generally, students discuss the answers of the questions among themselves, compare answers, and correct mistakes. Team is the most important component of STAD. The team contributes to the academic performance, communicational and social skills of students, and their self-esteem. After one to two teacher presentations and one to two group work practices, individual *quizzes* are given to the students. They are not allowed to help each other during the quizzes. Therefore, everyone in the classroom must know or master the material in order to get higher scores in the quizzes. *Individual improvement scores* are given to a student if he or she performs better than in the past. By this way, each student can contribute his or her team's overall score, but no student can do this without doing his or her best. Each student is given a "base" score which is his or her average score on similar quizzes in the past. Students then get points for their teams if they show an improvement on the scores of new quizzes. When teams' average scores go beyond a certain criterion, those teams earn rewards or a certificate. Also, the team having the highest average score may be rewarded. This provides *team recognition*. The main idea behind STAD is to stimulate students to support and help each other master skills presented by the teacher. If students want their group to get the reward, they must assist their group mates to learn the material (Slavin, 1989).

Teams-Games-Tournaments (TGT): According to Slavin (1995), in TGT, teacher presentation and group work are like in STAD, but there are weekly tournaments instead of quizzes, in which students play academic games with members of other groups who are like them in terms of their past academic performance in order to supply point to their team scores. The main function of the team is to prepare its members to do well in the tournament. Teams are formed like in STAD. After an initial class presentation by the teacher, the teams are given a worksheet or a task covering academic material similar to that to be included in the tournament. Teammates study together and quiz each other to ensure that all team members are ready and well prepared. Tournament is usually done at the end of a week or a unit, after the teacher's class presentation and team works. Students from different teams are put in groups of three students of similar ability. First assignment of students to the tournament tables are conducted by the teacher. The highest three students in past performance are to table 1, the next three to table 2, and so on. 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. This system provides each student to contribute their teams' average scores. After the first tournament, students change tables based on their own performance. For example, the winner of each table get together; the second scorers together and so on. Students enjoy challenge of the tournament and since they compete with others of similar ability, the competition is fair (Slavin, 1989). The assignment of students to the tournament tables are shown in Figure 2.2 (Slavin, 1995). Finally, team recognition procedure is conducted as in STAD.

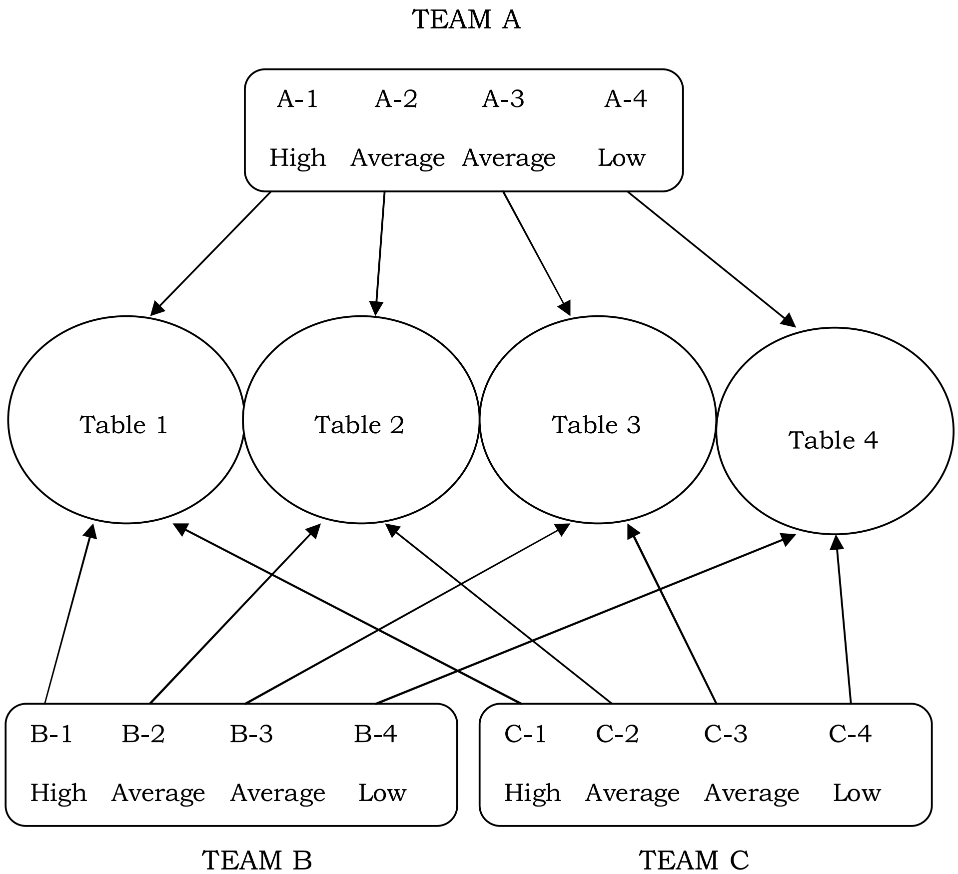


Figure 2.2 Assignments to Tournament Tables

Jigsaw Techniques: There are three kinds of jigsaw strategies: (a) Jigsaw developed by Aronson (1978); (b) Jigsaw II developed by Slavin (1987a); and (c) Jigsaw III developed by Kagan (1989). The only difference between Jigsaw and Jigsaw II is that competition among groups, who strive for group rewards, is permitted in Jigsaw II. In Jigsaw method, students work in the same four-member, heterogeneous teams as in STAD and TGT. They are assigned chapters or pieces of information to master. All groups may study the same topic, or different groups may cover different parts of the topic. Each member is randomly assigned to be an expert on some part of the reading task. After reading the material, experts from different teams come together to discuss their common topics, and they go back to their own group to teach their topics to other members of the group. There are two kinds of groups: one is "home group" and the other is "jigsaw group". Initially students meet in their homegroups and then members of home group is assigned to jigsaw group to master the material as an expert (Doymuş, Şimşek & Bayrakçeken, 2004; Slavin 1991). At the end, there is a quiz or other evaluation on all topics. Grades are based on individual performance on the exam. There is no specific reward for achievement. In Jigsaw II, a team earns points if group members express improvement in their quiz scores compared to the ones in the past. There is a competition among groups for a reward. On the other hand, Jigsaw III is for bilingual classrooms. Cooperative groups are composed of one English speaker, one non-English speaker and one bilingual student. All materials used are bilingual.

Group Investigation (GI): It is suggested by Sharan & Sharan (1987). Students arrange groups of five or fewer and select specific topics or problems in a general subject area of science. There is more student choice and control than other cooperative methods. Groups are formed based on students' interests. Teacher and students in each team arrange specific procedures, tasks, and goals in agreement with the subtopics of the problem selected. The students determine who will investigate what. Then they perform the plans designed in the second step. Learning should include a number of activities and skills and should direct students to different kinds of sources, both inside and outside of school. Students might work in small groups or individually to collect data and information. They meet to discuss, analyze, and evaluate the information they collected individually or by their subgroup. One of the attractive characteristics of GI is that each group makes a presentation to the whole class. Students have to work cooperatively to prepare a presentation. Presentation may take several class periods. Students in the class provide feedback to the groups after presentations. Moreover, each group submits some questions to be used in final exam to the teacher. They also give correct answers or criteria to evaluate the sufficiency of a response. During the examination, the students answer the questions except for the ones their group supplied. Group Investigation method improves student responsibility for learning and emphasizes cooperative skills (Sharan & Sharan, 1992).

Cooeprative learning methods involving reward improves students' motivation to learn (Slavin, 1977, 1983, 1995). The effect of cooperative learning on motivation is explained in the next section.

2.3.4 Research on Cooperative Learning

There are some research studies on the effectiveness of cooperative learning on students' achievement, attitudes or understanding of lessons. For example, Shachar and Sharan (1994) investigated the effect of cooperative learning with Group Investigation method compared to traditional Presentation-Recitation method on 8th grade students in ethnically mixed classrooms in Israel compared with effects of traditional Presentation-Recitation method. 351 Jewish students from Western and Middle Eastern backgrounds, with 154 in four classes instructed by traditional method and 197 in five classes instructed by Group Investigation method, participated in the study. Students' academic achievement in geography and history was measured by tests composed collectively by all of the teachers, their verbal behavior was observed during 30-min videotaped discussions in 27 six-person groups (heterogeneous groups from each classroom) and the nature of their social interaction was examined during the group discussions. Students in Group Investigation method classroom expressed themselves more frequently than the students in Presentation-Recitation method classroom. In Presentation-Recitation class, Western students dominated. On the other hand, in Group Investigation class turn-taking was almost symmetrical among students from each ethnic group. Moreover, students' achievement scores were higher in class instructed with Group Instruction. They also stated that students taught by Group Investigation method used more words per turn of speech than the students in traditional classroom. The pretest administered to all students to measure their preknowledge in history and geography showed that students from the same ethnic group in all of the classes had approximately the same level of initial knowledge. This result indicated that students in two methods were of equal ability. Based on this fact, Shachar and Sharan (1994) concluded that the significant differences in verbal interaction found between students from two methods show a differential effect of the instructional method, Group Investigation.

In another study, Kreke, Fields, Towns, and Hamby (1998) investigated students' perspectives on cooperative learning in physical chemistry to understand efficacy of small-group activities. The participants were 32 undergraduate students in United States. Majority of students were science majors, one student was a minority, and all of the students spoke English as a first language. During the course, the lecture was composed of 15-30 min teacher presentation and 5-10 min small group activities. Students solved conceptual problems in their cooperative groups that contained four to six students. After that, each group presented their solution to the whole class. Field notes and student questionnaire analysis showed that cooperative activities provided a mechanism for students to create a sense of community in the classroom and relationships were viewed as a positive force in learning that improves achievement through shared goals. Students were able to support each others' learning by teaching each other, sharing their different perspectives, and asking questions to each other. The study concluded that cooperative environment supports a wide range of student learning style.

Other study conducted by Eilks (2005) aimed to explore the students' ideas about learning in a jigsaw classroom. It was investigated whether jigsaw classroom learning has the potential to make chemistry learning more attractive and, whether it can help students to develop their communicative and social skills or their personal improvement (e.g. developing a positive, realistic self-image). The study was conducted during atomic structure unit in grade 9 and 10 chemistry classes in Germany. The participants were six groups from grammar schools, three groups from middle schools, and two groups from comprehensive schools in grade 9. Also, there were two classes at grade 10, one from grammar school and one from a comprehensive school. The class size was 22-23 students. A cognitive test in which students were asked to provide as much information as possible about the atoms of different elements (atomic mass, number of protons, neutrons, etc.) with very limited given information was applied to students to measure their cognitive achievement. Moreover, two questionnaires were used to collect data about the followings: (a) to find out if there is potential to improve students' attitudes towards science by using jigsaw method, (b) to find out if there is potential to improve communicative and social skills and personal development by using jigsaw method in science classes. The teaching materials included texts, models, small experiments, and written tasks. There were three subtopics for expert group work in jigsaw classroom design. Each of them was assigned to two different expert groups. The students worked on the subtopics using given materials. Working on these subtopics in the expert groups took about two lesson periods. Expert groups were composed of five students. Working in home groups took up about two lesson periods. Home group size was six students each. A fifth lesson was used to compare results, for discussion and feedback and completing the evaluative questionnaire.

According to the results, students liked science lessons more when jigsaw lesson was integrated into science lessons. They stated that they enjoyed working in small groups and they had more freedom to make individual or group decisions about their learning. A lot of students mentioned their own improvement in communicative and social skills. Eilks (2005) concluded that these positive results can be interpreted that use of this method would help to improve students' attitudes towards science lessons. High attitudes could have positive effect on their cognitive achievement. Similarly, the cognitive test indicated that jigsaw class students had higher cognitive achievement.

In addition to these studies, Bilgin & Geban (2006) studied the effects of the cooperative learning based on conceptual change strategy compared to traditional instruction on 10th grade students' understanding and achievement of computational problems about chemical equilibrium. 87 students from two intact classes participated in the study over four weeks. Classes were randomly assigned to experimental and control groups. Experimental group was taught by cooperative learning including four-membered groups and the control group by traditional method. Chemical Equilibrium Concept Test was given to both groups as pre and post test to measure students conceptual understanding, and Chemical Equilibrium Achievement Test was given to both groups as a post test to measure students' achievement in computational problems. Moreover, Science Process Skill Test was administered as a pretest to measure their science process skills. In experimental group, the teaching strategy was designed to replace alternative conceptions with scientific ones and to integrate existing conceptions with new conceptions. After students completed their group study, they were given three quizzes individually. The quizzes were given back to the student after grading in order to help students see their in-group performances and development. The first three successful groups were rewarded to encourage students in their group works. Since students' science process skills in experimental group were better, it was controlled in analysis of achievement and concept test scores. According to the results, students taught by cooperative learning based on conceptual change conditions had better conceptual understanding, and achievement of computational problems about the chemical equilibrium concepts. The cooperative learning approach based on conceptual change conditions explicitly coped with the students' misconceptions while the traditional instruction did not. Conceptual change based cooperative learning presented opportunities to activate students' misconceptions, provide descriptive evidence with analogies that typical misconceptions are incorrect, and offer a scientifically correct explanation of the situations.

In another study, Doymuş (2007) compared the cooperative learning (jigsaw) versus individual learning method on students' understanding of chemical equilibrium in a first-year general chemistry course at university. In the non-jigsaw (control) group; chemical equilibrium concept was instructed by researcher using individual teaching methods by giving assignments to students on the subjects of chemical equilibrium. In jigsaw group, students were divided into groups and subgroups based on jigsaw principles. According to results, the jigsaw group was more successful than the non-jigsaw group (individual learning method). Data obtained in this study indicated an easier understanding of chemical equilibrium in students that used the jigsaw technique.

Similarly, Acar and Tarhan (2008) investigated the effect of cooperative learning on 9th students' understanding of metallic bonding compared to traditional instruction. 57 students from the same high school in Turkey took part in the study. Students' understanding was measured by Metallic Bonding Concept Test. In addition, achievement test was used to measure their pre-knowledge. As another instrument, interviews were conducted with students to get more information about their conceptions on metallic bonding after the instruction. The major purpose of the material given to the students in cooperative learning group was to prevent or deal with students' misconceptions related to metallic bonding. The groups in cooperative learning classroom were composed of five to six students and they were given some roles like leader, recorder, timekeeper, and reflector. The given tasks were discussed in groups and after the group work, presentation of finding of each group was done by group leaders. In traditional classroom, students listened to the teacher and took notes. They were passive listeners. The interview conversations revealed that cooperative groups provided teacher-student and student-student social interaction by teacher-guided discussions. These discussions supported students to share their ideas and knowledge, make connection between existing knowledge and new information, and construct their knowledge effectively. Therefore, Acar and Tarhan (2008) concluded that cooperative learning caused significantly better acquisition of scientific knowledge than traditional instruction. Moreover, concept test results indicated that cooperative learning has a positive impact on removing students' misconceptions on metallic bonding. Besides to students' conceptions in metallic bonding, this method had positive effects on students' social abilities. They generally had positive thoughts about cooperative learning and they enjoyed working in groups and learning. A lot of students believed that cooperative learning was helpful for their learning and social improvement. Acar and Tarhan (2008) suggested that developing new cooperative learning materials based on constructivism for other chemistry subjects would be supportive to improve achievement and enhance students' social skills.

Other study conducted by Davison, Galbraith and McQueen (2008) reported a project that they started in a mainstream primary school to support cooperative learning throughout the school to teach social and emotional skills by using lesson process (or the "Hidden Curriculum") rather than lesson content (or the "Taught Curriculum") to be sure that the teaching of “cooperation” was embedded throughout the school. They aimed specifically to encourage children to take responsibility for their own learning and the learning of their classmates, to help socially isolated children be more socially included, actively teach skills necessary for cooperation and to encourage the use of cooperative learning techniques within the school and in other schools. Two Year 2 teachers were included in the study to establish cooperative learning in their classrooms. Furthermore a headteacher who was responsible for monitoring cooperative learning practice and observations of lessons of individual teachers. During the project, staff of the school began to share the experience of the Cooperative Learning Project with teachers from other schools with the help of the authors. Structured interviews and questionnaire were used to collect data. The headteacher reported his observation that pupils actively helping each other with their work. He also reported that there had been a significant reduction in the number of lunchtime incidents reported to him since the implementation of the project. Semi-structured interviews with a sample of children in two classes, Year 3 and Year 4 indicated that they understood that active listening involved keeping eye contact and listening carefully to the speaker’s message. This was important to help children “cooperate”. Interviews with teachers were also conducted. They felt that there was a more “positive atmosphere” and that groupwork was “much easier”. One of them reported that children now cooperated spontaneously to help each other learn their spellings. According to the questionnaire results, the teachers reported that their active listenning techniques were promoted on a daily basis. The researchers concluded that pupils were tended to view each other as learning resources and children sought to actively help each other with their work. In addition, the results indicated that children had been actively taught the skills of cooperation.

Different from studies presented above, Gillies (2008) examined the effects of structured and unstructured cooperative groups on students' behaviors, discourse, and learning during an inquiry-based science classes in junior high school. 164 students at 9th grade from six high schools in Australia took part in the study. Pre-test results showed that there were no significant differences among schools in terms of teachers' ratings of students' achievements in science before the study. The teachers' ratings were based on the children's test results in science during the first term in grade 9. The students' working in their three to four-membered, mixed gender and ability groups were videotaped. Videotaping occurred during the second unit of science (four to six weeks). Moreover, a science probe questionnaire was used to decide how students were constructing knowledge between what they had been learning in their science lessons and the classification activity they had discussed in their small groups. In structured cooperative groups, basic elements of cooperative learning (positive interdependence, promotive interaction, individual accountability, and group processing) were present and students were trained in the social skills necessary to support cooperation. In unstructured groups, those key elements were not evident and students were involved in small group activities irregularly. The results revealed that students in structured cooperative groups exhibited more cooperative and helping behaviors like giving more elaborated help and directions to encourage each others' understanding and less individually-oriented behavior than the students in unstructured groups. In addition, they expressed more complex thinking and problem-solving skills in their discourse. Students in structured groups employed more evaluative statements showing the use of critical and reflective analysis of different issues. They were the indicative of self-monitoring awareness. As Abram et al. (2002) states, evaluative talk is a significant predictor of learning and achievement of group members. On the other hand, students in the unstructured groups engaged in making more repetitive comments (such as repeating information) and used a language that is generally regarded as less likely to promote higher order thinking skills and challenge their peers' interests in the task. Also, science probe results indicated that students in structured groups used more complex and higher order thinking skills than the students in unstructured group.

In another sudy, Taşdemir, Taşdemir and Yıldırım (2009) studied the effect of portfolio evaluation, which was applied along with cooperative learning on students' achievement of Planing and Evaluation in Teaching course. 81 second year students in Faculty of Education participated in the study. Two experimental groups and one control group were involved. One of the experimental groups was instructed by the portfolio evaluation method along with cooperative learning (experiment group 1), other experimental group was instructed by only the portfolio evaluation method (experiment 2) and the control group was taught by traditional instruction. The instruction took ten weeks and a 75-item multiple choice test was used to collect data. In experiment group1, four membered seven heterogeneous groups with respect to academic achievement and sex were formed. The students in this group were informed about the cooperative learning method, its basic elements, and student product files for five hours. In addition, the students were informed about the fact that their files were instruments of evaluation. According to the results, the students in experiment group 1 had better achievement in the course than the students treated by traditional instruction. The researchers concluded that portfolio evaluation when used in combination with cooperative learning was influential over academic achievement. The stated that cooperative learning associated with portfolio evaluation improved students' success more than the instruction including portfolio evaluation alone, which shows that portfolio evaluation is more effective when used within the cooperative learning instruction.

Besides to these, there are several studies about the effectiveness of cooperative learning on achievement (Chang & Chen, 2009; Doymuş et al., 2004; Gök & Sılay, 2008; Graham, 2005; Kurtuluş & Kılıç, 2009; Nakiboğlu, 2001; Sadler, 2002; Sisovic & Bojovic, 2000), science process skills (Bilgin, 2006; Bozdoğan, Taşdemir & Demirbaş, 2006), attitudes towards the subject area (Atkinson, 2008; Barbato, 2000; Klein & Schnackenberg, 2000; Tarim & Akdeniz; 2008), social or cooperative skills (Feagins, 2002; Gillies, 2004; Koçak & Akın, 2008; Merry, 2000), motivation (Al-Badawi, Ghaith & Shaaban, 2006; Fuller, 2001; Law, 2008; Shachar & Ficher, 2004; Wang, 2006), conceptual understanding (Abdullah & Shariff, 2008; Barbosa et al., 2004; Erdemir, 2006; Tok, 2008; Towns & Grant, 1997) and teachers' and students' verbal behaviours (Gillies, 2006) in recent years. All of these studies showed that cooperative learning promotes students' achievement, attitudes towards related subject area, social and communication skills and motivation.

2.3.5 Conceptual Change and Cooperative Learning

One of the most common statements about cooperative group work is that it forces learning with understanding and therefore encourages conceptual change. According to Brown and Palincsar (1986), conceptual change is most likely to occur when situations creating dissatisfaction with existing knowledge are provided and change is unlikely when status quo is unquestioned. Teaching strategy supporting questioning, evaluating, and criticizing is thought to be fruitful breeding ground for restructuring. Dissatisfaction provides mental experimentation, evaluation leads to uncertainty and group settings are suitable to raise questioning and criticism (Hatano, 1982; Inagaki & Hatano, 1983). When one is required to explain, elaborate or guard one's position to others (or sometimes to oneself), change is inevitable.

One of the common strategies for conceptual change is to create environments invoking disequilibration or cognitive conflict (Piaget 1985). Johnson and Johnson (1999b) stated that the more positive interdependence in a cooperative learning group exists, the more likelihood of intellectual disagreement and conflict among group members is. While students work in cooperative groups, their different perceptions, information, opinions, and conclusions will cause intellectual disagreement and conflict. When they face such opposition, they may manage the situation constructively depending on their interpersonal and small-group skills. If managed constructively, disagreement promotes uncertainty related to the accuracy of one's conclusions and search for more information and as a result better mastery and retention of the material being discussed and more frequent use of higher-order thinking skills. On the other hand, students working in competitive or individualistic situations do not have the chance for such intellectual challenge and so their achievement and quality of reasoning suffer. Avoiding conflict may be detrimental for learning. When controversies are repressed, either because one member of the group dominates the discussion or because students think it is socially unacceptable to challenge others, they may not recognize and explore different perspectives and strategies for solving problems. To provide group productivity, some conflict may be supportive in comparing ideas to reach the solutions or create products. On the other hand, spending too much time for arguing may prevent the group to complete the task (Webb, 1997).

Vygotsky (1978) claimed that conceptual development originates in social interaction. Children continuously observe and participate in group activities and conceptual change is basically a process of internalizing cognitive activities initially experienced in social environment. Similarly, Piaget (1950) considered peer interaction in which a child accepts not only his or her own perspective but also opposing ideas of peers as an experience helping children "decenter" their thinking from “egocentric” perspective, by this means facilitating them to consider multiple perspectives. According to this idea, “social interaction is a necessary condition for the development of logic” (Piaget, 1976, p.80). The group interactions and solution to the problem or conclusions reached are internalized by the child.

In the light of related literature, it can be concluded that students’ prior knowledge and misconceptions strongly influence their learning. The literature also showed that students had many misconceptions and difficulties related to reaction rate. In chemistry, reaction rate concept is important for students to understand how reactions occur (collision theory) and by which factors their rates are influenced. In addition, it underlies the concept of chemical equilibrium which is also among the most difficult topics in chemistry for students to understand. Moreover, besides to cognitive or developmental factors, affective or motivational factors are also important for students to learn a subject. Thus, it is necessary to design a suitable teaching strategy other than traditional method to deal with these misconceptions and promote students’ understanding and motivation.

Based on the studies presented in this section, cooperative learning seems to be a reasonable method or strategy to teach a subject and improve students’ understanding and motivation. On the other hand, more research studies are necessary on the effectiveness of conceptual change based cooperative learning to enhance students’ conceptions and motivation and remedy their misconceptions. Accordingly, in this study, it is intended to investigate the effectiveness of cooperative learning based on conceptual change conditions to improve students’ understanding of reaction rate and their motivation.

2.4 Motivation

Motivation is the inner force that drives people to attain personal or organizational goals and objectives (Lindner, 1998). It is also defined as internal state to activate or energize behavior and give it direction (Kleinginna & Kleinginna, 1981). Motivation is a continuous process which begins with needs, continues with goal-oriented behavior and finish with the satisfaction of needs. It is highly valued due to its consequences; teachers, managers, coachessnd parets are concerned with motivation because it generates results. Since motivation is complicated, it is necessary to examine various theories of motivation to reach better understanding.

2.4.1 Theories of Motivation

Motivational theories try to explain the energization and direction of human behavior (Deci & Ryan, 1985). Contemporary motivational theorists view motivation as a multidimensional construct including cognitive, environmental, and behavioral aspects (Weiner, 1990).

Maslow's Hierarchy Needs Theory: This theory, suggested by Maslow (1943), is related to the nature of the needs and goals of the individual and the interrelationship between these needs. Initial needs must be met before others are satisfied (Herbst, 2006). Maslow claimed that people are motivated by the desires to accomplish these needs (Maslow, 1970). He had stated a hierarchy of five levels of basic needs order from physiological, safety, belongingness, esteem and sel-actualization (Steers & Porter, 1975). It is often characterized by a pyramid. The higher needs in this hierarchy only come into consideration when the lower needs in the pyramid are satisfied.

Maslow's basic needs are as follows: (1) Physiological (biological) needs are vital. They include air, food, sleep, drink, warmth, stimulation, and activity. (2) Safety (security) needs consist of security, stability, and protection. When all biological needs are met, security needs can become active. (3) Social (Love and Belongingness) needs involve love, friendship, and feeling of belonging. (4) Self-esteem (ego) needs is active when the needs above are satisfied. These include needs for self-esteem, and for the esteem every person gets from others. (5) Sel-actualization (fulfillment) needs involve reaching one's full potential. It is the drive to become what one is capable of becoming. From the view of motivation, the theory implies that although no need is fully satisfied, a substantially satisfied need no longer motivates. As a result, if you want to motivate someone, you need to understand what level of the hierarchy that person is on and concentrate on meeting those needs or the needs above that level.

Attribution Theory: This theory is based on attribution. Weiner's (1986) theory of attribution for academic motivation involves all aspects of cognitive process (e.g. conscious and unconscious), all aspects of emotions (e.g. happiness, anger, guilt), and all aspects of actions (e.g. rational and irrational decision). It emphasizes that learners are strongly motivated by being able to feel good about themselves and learner's current self-perceptions will strongly affect the ways in which they interpret the success or failure and their future tendency to achieve the same behaviors. People analyze the situations and make attributions to explain the cause of success or failure. Attributions involve perceived cause instead of actual cause. They result from factors within the environment or within an individual. Environmental factors include societal norms, cultural beliefs, and situation; individual factors include prior beliefs, schemas, and biases. According to the theory, the explanations that people are likely to make for the cause of success or failure can be examined under three categories: (a) the cause of the success or failure may be *internal* or *external*. We may succeed or fail because of our skills or abilities or environment. (b) The cause of success or failure may be either *stable* or *unstable*. If we believe that the cause is stable, then the result is more likely to be the same if we do the same behavior on anther occasion. (c) The cause of the success or failure may be *controllable* or *uncontrollable*. It is controllable if we believe we can alter when we wish to do soand uncontrollable if we do not believe we can easily alter.

Attribution theory assumes that people will interpret their environment so that they keep a positive self-image. They will attribute their successes or failures to factors that will enable them to feel as good as possible. It relates to motivation in that an individual's own perceptions for success or failure decide the amount of effort the person will provide on that activity in the future.

Goal Setting Theory: This theory (Locke & Latham, 1990) is a modern social cognitive theory for academic motivation and suggests that goals motivate individuals to behave in a specific manner. In order for goals to increase performance, an individual must define them as difficult to achieve and as specific. Goals that are easily attained are more likely to correlate with lower performance than more difficult goals. Goals are self-generated, have significant value, and are originated by either conscious or unconscious process. Related to academic motivation, goals are ideas in studenrs' minds representating what they are striving to achieve (Pintrich & Schunk, 2002). Achieving a goal leads to a feeling of competence and success. Falling short of a goal creates dissaticfaction and motivates individual to work hard to avoid failure. Locke and Latham (1990) claimed that factors affecting goal choice and commitment include components such as previous performance, levels of ability, self-efficacy, causal attributions, values, and mood. A person's previous performance plays an important role to reach his or her goal. Individuals may strive for good grades if they have been successful in gaining good grades in the past. If they have been unsuccessful in the past, setting the goal for good grades is unlikey. Ability levels also affect students' goals. High achievers are more likely to set goals for receiving higher grades than less able students. Self-efficacy affects goals because of students' beliefs in their ability. A student believing his or her ability will have higher levels of motivation compared to a student that does not believe his or her ability. Moreover, social or environmental factors including group factors, role modeling, and reward structures also influence goal choice and commitment. Positive pressure from peers and group support improve achievement goals. Reward structure which provides extra encouragement also improves performance and goal achievement (Locke & Latham, 1990).

Achievement Goal Theory: Achievement goal theory proposed by Ames (1992) is related to academic motivation. He categorized achievement goals as mastery goals and performance goals. Mastery goals encourage individuals to achieve competencey. In an academic environment, mastery goals lead a student thoroughly to understand a material because of desire to gain new knowledge. Performance goals encourage student to show competency in relation to others. These goals are stimulated by a need to perform better than other students. Supporters of the mastery goal perspective state that mastery goals produce the greatest academic motivation (Ames, 1992; Dweek & Leggett, 1988). These researchers regard effort instead of ability as the key in improvingacademic motivation. Dweek and Leggett (1988) claimed that performance goals can lead to maladaptive behaviors. Individuals may avoid a challenging situation that could potentially threaten their ability. Motivation to avoid a situation is called performance-avoidance goals. Individuals having performance-avoidance goals are motivated to avoid a situation that would underline a lack of ability (Middleton & Midgley, 1997). On the other hand, some researchers support a multiple goal model in which they believe both mastery and performance goals are helpful in encouraging academic motivation (Barron & Harackiewicz, 2001; Linnenbrink, 2005). Recently, Senko and Harackiewicz (2005) revealed that individuals assigned to a performance goal did better than individuals assigned to a mastery goal. They also found that when mastery goal participants were told their goal could be difficult, those individuals performed better than the regular mastery goal participants. As a result, the difficulty of the goal mattered more than the type of goal in the performance of the participants.

Self-Determination Theory of Motivation: It was proposed by Deci and Ryan (1985). According to self-determination theory, human beings are acting in advance, oriented towards growth, and competent. A self-determined person prefers to behave in a manner reflecting his autonomy and his or her behavior is not to reach an external reward or escape disgusting stimuli in the environment. Motivation for a specific behavior is controlled by either internal choice (e.g. self-determined or intentional) or external force (e.g. non-self-determined or nonintentional). Internal behavior includes behavior that is self-determined and behavior that is controlled. Self-determined behavior is motivated by one's sense of self, and controlled behavior is motivated by an interpersonal power. When the the behavior is self-determined, causality is perceived as internal, and when it is controlled, the causality is perceived as external. Deci and Ryan (1985) categorized motivation as *intrinsic motivation, extrinsic motivation,* and *amotivation.* Intrinsic motivation directs individuals to engage in behaviors increasing views of competency (e.g. performing a task well) and self-determination (Deci, 1975). Intrinsically motivated behaviors originate from personal interest and satisfaction, and the performance of activities are on a voluntarily basis. Extrinsic motivation is one step below intrinsic motivation. Extrinsically motivated behaviors originate from instrumental factors, such as rewards or consequences (Deci, 1980). An extrinsically motivated person will perform a task even when he or she has little interest in it because of the anticipated satisfaction he or she will get from some reward. The lowest form of motivation is amotivation. Amotivated individualsdo not see a link between behaviors and the ensuring outcomes (Deci & Ryan, 1985). Therefore, individuals feel as if they cannot achieve a desired goal. Learned helplessness, originating from a perceived lack of control, is evident in amotivated individuals. Amotivation includes actions that are void of intention, purpose, or logic.

According to Deci and Ryan (1985), social context that maintain one's competency levels, relatedness, and autonomy (three basic needs) improve self-determined motivation. Contexts that do not meet these basic needs lead to decreased motivation and academic performance. In educational settings, academic performanceis affected by teachers, peers, or family members as they can support the three basic needs. As a result, teacher or family involvement and acceptance of peers encourage the basic need of relatedness, which in turn enhances academic motivation. Positive feedback of a student's performance improves competency and as a result academic motivation. When these three needs are satisfied, students appear better adjusted and perfom better academically.

In the light of these motivational theories, some motivational constructs have been suggested by researchers, which are explained in the next section (Garcia, McKeachie, Pintrich, & Smith, 1991).

2.4.2 Motivational Constructs

One way of improving students' interest in science is by engaging the affective domain (Alsop & Watts, 2000). Golemon (1996) proposed that the affective and cognitive domains are related. It is a common idea that if someone is interested in something, they are more probably to learn it. This idea is supported by some research (LeDoux 1998; Sylwester 1995). Motivation is important among affective components because students' motivation has an important role in their conceptual change processes (Lee, 1989; Lee & Brophy, 1996; Pintrich, Marx & Boyle, 1993) and science learning achievement

(Napier & Riley 1985). There are a number of motivational factors revealed by some educational research including: Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance and Test Anxiety. *Intrinsic goal orientation* is having a goal orientation toward an academic task indicating students' participation in the task for reasons such as challenge, curiosity, and mastery instead of reasons such as grades, reward or evaluation by others (Garcia et al., 1991). *Extrinsic goal orientation* refers to the degree to which students perceive themselves involving in a task for reasons such as grades, reward and performance evaluation of others. Students having high Extrinsic Goal Orientation concern issues other than those directly related to participating in the task itself (Garcia et al., 1991). *Task value* refers to student's evaluation of the task itself related to its importance, usefulness and being interesting. High task value leads to more involvement in learning (Garcia et al., 1991). *Control of learning beliefs* refers to students' belief that their efforts to learn will bring about positive outcomes which depend on one's own efforts instead of teacher or another external factor. If students think that they can control their academic performance, they are more likely to present the effort to effect the desired changes (Garcia et al., 1991). *Self-efficacy for learning and performance* involves two types of expectancy: expectancy for success and self-efficacy. Expectancy for success means performance expectations, and is related to specifically to task performance. Self efficacy is an evaluation of one's ability to master a task and one's confidence in having the skills necessary to perform that task (Garcia et al., 1991). *Test anxiety* is an index of worry and concern reported by students about examinations. It was found to be negatively related to expectations and academic performance. It has two components: a worry or cognitive component and an emotionality component. Worry component implies students' negative thoughts disturbing performance and emotionality component implies affective and physiological arousal aspects of anxiety (Garcia et al., 1991).

In the present study, effect of cooperative learning on the motivational constructs mentioned above is examined. Cooperative learning and motivation is discussed in the next section.

2.4.3 Motivation and Cooperative Learning

Motivational components of academic performance are important on students' classroom learning (Garcia & Pintrich, 1994; Pintrich & De Groot, 1990). Motivational components involve students' perceptions of the classroom environment as well as their self-related beliefs such as personal goals, self-efficacy, interest, and value beliefs. Researches indicated that positive motivational beliefs such as perceptions of high self-efficacy, a focus on mastery goals, high value and interest in the task or content, and low levels of test anxiety are positively related to higher academic performance and greater use of cognitive strategies (Pintrich & Schrauben, 1992).

Motivational perspectives on cooperative learning mainly concentrate on the reward or goal structures that students operate (Slavin, 1977, 1983, 1995). From a motivationalist perspective (e.g. Johnson & Johnson, 1992; Slavin, 1983, 1995), cooperative goal structures (as opposed to competitive or individualistic goal structures) necessitate that only way group members can achieve their own personal goals is if the group is successful. Thus, in order to reach his or her own personal goals, a student, as a group member, must both assist other group members and more importantly, support group mates to exercise maximum efforts. Rewarding groups depending on their performances constructs an interpersonal reward structure in which group members will provide or hold back reinforcers (such as praise and encouragement) in answer to efforts of group members (Slavin, 1995).

Traditional classrooms are criticized by motivational theorists. In a competitive environment, one student's success negatively affects others' achievement. Therefore, students tend to develop norms that high achievement is for nerds. On the other hand, having students work together toward a shared goal may motivate students to express norms supporting academic achievement and to reinforce one another for academic efforts. In cooperative classrooms, students working hard, attending class regularly, and helping others to learn are praised and appreciated by group mates, in contrast to traditional environment. Rewards in cooperative learning contribute to motivation of students to improve their academic success because, reward provides students to value the success of the group and so the students will encourage and assist each other to achieve (Slavin, 1995).

Reviews of cooperative learning research (Cohen, 1994; Qin, Johnson & Johnson, 1995) have indicated that cooperative learning increases and improves achievement, positive attitudes toward the subject area studies, self-esteem, acceptance of differences among peers and conceptual development. For example, Law (2008) stated that cooperative learning improved students' motivation, which in turn developed their higher-order reading skills in learning from text. According to Johnson and Johnson (1999b), working in cooperative groups and valuing cooperation brings about better psychological health and self-esteem than does competing with class mates or working alone. When students work together to complete assignments, they interact (developing social skills and competencies), encourage each other's success (increasing self-worth), and structure personal and professional relationships (building the base for healthy social development). Working cooperatively improves personal ego-strength, self-confidence, independence, and autonomy and therefore, students will have the opportunity to share and solve personal problems, which enhances an individual's resistance and ability to deal with trouble and stress. The more students engage in cooperative activities, the more they see themselves as worthwhile and more autonomous. Cooperative groups create an environment where students develop interpersonal and small group skills necessary to work efficiently with diverse schoolmates. They learn to build trust, repair hurt feelings, communicate effectively, and understand other's viewpoints. Even kindergartners can exercise social skills during cooperative activities. Cooperative experiences are necessary for healthy social and psychological development of individuals who can act independently.

CHAPTER 3

PROBLEMS AND HYPOTHESIS

3.1 The Main Problems and Sub-problems

3.1.1 The Main Problems

The purpose of the study is to investigate the effect of cooperative learning rooted in conceptual change conditions on 11th grade students' understanding of reaction rate and their motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety). In addition, 11th grade students' conceptions about reaction rate and their ideas about cooperative learning are examined.

3.1.2 The Sub-problems

1. Is there a significant mean difference between 11th grade students who are taught by cooperative learning based on conceptual change conditions and traditionally designed instruction in terms of their understanding in reaction rate when the effect of science process skills is controlled as a covariate?

2. Is there a significant mean difference between 11th grade students who are taught by cooperative learning based on conceptual change conditions and traditionally designed

instruction in terms of their motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety)?

3. What are 11^{th} grade students' conceptions about reaction rate?

4. What are 11^{th} grade students' ideas about cooperative learning?

3.2 Hypothesis

$H_0 1$: There is no significant mean difference between 11^{th} grade students who are taught by cooperative learning based on conceptual change conditions and traditionally designed instruction in terms of their understanding in reaction rate when the effect of science process skills is controlled as a covariate.

$H_0 2$: There is no significant mean difference between 11^{th} grade students who are taught by cooperative learning based on conceptual change conditions and traditionally designed instruction in terms of their motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety).

CHAPTER 4

DESIGN OF THE STUDY

This chapter presents the design, variables and sample of the study, instruments to collect data, description of the treatment, methods to analyze data, and assumptions and limitations.

4.1 The Experimental Design

In this study, Non Equivalent Control Group Design as a type of Quasi-Experimental Design was used. This design does not involve random assignment of subjects to the groups; instead, already formed groups are used (Gay & Airasian, 2000). It is suitable for this study because the schools' administrations had already constituted the classrooms at the beginning of the semester. On the other hand, one class was randomly assigned as control group (CG) and one class was randomly assigned as experimental group (EG) from each of two schools for this study. Therefore, experimental group involved two classes from two different schools and similarly, control group involved two classes from two different schools. The group instructed by cooperative learning based on conceptual change conditions was experimental group and the other group instructed by traditional instruction was control group. Table 4.1 illustrates the design of the study.

Table 4.1 Research Design of the Study

Groups	Pretest	Treatment	Post-test
Experimental Groups (EG)	RRCT MSLQ SPST	CLCC	RRCT MSLQ
Control Groups (CG)	RRCT MSLQ SPST	TI	RRCT MSLQ

The meanings of the abbreviations in the table are given below:

RRCT: Reaction Rate Concept Test

MSLQ: Motivated Strategies for Learning Questionnaire

SPST: Science Process Skill Test

CLCC: Cooperative Learning based on Conceptual Change

TI: Traditional Instruction

In this study, RRCT was given to both experimental and control group to see if any difference exists among groups in terms of students' existing knowledge related to reaction rate before instruction. Moreover, MSLQ was administered to both groups as a pre-test to determine whether there was a significant difference among groups with respect to students' motivation to chemistry. SPST was also applied before study to compare the groups in terms of their science process skills and to control it in the case that the groups are different. RRCT and MSLQ were given as post-tests after the instruction to investigate the effect of cooperative learning based on conceptual change conditions on students' understanding of reaction rate and their motivation.

4.2 Variables of the Study

4.2.1 Independent Variable

The independent variable of this study was the teaching methods which were the instruction through cooperative learning based on conceptual change conditions and the traditional instruction.

4.2.2 Dependent Variables

One of the dependent variables of this study was students' understanding of reaction rate measured by RRCT. Furthermore, students' intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety measured by MSLQ were motivation related dependent variables. To obtain better results, motivation was examined under these factors and each of these factors was taken as a dependent variable. As a result, there were seven dependent variables in the present study in total.

Students' science process skills measured by SPST was assigned as covariate to control its effect on students' understanding of reaction rate.

4.3 Subjects of the Study

Target population of the study is all 11th grade students in Ankara, Turkey. On the other hand, accessible population is all 11th grade students in Çankaya which is a district of Ankara because it was not possible to get acceptance from chemistry teachers to be involved in the study from other districts. Unfortunately, chemistry teachers in Turkey prefer to use lecturing in their classrooms and most of them are not trained and eager to use more student centered and constructivist methods. The meetings with more than ten chemistry teachers in Ankara indicated that they were resistant to change their way and habits of teaching since student centered methods require them to prepare some materials before lesson and so increase their workload. Therefore, purposive sampling technique was used to select the schools which were willing to participate.

An Anatolian high school and an ordinary state high school were chosen from Çankaya, Ankara. Students in Anatolian high school had better academic achievement or were brighter compared to students in ordinary state high school since they were accepted that school by getting higher points from Anatolian High School Examination. Two classrooms from each school were randomly selected. It was not possible to assign students to experimental and control group randomly since the school administration had already formed the classrooms at the beginning of semester. Therefore, from the Anatolian high school, one class was assigned randomly as experimental group and one class as control group. Similarly, from the other school, one class was assigned randomly as experimental group and one class as control group. 110 eleventh grade students (59 students from Anatolian high school and 51 students from ordinary state high school) were involved in the study. Ages of students were 16-17. The classrooms in each school were instructed by the same teacher in first semester of 2008-2009 over 6 weeks. There were 56 students in experimental group which was instructed by cooperative learning based on conceptual change conditions, and 54 students in control group which was instructed traditionally.

4.4 Instruments

This is mostly quantitative but also involves some qualitative data. For quantitative part, RRCT, MSLQ, and SPST were used to collect data. To control the effects of science process skills and students' pre-knowledge related to reaction rate, RRCT and SPST were given as pretest to both groups. Since the scores of two groups in terms of science process skills were significantly different, science process skills of students was assigned as covariate. RRCT was also given after the instruction in order to determine the effect of cooperative learning based on conceptual change conditions on dealing with students' misconceptions related to reaction rate. MSLQ was applied before and after the instruction to both groups to examine the effect of treatment on participants' motivation.

For qualitative part of the study, interviews with students from both experimental and control group were conducted after the instruction in order to reveal their conceptions about reaction rate topic. Moreover, ideas of students who were exposed to cooperative learning instruction, about cooperative learning were obtained by Feedback Form for Cooperative Learning including seven open-ended questions.

4.4.1 Reaction Rate Concept Test (RRCT)

Reaction Rate Concept Test was developed by the researcher. While some questions were constructed by the researcher, some other questions were developed by the authors with the consideration of students' misconceptions and difficulties in reaction rate (İcik, 2003; Çakmakçı, 2005; Balcı, 2006). The content of the test was determined by examining chemistry textbooks and instructional objectives for reaction rate unit. The first step of the development of the test was to determine the instructional objectives (see Appendix A). The items of the test were constructed based on these instructional objectives. Secondly, students' misconceptions about reaction rate were investigated from the literature.

The instrument is composed of two sections; first section contains 16 two-tier items and second section contains 7 multiple choice items in Turkish (see Appendix B). For two-tier questions, there are two parts. First part consists of two or three choices to be selected. In the second part, students are expected to give their reasoning about their answer in the first part by selecting from four alternatives. The alternatives in second part are prepared based on the students' misconceptions. As Treagust (1987) stated, second part of two tier tests involve four alternatives some of which are misconceptions and some are wrong statements. Similarly, the multiple choice items in second section were prepared based on students' misconceptions. They were placed in the alternatives. Misconceptions were investigated from research studies in the literature (Haim, 1989; Garnett et al., 1995; Nakiboğlu et al., 2002; İcik, 2003; Bozkoyun, 2004; Çakmakçı, 2005; Balcı, 2006; Çakmakçı et al., 2006; Kıngır & Geban, 2006). The misconceptions included in RRCT are given in Table 4.2.

Table 4.2 A list of common misconceptions covered by RRCT

Reaction Rate	**Item**
1. Students were failed to grasp the fact that reaction yield and reaction rate are different concepts that are not directly related to each other (Kousathana, & Tsaparlis, 2002).	14, 16
2. The reaction rate is zero at the beginning. During time, interaction of molecules increases and as a result the reaction rate increases (Çakmakçı, 2005).	2
3. As reactants are used up, the formation of product increases and accordingly the reaction rate increases until all reactants are consumed where the reaction rate is constant. (confusion of the reaction rate and the amount of product) (Çakmakçı, 2005).	2, 16
4. The rate of the reaction increases at the beginning of the reaction. When reactants are used up the reaction rate drops and at the end of the reaction, the rate is zero (Çakmakçı, 2005).	16
5. Reaction rate is the time required for reactants to form products (Nakiboğlu et al.,2002).	1, 19

Table 4.2 (Continued)

6. Reaction rate is the amount of substance turning into products per unit time at constant temperature and concentration (Nakiboğlu et al.,2002).	1
7. The forward reaction rate always equals the reverse reaction rate (Garnett et al., 1995).	1
8. The students made a general statement as “rate of reactions decreases as reactions progress” and so they tended to make over-generalizations of principles and ignoring some variables (i.e. the order of the reaction) (Çakmakçı, 2005).	2
9. Rate equation is written according to fast step or net reaction equation (Bozkoyun, 2004).	19
10. Reaction rate is equal to the product of concentrations of reactants (Nakiboğlu et al., 2002).	19
11. Reaction rate= ΔHproducts – ΔHreactans so; If rate of products is greater than reactants, reaction rate (ΔH) will be $\Delta H>0$. If rate of reactants is greater than products, reaction rate will be $\Delta H<0$ (Çakmakçı, 2005).	19
Factors Affecting Reaction Rate	
12. Many of the students assumed that as long as certain factors (e.g. temperature, concentration or catalysts) were not altered, the reaction rate would remain constant or remain the same during a reaction (Çakmakçı, 2005).	16
13. When the temperature is increased, the rate of the endothermic reaction increases but the rate of the exothermic reaction decreases (Hackling & Garnett, 1985; Nakiboğlu et al.,2002; İcik, 2003).	4
14. Exothermic reactions occur faster than endothermic reactions (Çakmakçı, 2005).	3
15. An increase in temperature (temperature change) does not affect (change) the rate of exothermic reactions. Since exothermic reactions release energy they do not need energy to proceed and a rise in temperature would not affect the reaction rate (Çakmakçı, 2005).	4
16. A rise in temperature would not affect the reaction rate, because the reaction rate is independent of temperature. Reaction rate only depends on the rate constant and molarities (Çakmakçı, 2005).	4
17. Increasing temperature increases time necessary for a reaction to occur (Nakiboğlu et al., 2002).	8
18. Increasing the concentration of reactants always increases the rate of reaction (İcik, 2003; Kıngır et al., 2006).	8
19. Change in concentration does not affect reaction rate (İcik, 2003).	8
20. There is a linear relationship between the concentration of reactants and reaction rate. (they did not anticipate the order of the reaction or the role of the solid catalyst.). They expected a higher rate from increasing concentrations of reactants (Çakmakçı et al., 2006).	8
21. The volume of a container does not affect reaction rate (Çakmakçı, 2005).	5

Table 4.2 (Continued)

22. When the volume of the container is decreased, kinetic energy of molecules increases (Çakmakçı, 2005).	5
23. When the volume of the container is decreased, the frequency of collisions/effective collisions between reactants molecules will increase (Çakmakçı, 2005).	5
24. Students do not anticipate that a catalyst lowers both the forward and reverse activation energies; rather they believed that a catalyst just reduces the forward activation energy and as a result they may reach the conclusion that the catalyst favors the yield of the product. (Hackling & Garnett, 1985; Garnett et al., 1995; Voska & Heikkinen, 2000; Çakmakçı, 2005).	14, 20
25. A catalyst speeds up only the forward reaction (Voska & Heikkinen, 2000).	20
26. A catalyst gives energy to a reaction; therefore it increases the activation energy of the reaction (Çakmakçı, 2005).	6
27. Catalyst is needed to initiate reaction (Kıngır & Geban, 2006).	6
28. Most of the students confuse reaction intermediate and catalyst in the reaction mechanism (Bozkoyun, 2004).	15
29. Catalyst increases the average speed of the molecules (Kıngır & Geban, 2006).	14
30. When catalyst is used, more substances react (İcik, 2003).	6
31. Catalyst facilitates collision of particles by interposing them (İcik, 2003).	17
32. A catalyst does not affect/change the mechanisms of the reaction (Çakmakçı, 2005).	17
33. If reactants are in solid or liquid phase, a catalyst doesn't affect the rate of reaction (Çakmakçı, 2005).	17
34. A catalyst did not react with any of the reactants or products (İcik, 2003; Çakmakçı, 2005).	17, 20
35. Reaction rates are the same whether the reactant is granulated or powdered since the molarities are equal for both cases (Çakmakçı, 2005).	9
36. Molecules of granulated MgO were more strongly bonded to each other than those of powdered ones (Çakmakçı, 2005).	9
37. Surface area of reactants doesn't affect reaction rate (İcik, 2003).	9
Activation Energy	
38. Activation energy is the kinetic energy of reactant molecules (Çakmakçı, 2005).	3
39. The faster a reaction, the more energy is released (Çakmakçı, 2005).	3
40. Temperature affects activation energy (Kıngır & Geban, 2006).	10, 12
41. Increasing the temperature increases the activation energy (Kıngır & Geban, 2006; Çakmakçı, 2005).	7, 10
42. Bigger the activation energy, the faster a reaction occurs (Çakmakçı, 2005).	21
43. Exothermic reactions have a lower activation energy (Çakmakçı, 2005).	21

The test covered rate of reactions concept including reaction rate, collision theory, activation energy, heat of reaction, potential energy diagrams, reaction mechanisms, rate equations and orders and the factors affecting reaction rate (concentration, temperature, surface area, and catalyst). Test items were developed through examination of related literature (İcik , 2003; Çakmakçı 2005, Balcı, 2006), chemistry textbooks (e.g. Ebbing & Gommon, 1999) and several high school test books. Each item of RRCT was examined by four chemistry educators and two chemistry teachers to check its content validity, accuracy, and format of items. RRCT was piloted to 203 students, who had already learned reaction rate concept, from different schools. Based on the reliability analysis, some of the items' alternatives were altered; some of the items were excluded from the test. It was piloted again with its final form to 251 high school students having learned reaction rate before. Related to reliability analysis, Cronbach's alpha value was found as 0.78, which is functionally equal to Kuder Richardson Formula 20 (KR-20). KR-20 is used when data is dichotomuous (Rudner & Schafer, 2001). In this study, students' answers to the items of RRCT were coded as zero indicating incorrect answer and one indicating correct answer in SPSS program. As a result, it can be stated that reliability coefficient is KR-20 which is equal to 0.78.

RRCT was administered to both experimental and control group before instruction to compare pre-knowledge of students on reaction rate and so to control the difference if it existed. It was also given after the instruction to examine whether cooperative learning based on conceptual change conditions was effective to remove students' misconceptions about reaction rate.

4.4.2 Motivated Strategies for Learning Questionnaire (MSLQ)

MSLQ was constructed by Pintrich, Smith, Garcia & McKeachie (1991) to assess students' motivational orientations and their use of different learning strategies for a college course. It is a self-report questionnaire in which students rate themselves on a seven point Likert scale from "not at all true of me" to very true of me". There are two sections in MSLQ, a motivation section and a learning strategies section. In motivation section, there are 31 items assessing students' goals and value beliefs for a course, and their anxiety about tests in a course. Motivation part is composed of six sub-scales: (1) intrinsic goal orientation (2) extrinsic goal orientation (3) task value (4) control of learning beliefs (5) self-efficacy for learning and performance (6) test anxiety.

The learning strategy section is composed of 31 items concerning students' use of different cognitive and metacognitive strategies. Moreover, this section includes 19 items related to student management of different resources. The learning strategy section consists of nine sub-scales: (1) rehersal (2) elaboration (3) organization (4) critical thinking (5) metacognitive self-regulation (6) time/study environmental management (7) effort regulation (8) peer learning (9) help seeking. There are totally 81 items in this 1991 version of MSLQ and it is in English.

Pintrich et al. (1991) conducted confirmatory factor analysis and calculated fit statistics ($\chi 2$/df, GFI, AGFI and RMR) for MSLQ. $\chi 2$/df ratio of less than 5 is considered to indicate a good fit between the observed and reproduced correlation matrices. Moreover, GFI or AGFI of 0.9 or greater and an RMR of 0.05 or less are acceptable values indicating that the model fits the input data well (Hayduk, 1987). For motivation part, confirmatory factor analysis resulted in

$\chi 2/df = 3.47$, GFI= 0.77, AGFI= 0.73 and RMR= 0.07. The values are not within acceptable ranges. On the other hand, Pintrich et al. (1991) claimed that these values are reasonable since the study included a broad range of courses and subject domains and motivational attitudes may differ depending on course characteristics, teacher demands, and individual student characteristics.

Sungur (2004) adapted MSLQ into Turkish for biology lesson and piloted on 319 tenth and 169 eleventh grade students. She conducted confirmatory factor analysis and calculated fit statistics for Turkish version to test six latent factors: Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety. The results were $\chi 2/df = 5.3$, GFI = 0.77, and RMR = 0.11. Sungur (2004) stated that these values are reasonable by considering the results of English version.

Pintrich et al. (1991) stated that MSLQ can be used together or singly depending on the needs of researcher. Therefore, in order to measure students' motivation, only motivation part and scales or factors under it were included in this study. In the present study, Turkish version of MSLQ adapted by Sungur (2004) was used with minor changes for chemistry lesson (see Appendix C). Since some research studies indicated that cooperative learning methods mostly improve students' motivation to learn in terms of efficacy, intrinsic value of the subject, learning goal orientation, and usage of deep processing strategies, motivation part of MSLQ was used to evaluate students' motivation (Slavin, 1995; Nicholes, 1996; Hancock, 2004).

The test was piloted on 316 eleventh and twelveth grade students with an age range of 16-17 in different schools of Ankara. The questionnaire was given to entire class at one time and the students were suggested to be as sincere as possible. For the verification of the factors, confirmatory factor analysis was made and following values were found: $\chi 2/df = 5.6$, GFI = 0.70, AGFI = 0.64 and RMR = 0.09. Although these values are not within accepted range for good fit, they are reasonable when English version and Sungur (2004)'s version are considered. On the other hand, it should be noted that values for both English version and current study do not show a good fit. Fit indices of English version, Turkish version by Sungur (2004) and current study of MSLQ's motivation section is given in Table 4.3. ENG is the English version, TUR is the Turkish version.

Table 4.3 Comparison of fit indices for of English version, Turkish version by Sungur (2004) and current study of MSLQ's motivation section (31 items)

	N(sample size)	$\chi 2/df$	GFI	RMR
ENG	356	3.49	0.77	0.07
TUR(Sungur,2004)	488	5.3	0.77	0.11
TUR (current)	316	5.6	0.70	0.09

Lambda-ksi estimates for the latent factors for English version and current study of the questionnaire are presented in Table 4.4. Lambda-ksi estimates are similar to factor loadings in an exploratory factor analysis, and values of 0.8 or higher show well-defined constructs (Pintrich et al., 1991).

Table 4.4 Lambda ksi Estimates for Motivation

	Indicator	English version LX Estimate	Current LX Estimate
Intrinsic Goal Orientation	q1	0.64	0.59
	q16	0.69	0.56
	q22	0.66	0.81
	q24	0.55	0.55
Extrinsic Goal Orientation	q7	0.71	0.66
	q11	0.58	0.68
	q13	0.48	0.69
	q30	0.44	0.68
Task Value	q4	0.57	0.61
	q10	0.64	0.85
	q17	0.88	0.81
	q23	0.86	0.85
	q26	0.88	0.78
	q27	0.84	0.86
Control Beliefs about Learning	q2	0.57	0.86
	q9	0.38	0.42
	q18	0.84	0.90
	q25	0.47	0.66
Self-Efficacy for Learning	q5	0.83	0.79
	q6	0.70	0.68
	q12	0.63	0.76
	q15	0.71	0.77
	q20	0.86	0.83
	q21	0.89	0.89
	q29	0.77	0.86
	q31	0.87	0.72
Test Anxiety	q3	0.60	0.60
	q8	0.42	0.70
	q14	0.62	0.64
	q19	0.88	0.45
	q28	0.76	0.64

Altough some of lambda-ksi values for the latent factors for the current study were not good enough to show well-defined constructs, they are accaptable when compared to the ones for English version.

In terms of reliability analysis, reliability coefficients (Cronbach alpha values) were calculated by using SPSS. Similarly, comparison of

Cronbach alpha values of three versions for motivation section was given in Table 4.5.

Table 4.5 Reliability Coefficients

	N (sample size)	IGO	EGO	TV	CLB	SELP	TA
ENG	356	0.74	0.62	0.90	0.68	0.93	0.80
TUR(Sungur's)	488	0.73	0.54	0.87	0.62	0.89	0.62
TUR(current)	316	0.59	0.65	0.81	0.63	0.87	0.65

Rudner and Shafer (2001) stated that reliability is highly dependent on the characteristics of sample and it might change from one sample to another so, the minor differences in values of reliability coefficients between the current study, English version and Sungur's (2004) version may be because of the differences in sample characteristics.

4.4.3 Science Process Skill Test (SPST)

As another instrument, SPST was used in the current study. The test, which was developed by Okey, Wise and Burns (1982), is composed of 36 multiple choice questions measuring five skills: identifying variables, operationally defining variables, identifying appropriate hypotheses, interpreting data and designing experiments. Strawitz (1989) found a reliability of 0.89 (Cronbach's alpha) for this instrument. She also stated that it contained satisfactory content validity. It was adapted into Turkish by Geban, Aşkar & Özkan (1992). The reliability of the test was found to be 0.85 for Turkish version

(Geban et al., 1992). Science process skills consist of classifying, creating models, formulating hypotheses, generalizing, identifying variables, inferring, interpreting data, making decisions, manipulating materials, measuring, observing, predicting, recording data, replicating, and using numbers to determine relationships, or calculating or applying mathematical formulas (Carin & Sund, 1989). Blosser (1975) stated that science process skills contribute to students' success in education. Moreover, Brotherton and Preece (1995) claimed that there is a close link between cognitive development and science process skills. Most of science misconceptions among secondary school students could be related to the lack of formal reasoning patterns such as the isolation and control of variables, probabilistic thinking, and the schema of proportion. Science process skills cannot be separated from the conceptual understanding being involved in learning and applying science. Science process skills are means for understanding science and also major goal of science education. Science learning must engage students in activities which call for higher cognitive stage (Harlen, 1999). Therefore, it is necessary to control students' science process skills while investigating improvement in their scores on Reaction Rate Concept Test measuring their understanding and misconceptions of related concepts. For this reason, Science Process Skill Test (see Appendix D) was given before the instruction to both groups in order to get its effect on students' understanding of reaction rate under control.

4.4.4 Interview Questions

Semi-structured interviews were conducted with six students from both experimental and control group each. Students were selected depending on their post RRCT results as low, average, and medium achievers. Two low, two medium and two high achievers were selected from each group. Interview questions (see Appendix K) were based on students' answers to RRCT. It was intended to get deep information related to students' understanding of reaction rate, find out any misconceptions if they still existed after the treatment and compare students' conceptions both in control and experimental group. Interviews were conducted individually and each interview lasted about 20 minutes. All interviews were audio-taped and transcribed later. Interviews showed that students still had some misconceptions after the treatment. Detailed explanations about interviews were given in results and conclusions chapter.

4.4.5 Group Evaluation Form

This form was developed by the researcher for teacher in order to check or control works of students in their groups and give feedback (see Appendix G). The items were prepared based on the basic features of cooperative learning and functions of group works. It was intended to evaluate groups in terms of students' social skills, participations, and contributions to the completion of task. During implementation, teacher observed the groups while they were working on the task and filled the form for each group once a week and provided feedback to increase the performance of the groups next week. Since the students were new to cooperative learning environment, they needed as much feedback as possible from their teacher. This instrument was not used in statistical data analysis.

4.4.6 Feedback Form for Cooperative Learning

It is a survey instrument including seven open-ended questions and developed originally by Sungur (2004) to get opinions of students' on Problem Based Learning (PBL) method. It was adapted to cooperative learning method by the researcher and administered to experimental group students in order to obtain deeper information related to students' thoughts and suggestions on cooperative learning method (See Appendix H). It was not used in statistical data analysis.

4.5 Treatment (CLCC vs TI)

This study was conducted over six weeks during the 2008-2009 fall semesters. Two schools in Ankara were included and two classes of 11th grades in each school were selected randomly. One of the schools was a regular state high school and the other was an Anatolian high school. Students in Anatolian high school were brighter in terms of academic achievement compared to regular state high school since they were accepted in the school by having a high score from Anatolian High School Examination which was done after middle school. 110 eleventh grade students (59 students from Anatolian high school and 51 students from regular state high school) were involved in the study. The classrooms in each school were instructed by the same teacher. Students in experimental group were instructed by cooperative learning based on conceptual change conditions (CLCC) and students in control group were instructed by traditional instruction (TI). The topics under rate of chemical reactions concept were taught as part of curriculum in chemistry course. Classroom instruction was three 45-minute sessions in a week.

In traditionally instructed classroom, teacher taught reaction rate through discussion and lecture. The teacher described and defined the concepts, wrote related chemical equations and key words on the board, students took notes, and after teacher's explanations, the concepts were discussed through teacher-directed questions. Teacher sometimes used analogies to make some points more concrete since reaction rate is an abstract topic of chemistry. After solving one or two example problems in related content, teacher expected students to solve similar problems given on the board. To solve these problems, teacher mostly selected eager students or brighter ones. It was observed that most of the students were passive listeners and note takers. Generally, the same students answered the questions asked or solved the content related problems. The students were given worksheets for each chapter of unit as homework and the answers were given next week. It was intended for students to practice related problems and interpret verbal questions. Similar questions and content were covered in the control group as conceptual change based cooperative learning class. On the other hand, teacher didn't consider students' misconceptions or their existing knowledge during instruction. He was the center of the classroom and the students listened to him quietly during the lesson. There was a limited teacher-student interaction and no student-student interaction. For example, before presenting the concept of the effect of temperature on reaction rate, teacher asked to the class that how rate of reaction changes when the temperature is increased. The students said that it increases but did not know why. Then he explained how kinetic energies, the collisions of the particles and so the rate of reaction are affected by increasing temperature. Next, he wrote these on board item by item briefly. After that, he waited for the students to copy the board on their notebooks. Next, he drew the curve which exists in all textbooks of chemistry at eleventh grade to express effect of temperature change on reaction rate. It is the curve of Kinetic Energy of Particles vs Number of Particles at two different temperatures, which is given in Figure 4.1.

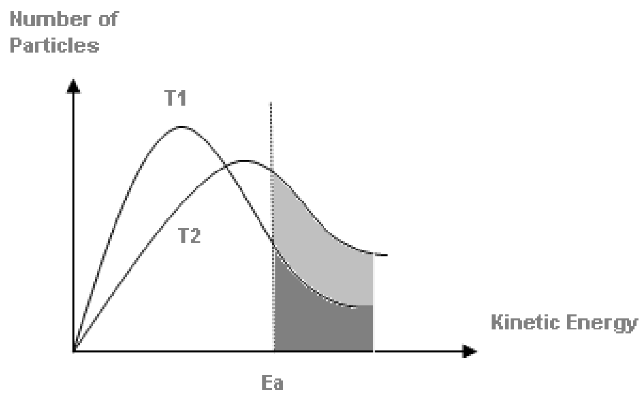


Figure 4.1 Distribution of kinetic energies of particles at two different temperatures, T_1 and T_2.

He told that darker colored area on the curve shows the number of particles reacting at T_1 and total of dark and light colored areas indicates the number of particles reacting at T_2 temperature. He explained that number of particles exceeding Ea (Activation Energy) is greater at T_2. As a result, T_2 is greater than T_1. While the teacher talking about the curve, the students were copying the board. They could ask questions to the teacher when they needed but they were not allowed to talk to their peers. Generally, students prefer to ask the questions related to a concept that they do not understand to their peers before asking the teacher. They hesitate to ask the teacher. Therefore, when teacher ask the class if there are any questions and get no answer, this does not mean that everybody understand the related content. The point is, students were passive listeners, and they only copied the board and answered questions when teacher asked in this study. Then the teacher passed to the next concept. Some photos of the traditional classes are given in Appendix N.

In experimental group, cooperative learning strategy based on conceptual change conditions was applied by using Student Teams-Achievement Divisions (STAD) method of cooperative learning. This instruction was designed to fulfill the conditions in which misconceptions can be replaced with scientifically accepted ideas and new conceptions can be integrated with existing conceptions. It was intended to create an environment where there were teacher-student and student-student interaction.

Before instruction, two teachers of the schools were provided with information about cooperative learning, conceptual change conditions, and the application of cooperative learning based on conceptual change conditions in the content of reaction rate. All of the documents including detailed explanations of cooperative learning and conceptual change model, instruments, lesson plan, group work activities, appropriate questions that could be asked to group members to create contradiction and discussion within groups during group work, a teacher manual providing information about the role of the teacher and the quizzes were given to the teachers to be examined beforehand. After a week, two-hour meetings were done with the teachers to inform and discuss the application of cooperative learning and answer related questions if there were any.

After giving necessary information about cooperative learning and its application, teacher informed students about cooperative learning, its basic elements, function and aim of group work, social skills necessary to conduct group work and what is expected from students during group work in two class hours. Afterwards, students were assigned to four-member heterogeneous groups based on their achievements in previous semester chemistry course. Therefore, each group consisted of one high, two average and one low achiever students. Also, the groups were heterogeneous with respect to sex. Depending on the total number of students, a few groups involved five students. There were approximately equal number of males and females in the groups depending on the composition of the class. Before starting the instruction, the positions of the desks were arranged so that they were face to face and they could change their place quickly when group work started in Anatolian high school. This was for meeting *face to face promotive interaction*. However, in ordinary state school, the teacher and the students preferred to change position of the students not the desks. Some students turned back and passed their legs through the desks in order to be face-to face with their group mates during the group work. The instruction began with class presentation by the teacher. Teacher presented the topic and gave basic information necessary in order for students to discuss related questions in worksheets that would be given later for group work.Teacher presentation took about one or one and a half lesson depending on the content for each week. After that, the teams were formed and the worksheets were given to be worked on. The worksheets contained questions activating students' misconceptions and providing opportunities to integrate new information into their existing conceptions because questions from daily life were also involved in worksheets (see Appendix E). Cooperation among group members was required to reach a solution. The questions in worksheets were aimed to create contradictions among group members since they were prepared based on students' misconceptions about reaction rate. A sample of group sheet was given in Appendix L. The teacher also asked some disequilibrating questions to the group members during group work to encourage discussions. In each group, students had some roles like reader, recorder, controller, and reporter. The roles were changed for each group activity. The students decided their roles but the teacher chose the reporter randomly for each worksheet activity. Choosing someone from each group randomly aims to establish *individual accountability.* By this way, each member must understand the task given and have the responsibility to represent the group well. The reader was expected to read the questions in worksheet to the group whereas the function of the controller was to check whether every member was actively involved in group study. The students discussed the questions in the worksheets and listened to each other's ideas and decided the solution. Every member must have expressed their ideas and been involved in discussions. They knew that unless everybody in the group grasped the solutions and the ideas behind them, the work was not finished. At the end of the group work, the recorder wrote down the final answers of the questions on which a consensus was reached by team members. The aim of assigning roles to the group members is to establish *positive interdependence* so that each student understands the fact that each member's contribution is crucial and each member has a unique contribution to support his/her group to achieve its goals. While the groups were working on the task, they could ask for help from teacher if they couldn't reach a conclusion. So the teacher guided the groups during group activities. Furthermore, during group work phase, teacher evaluated each group's work by Group Evaluation Form and provided feedback to groups being in need of it, each week. Moreover, students were guided and oriented related to social skills required for cooperative learning during the group activities to ensure the establishment of one of the basic elements of cooperative learning, *social skills*. When all groups completed the task, the teacher randomly selected someone (reporter) in each group to discuss and present their answers to the classroom. During this phase, teacher guided students by asking questions to reach correct explanations and scientific descriptions when they made mistakes and feedback was given when necessary. Since the students wrote their answers on worksheets, teacher collected and evaluated those papers and in the following lesson, some additional feedback was given to groups. Interpretations of students' worksheets were presented in chapter 6. For example, as a first group activity, students were given the question below:

Four friends discuss about reaction rate among themselves:

According to Serap, reaction rate is *"the time required for a reaction to be completed"*

Murat defines the rate as: *"the amount of product formed in a chemical reaction"*

Sevim stated that *"reaction rate is the change in molar concentration of reactants or products per unit time at constant temperature.*

Ali claimed that *"reaction rate is the amount of product formed per unit time at constant temperature and concentration"*

Who does define reaction rate correctly? Please explain the ones giving wrong definitions why they are incorrect.

SERAP:

MURAT:

SEVİM:

ALİ:

This question was prepared by using common misconceptions related to the definition of reaction rate. Using misconceptions in the questions created contradiction or disequilibrium among group members and they started to discuss the different definitions given in the task. The researcher observed the groups. In some groups, some of the students claimed that there was more than one correct definition. Mostly, these students insisted on Serap's and Ali's explanations in addition to the correct definition. Teacher guided students to compare rate of a chemical reaction with the term "speed" in physics and then think over the definitions given in the question again. He also asked for the students thinking about how the concentrations of reactants change during a reaction. The teacher continuously guided students and provided help and feedback when necessary. The groups discussed their ideas. For example, one of the students stated that: *"faster reactions occur in a shorter time so Serap's definition may be correct*". Her group mate claimed that *"time is not enough by itself to define the rate; we must consider the amount of product so Murat's definition may be correct"*. This discussion indicated that students sometimes contradicted with each other and thought over others' perspectives and argued actively to reach a consensus. They were actively involved in their own learning and construct knowledge on their own not by recording information directly transmitted from teacher in their minds. The idea was that children learn better by teaching something to a peer. Teacher guided the groups by giving following example: "*we define speed of a car in terms of km/hour so we must consider the distance to be traveled in addition to time passed".* After each group finished its discussion, teacher asked one of the members of each group randomly for explaining the answer and their reasoning.

Depending on the content, after two to three group activities, the students were administered a quiz to answer individually. These individual quizzes (see Appendix F) provided individual accountability among groups because each member must have been ready for the quiz. The quizzes were collected, corrected, and graded by the instructor and the students reviewed their quizzes after the correction in the next week. This would help students see their in-group performances and progressions and establish *group processing*. There were four quizzes in total. Based on the quiz results, the first group in rank of success was rewarded for their improvement. The reward was used to encourage and motivate students' in group work. A sample reaction rate lesson implemented by cooperative learning based on conceptual change conditions is given in Appendix M and some photographs from experimental group are given in Appendix O.

When the group activities were completed, the researcher and a chemistry education PhD student who observed the groups once a week filled the treatment verification checklist (see Appendix I) prepared by the researcher in order to decide whether the cooperative learning method was applied as intended. The checklist is composed of two parts: first part items were answered as "yes" or "no", and second part items were 5-point Likert-type scale (always, usually, sometimes, rarely, and never). At least 75% of the items were marked as "usually" and "yes".Utilizing this checklist indicated that many of expected characteristics of cooperative learning were provided: (a) physical arrangement of the classroom was appropriate for face-to-face interaction during group activities (b) the students were informed about characteristics of cooperative learning, social skills (listening to each other, being respectful and democratic, make every member involved in the activity, being able to ask for help from each others) expected from them and aim of group activities (c) the groups were heterogeneous in terms of achievement and gender (d) each member of ever group was assigned a role for each activity (e) individual quizzes were given after group activities (f) the quizzes were graded, corrected and given back to the students to be examined (g) quiz scores were announced in the next lesson (h) the most successful group was rewarded (i) almost all members of the groups were involved in the activity most of the time, otherwise encouraged by the teacher (j) students could listen each other and be respectful to others' ideas (k) teacher walked around the groups and ask disequilibrating questions or the questions supporting discussions (l) groups evaluated their performances by examining their quizzes and considering feedbacks from teacher (m) the student explaining their solutions or conclusions to the classroom was chosen by the teacher randomly and (n) teacher provided guiding explanations or help when necessary related to the tasks. Therefore, treatment fidelity was provided by using a treatment verification checklist and training the teachers for conceptual change based cooperative learning instruction.

At the end of the instruction, RRCT and MSLQ were given to both experimental and control group. In addition to these tests, Feedback Form for Cooperative Learning was given to the students in experimental group. Students' answers to the items of the instrument were discussed in results and conclusions chapter.

The cooperative learning being applied in this study matched the basic conditions of conceptual change. The teamwork activities were based on activating students' misconceptions and replacing them with scientifically accepted ideas. Since the students shared their ideas and understood that others may have different perspectives in group work, this may create *dissatisfaction* in their minds. Moreover, sometimes the teacher asked some contradicting questions to the groups to encourage discussions. During groupwork, students were able to ask questions to the teacher about any unclear points in worksheets except for the solutions of the questions and the teacher gave feedback to the students. After the groupwork, teacher wanted students to discuss their answers and share their ideas with the classroom. After the discussions, teacher made reasonable explanations about the problematic points to clarify their minds. These will provide *intelligibility* and *plausability*. During teacher presentation, teacher sometimes drew students' attentions to the daily life events about reaction rate and he expected them to consider other examples together with their team mates. He also emphasized why gaining information about rates of some reactions is important in industry. Furthermore, some of the questions in group activities were prepared by considering examples or connections with daily life experiences of students. This strategy met *fruitfulness* condition.

This study didn't result in any physical or physchological harm to students and the teachers involved in the study. Before implementing the instructions in two schools, related permissions from ethical committee of the university which examined the aim, procedure and the instruments used in the study were gotten. In addition, names of the subjects and schools were hidden during the statistical analysis and interpretation of test results. Numbers instead of names were assigned to the students' papers. Only researcher had chance to reach data to meet confidentiality.

4.6 Internal Validity Threats

Internal validity is related to threats or factors except for the independent variable that influence the dependent variable. Internal validity concentrates on threats that affect the results of an experimental study but are not part of the independent variable (Gay & Airasian, 2000). Campbell and Stanley (1971) and Cook and Campbell (1979) identified the threats to internal validity as: history, maturation, testing, instrumentation, statistical regression, differential selection of participants, mortality, and selection-maturation interaction.

History means the occurence of events that are not part of the experimental treatment but occur during the study and influence the dependent variable. When the period of the study increases, the probability of history threat increases (Campbell & Stanley, 1971). During this study, the researcher continually observed and sometimes talked to students and the teachers to identify any extraordinary event that could affect the results of the study if it existed. There was no such an event so history threat was assumed to be controlled.

Maturation threat is resulted from natural physical, intellectual, and emotional changes that occur in the participants over a period of time. These changes may affect dependent variable. Maturation will be a problem in studies taking a long time since the participants may become older, more coordinated, anxious, or unmotivated (Cook & Campbell, 1979). Since this study lasted six weeks and the instruments were administered to both EG and CG in their regular classrooms at the same time, maturation was not a threat to internal validity.

Testing refers to improvement in scores of post-test because of having taken a pretest regardless of whether there is any treatment in between. Testing is a problem especially if the time between pre and post-test is short and if the study measures factual information. Factual information is more likely remembered compared to algebraic equations (Cook & Campbell, 1979). The instruments of this study measured their misconceptions, understanding and science process skills, not factual information. Furthermore, there was six weeks between pre and post-test. Therefore, testing threat was controlled.

Instrumentation threat means unreliability or lack of consistency in measuring instruments causing an invalid assessment of performance. If different tests are used for pretest and posttest, and if the difficulties of them are different, then instrumentation is a threat (Cook & Campbell, 1979). The pretests and the posttests (pre and post RRCT and MSLQ) were the same tests in this study and their reliabilities were reasonable. As a result, instrumentation threat was controlled.

Statistical regression usually occurs when participants are selected based on their extremely high or low scores (Campbell & Stanley, 1971). Since the participants were not selected among high or low scorers, regression threat was controlled.

Differential selection of participants means that when already formed groups are used, initial group differences may responsible for posttest differences (Campbell & Stanley, 1971). To overcome this threat, pretests measuring students' preknowledge, science process skills and motivation were given to both groups before study in order to control any differences.

Mortality refers to case in which participants are drop out of a study. Mortality was not a problem in this study because; no one was dropped out of the study from the beginnig to the end.

Selection-maturation interaction threat occurs when already formed groups are used since one group may profit more from a treatment or have an initial advantage because of maturation, history, or testing. Since all three threats were controlled, selection-maturation interaction was controlled in this study.

4.7 Analysis of Data

ANCOVA was used to analyze the data in order to investigate the effect of cooperative learning based on conceptual change on removing students' misconceptions about reaction rate. Since science process skills of experimental and control groups were different, scores of SPST was assigned as a covariate. MANOVA was conducted to examine the effect of cooperative learning based on conceptual change on students' motivation to chemistry lesson which was considered under six factors: intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety.

4.8 Assumptions and Limitations

4.8.1 Assumptions

1. The participants of the study sincerely answered the questions of the instruments.
2. All instruments were administered to the experimental and control group under the same conditions.
3. Teachers were not biased during the treatment.

4. Students of control group didn't interact with students of experimental group about the treatment.
5. The only reason of difference between experimental and control group, in students' scores of post-tests was the cooperative learning based on conceptual change approach.

4.8.2 Limitations

1. The subjects were not randomly assigned to the groups. Already formed groups were used because of school restrictions. Those intact groups were randomly assigned as experimental and control group.
2. Subjects of the study were limited to 110 eleventh grade students from two schools in Ankara.
3. This study was limited to rate of chemical reactions concept in chemistry.
4. Since cooperative learning requires cooperation and interaction among group members, this might have violated independence of observations assumption of MANOVA.
5. Fit statistics calculated through Confirmatory Factor Analysis were not within acceptable limits although they were reasonable values.

CHAPTER 5

RESULTS AND CONCLUSIONS

Hypothesis in chapter 3 was tested by MANOVA and ANCOVA in this chapter. Statistical analysis of pre-tests and posttests, analysis of interviews, and students' opinions about cooperative learning was given in this section.

5.1 Statistical Analysis of Pre-test Scores

Before treatment, independent-samples t-test was conducted to investigate any difference among EG and CG in terms of pre-RRCT and SPST scores. Moreover, MANOVA was executed to examine any difference among groups with respect to MSLQ scores at 0.05 significance level.

5.1.1 Statistical Analysis of pre-RRCT and SPST Scores

Previous to treatment, independent-samples t-test was conducted by using Statistical Package for Social Sciences (SPSS) to determine whether there was a significant mean difference between experimental group and control group in terms of SPST and pre-RRCT scores.

According to the analysis of the total results (an Anatolian high school and ordinary state school), there was no significant mean difference between EG and CG with respect to previous reaction rate concept understanding measured by pre-RRCT, $t(108) = -0.272$, $p > 0.05$. On the other hand, there was a significant mean difference between EG and CG with respect to science process skills measured by SPST, $t(108) = 2.59$, $p < 0.05$. As a result, SPST was assigned as covariate in the analysis of post-RRCT scores of all students in the study.

The results for Anatolian high school indicated that there was no significant difference between EG and CG with respect to previous reaction rate concept understanding measured by pre-RRCT ($t(57) = -0.893$, $p> 0.05$) and science process skills measured by SPST ($t(57) = 0.660$, $p> 0.05$).

The results for ordinary state high school indicated that there was no significant difference between EG and CG with respect to previous reaction rate concept understanding measured by pre-RRCT, $t(49) = 0.672$, $p> 0.05$. On the other hand, there was a significant mean difference between EG and CG with respect to science process skills measured by SPST, $t(49) = 3.501$, $p< 0.05$. Therefore it was assigned as covariate in the analysis of post-RRCT scores of ordinary state high school students.

Descriptive statistics of EG and CG students' pre-RRCT and SPST scores for all groups in two schools, for Anatolian high school and for ordinary state school are given in Table 5.1, Table 5.2 and Table 5.3.

Table 5.1 Descriptive Statistics for All Groups in Two Schools

Group	N	Pre-RRCT		SPST	
		Mean	SD	Mean	SD
EG	56	8.66	3.58	23.10	3.84
CG	54	8.83	3.03	21.20	3.83

Table 5.2 Descriptive Statistics for Anatolian High School

Group	N	Pre-RRCT		SPST	
		Mean	SD	Mean	SD
EG	30	9.73	3.85	23.70	4.06
CG	29	10.48	2.47	23.06	3.21

Table 5.3 Descriptive Statistics for Ordinary State High School

Group	N	Pre-RRCT		SPST	
		Mean	SD	Mean	SD
EG	26	7.42	2.85	22.42	3.52
CG	25	6.92	2.46	19.04	3.72

5.1.2. Statistical Analysis of pre-MSLQ Scores

MANOVA was performed prior to treatment to investigate whether there was a significant mean difference between EG and CG in terms of motivational collective dependent variables of students' Intrinsic Goal Orientation (IGO), Extrinsic Goal Orientation (EGO), Task Value (TV), Control of Learning Beliefs (CLB), Self-Efficacy for Learning and Performance (SELP), Test Anxiety (TA) for all groups in two schools, for Anatolian high school and for ordinary state high school.

5.1.2.1 Statistical Analysis of pre-MSLQ Scores for all Groups in Two Schools

Descriptive statistics of motivational dependent variables for all groups in two schools is given in Table 5.4.

Table 5.4 Descriptive Statistics of IGO, EGO, TV, CLB, SELP, and TA for All Groups in Two Schools

	N		Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
IGO	54	56	17.96	19.78	5.22	4.29	-0.33	-0.53	-0.98	-0.49
EGO	54	56	20.68	21.32	4.20	4.91	-0.72	-1.27	0.30	1.62
TV	54	56	29.81	31.03	6.85	5.79	-0.19	-0.85	-0.91	0.42
CLB	54	56	22.20	22.62	3.77	3.91	-0.56	-1.98	0.23	8.11
SELP	54	56	40.96	42.94	9.45	8.54	-0.41	-1.00	-0.60	1.03
TA	54	56	19.75	19.94	5.57	5.62	0.04	-0.24	0.36	-0.74

Skewness and kurtosis values should be between -2.00 and +2.00 for satisfying univariate normality in EG and CG scores (George & Mallery, 2003). As seen from Table 5.4, skewness and kurtosis values are acceptable except for kurtosis value of CLB in EG, which was 8.11. On the other hand, Stevens (2002) stated that the effects of kurtosis on level of significance, although greater than the effect of skewness, tend to be slight and deviation from normality for only one variable is not so important to be concerned with. Therefore, it can be claimed that univariate normality assumption which may be the indicator of multivariate normality (Stevens, 2002) is met. Moreover, Box's M test result is not significant so assumption of homogeneity of covariance matrices is satisfied, $F(21, 427777) = 0.89$, $p = 0.60$, $p > 0.05$.

Levene's Test of Equality of Error Variances is used for homogeneity of variance assumption. It checks whether each dependent variable has similar variance for all groups. When levene statistics is not significant at 0.05 level of significance, the researcher fails to reject the null hypothesis that the groups have equal variances. Table 5.5 indicates results of Levene's test for all groups in two schools.

Table 5.5 Levene's Test of Equality of Variance for All Groups in Two Schools

Dependent Variables	F	df1	df2	Sig.
IGO	3.99	1	108	0.048
EGO	1.49	1	108	0.22
TV	2.61	1	108	0.10
CLB	0.17	1	108	0.67
SELP	2.11	1	108	0.14
TA	0.23	1	108	0.62

Table 5.5 shows that significance values for all dependent variables except for IGO are not significant, which means that population variances for groups are equal with these dependent variables. Since there is nothing unusual in the distributions for measures of normality (skewness and kurtosis) and F value of IGO is not large, the significant value of it can be ignored and MANOVA analysis can be accepted as valid for all groups in two schools (George & Mallery, 2003).

After satisfying the assumptions, MANOVA was performed to examine whether a significant difference existed between groups in terms of collective dependent variables of IGO, EGO, TV, CLB, SELP, and TA prior to treatment for all groups in two schools. Table 5.6 presents MANOVA results.

Table 5.6 MANOVA Results for Collective Dependent Variables of IGO, EGO, TV, CLB, SELP, and TA for All Groups in Two Schools

Effect	Wilks' Lambda	F	Sig. (p)
GROUP	0.96	0.70	0.64

Based on the results in Table 5.6, it can be concluded that there was no significant difference between EG and CG with respect to collective dependent variables of IGO, EGO, TV, CLB, SELP, and TA for all groups in two schools. That means, students' motivational characteristics were similar in EG and CG before instruction in two schools.

5.1.2.2 Statistical Analysis of pre-MSLQ Scores for Anatolian High School

Descriptive statistics of motivational dependent variables for Anatolian high school is given in Table 5.7.

Table 5.7 Descriptive Statistics of IGO, EGO, TV, CLB, SELP, and TA for Anatolian High School

	N		Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
IGO	29	30	16.89	19.36	4.81	4.27	0.70	-0.23	-0.33	-0.57
EGO	29	30	20.82	22.13	4.02	4.04	-0.40	-0.82	0.30	-0.05
TV	29	30	29.48	32.80	6.75	4.71	-0.04	-1.23	-0.74	1.79
CLB	29	30	21.48	22.90	4.08	2.92	-0.43	-0.13	0.33	-0.82
SELP	29	30	42.10	47.23	10.56	5.64	-0.88	-0.56	-0.25	0.32
TA	29	30	18.79	18.46	5.38	5.41	0.28	0.10	2.101	-0.47

As seen from Table 5.7, skewness and kurtosis values are acceptable except for kurtosis value of TA in CG, which was 2.101. However, it was slightly bigger than 2.00 so it is not so important to be concerned with. Therefore, it can be claimed that univariate normality assumption which may be the indicator of multivariate normality (Stevens, 2002) was met. Moreover, Box's M test result is not significant so assumption of homogeneity of covariance matrices is satisfied, $F (21, 11919) = 1.07$, $p = 0.36$, $p > 0.05$.

Levene's Test of Equality of Error Variances is used for homogeneity of variance assumption. Table 5.8 indicates results of Levene's test for Anatolian high school.

Table 5.8 Levene's Test of Equality of Variance for Anatolian High School

Dependent Variables	F	df1	df2	Sig.
IGO	0.94	1	57	0.334
EGO	0.66	1	57	0.799
TV	4.75	1	57	0.033
CLB	1.94	1	57	0.169
SELP	1.30	1	57	0.001
TA	0.28	1	57	0.597

Table 5.8 shows that significance values for all dependent variables except for TV and SELP are not significant, which means that population variances for groups are equal with these dependent variables. Since there is nothing unusual in the distributions for measures of normality (skewness and kurtosis) and F values of TV and SELP are not large, the significant value of them can be ignored and

MANOVA analysis can be accepted as valid for all groups in two schools (George & Mallery, 2003).

After satisfying the assumptions, MANOVA was performed to examine whether a significant difference existed between groups in terms of collective dependent variables of IGO, EGO, TV, CLB, SELP, and TA prior to treatment for Anatolian high school. Table 5.9 presents MANOVA results.

Table 5.9 MANOVA Results for Collective Dependent Variables of IGO, EGO, TV, CLB, SELP, and TA for Anatolian High School

Effect	Wilks' Lambda	F	Sig. (p)
GROUP	0.86	1.31	0.26

Based on the results in Table 5.9, it can be concluded that there was no significant difference between EG and CG with respect to collective dependent variables of IGO, EGO, TV, CLB, SELP, and TA for for Anatolian high school. That means, students' motivational characteristics were similar in EG and CG before instruction in Anatolian high school.

5.1.2.3 Statistical Analysis of pre-MSLQ Scores for Ordinary State High School

Descriptive statistics of motivational dependent variables for ordinary state high school is given in Table 5.10.

Table 5.10 Descriptive Statistics of IGO, EGO, TV, CLB, SELP, and TA for Ordinary State High School

	N		Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
IGO	25	26	19.20	20.26	5.50	4.35	-0.05	-0.93	-1.13	0.08
EGO	25	26	20.52	20.38	4.48	5.69	-1.02	-1.26	0.40	1.21
TV	25	26	30.20	29.00	7.08	6.32	-0.38	-0.44	-0.96	-0.03
CLB	25	26	23.04	22.30	3.27	4.86	-0.54	-2.21	-0.43	7.43
SELP	25	26	39.64	38.00	8.73	3.27	-0.40	-0.87	-0.64	0.03
TA	25	26	20.88	21.65	5.79	5.35	-0.26	-0.73	-0.43	-0.05

As seen from Table 5.10, skewness and kurtosis values are acceptable except for skewness and kurtosis value of CLB in EG, which are -2.21 and 7.43 respectively. However, skewness value is slightly bigger than 2.00 so it is not so important to be concerned with. Moreover, the effects of kurtosis on level of significance tend to be slight and deviation from normality for only one variable is not so important to be dealt with (Stevens, 2002).Therefore, it can be claimed that univariate normality assumption which may be the indicator of multivariate normality (Stevens, 2002) was met. In addition, Box's M test result is not significant so assumption of homogeneity of covariance matrices is satisfied, F (21, 8800) = 1.38, $p = 0.11$, $p > 0.05$.

Levene's Test of Equality of Error Variances is used for homogeneity of variance assumption. Table 5.11 indicates results of Levene's test for ordinary state high school.

Table 5.11 Levene's Test of Equality of Variance for Ordinary State High School

Dependent Variables	F	df1	df2	Sig.
IGO	3.40	1	49	0.07
EGO	2.16	1	49	0.14
TV	0.92	1	49	0.34
CLB	0.43	1	49	0.51
SELP	0.08	1	49	0.77
TA	0.09	1	49	0.75

Table 5.11 shows that significance values for all dependent variables except for IGO are not significant, which means that population variances for groups are equal with these dependent variables. Since there is nothing unusual in the distributions for measures of normality (skewness and kurtosis) and F value of IGO is not large, the significant value of it can be ignored and MANOVA analysis can be accepted as valid for ordinary state high school (George & Mallery, 2003).

After satisfying the assumptions, MANOVA was performed to examine whether a significant difference existed between groups in terms of collective dependent variables of IGO, EGO, TV, CLB, SELP, and TA prior to treatment for ordinary state high school. Table 5.12 presents MANOVA results.

Table 5.12 MANOVA Results for Collective Dependent Variables of IGO, EGO, TV, CLB, SELP, and TA for Ordinary State High School

Effect	Wilks' Lambda	F	Sig. (p)
GROUP	0.92	0.56	0.75

Based on the results in Table 5.12, it can be concluded that there was no significant difference between EG and CG with respect to collective dependent variables of IGO, EGO, TV, CLB, SELP, and TA for for ordinary stae high school. That means, students' motivational characteristics were similar in EG and CG before instruction in ordinary state high school.

The next section presents analysis of post-test scores on RRCT and MSLQ for each school separately and for two schools together.

5.2 Analysis of Post-test Scores

Statistical analysis of post-RRCT and MSLQ scores was performed to test hypotheses given in Chapter 3. The hypothesis given below was tested by using post-RRCT scores:

Hypothesis 1:

There is no significant mean difference between 11th grade students who are taught by cooperative learning based on conceptual change conditions and traditionally designed instruction in terms of their understanding in reaction rate when the effect of science process skills is controlled as a covariate.

This hypothesis was tested for two schools together and for each school separately.

5.2.1 Statistical Analysis of post-RRCT Scores for all Groups in Two Schools

The hypothesis was tested by one-way ANCOVA where treatment was independent variable and understanding of reaction rate concept (RRCT) was dependent variable for the participants of two schools together. Moreover, students' scores on SPST was assigned as covariate. Table 5.13 indicates the descriptive statistics of RRCT scores as dependent variable.

Table 5.13 Descriptive Statistics of RRCT for all Groups in Two Schools

Dependent variable	N		Mean		SD		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
RRCT	54	56	15.87	18.82	3.46	3.28	-0.38	-1.11	-0.67	-0.76

As seen from Table 5.13, skewness and kurtosis values are acceptable which means bivariate normality assumption is met. The RRCT scores on each group are normally distributed for any specific value of the covariate.

Another assumption of ANCOVA is the homogeneity-of-slopes assumption which means that the covariate is linearly related to the dependent variable across groups, and slopes relating the covariate to the dependent variable are equal within groups. Results of test of homogeneity of slopes are given on Table 5.14.

Table 5.14 Results of Test of Homogeneity of Slopes for All Groups in Two Schools

Source	df	F	Sig.
GROUP*SPST	1	3.94	0.50

The interaction source is labed as GROUP*SPST in Table5.14. The results suggest that the interaction between the covariate and the factor in prediction of dependent variable (RRCT) is not significant, which means there is no interaction between covariate (SPST) and the factor (GROUP). Therefore, it is possible to proceed to ANCOVA.

Moreover, in order to check homogeneity of variance assumption, Levene's Test of Equality of Error Variances is used. Table 5.15 indicates the results of Levene's test for 0.05 significance level.

Table 5.15 Levene's Test of Equality of Error Variances for All Groups in Two Schools

Dependent Variable	F	df1	df2	Sig.
RRCT	0.133	1	108	0.71

Table 5.15 shows that population variances across groups are equal for the dependent variable of RRCT when SPST scores are used as covariate since the related statistics is not significant.

After meeting the assumptions, ANCOVA was performed to examine whether a significant difference existed between groups in terms of students' understanding of reaction rate concept measured by RRCT when SPST scores was assigned as covariate. Table 5.16 presents ANCOVA results.

Table 5.16 Results of One-way ANCOVA for All Groups in Two Schools

Source	df	F	Sig.	Partial Eta Squared	Observed Power
SPST	1	28.23	0.00	0.20	1.00
GROUP	1	13.59	0.00	0.11	0.95

The results of analysis of post-RRCT scores of students in two schools indicated that there was a significant mean difference between EG and CG in terms of students' understanding of reaction rate concept when SPST scores were used as covariate. Specifically, as shown in Table 5.13, mean score of control group was 15.87 and that of control group was 18.82. Partial $\eta 2$ of 0.11 suggests a moderate relationship between treatment and dependent variable, implying that the magnitude of the difference among groups was not small. This means that, 11 % of variance on dependent variable was attributed to treatment. In addition, power, which is the probability of detecting a significant effect when the effect truly does exist in nature, was found to be 0.95. Therefore, the difference found between the groups arouse from the treatment effect and this difference had practical value (Gay & Airasian, 2000). Similarly, partial $\eta 2$ of 0.20 suggests a strong relationship between treatment and covariate. This means that, 20 % of variance, which is a large value, on dependent variable was explained by science process skills of the students. As a result, the effect of science process skills of students on their understanding in reaction rate concept can not be underestimated. Science process skills of participants should always be considered while investigating their conceptions or achievements in science.

5.2.2 Statistical Analysis of post-RRCT Scores for Anatolian High School

The hypothesis was tested by one-way ANOVA where treatment was independent variable and understanding of reaction rate concept (RRCT) was dependent variable for Anatolian high school. Table 5.17 indicates the descriptive statistics of RRCT scores as dependent variable.

Table 5.17 Descriptive Statistics of RRCT for Anatolian High School

Dependent variable	N		Mean		SD		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
RRCT	29	30	18.10	20.60	2.28	1.65	-0.88	-0.82	1.87	0.22

As seen from Table 5.17, skewness and kurtosis values are acceptable which means bivariate normality assumption is met. The RRCT scores on each group are normally distributed. Moreover, in order to check homogeneity of variance assumption, Levene's Test of Equality of Error Variances is used. Table 5.18 indicates the results of Levene's test for 0.05 significance level.

Table 5.18 Levene's Test of Equality of Error Variances for Anatolian High School

Dependent Variable	F	df1	df2	Sig.
RRCT	1.967	1	57	0.16

Table 5.18 shows that population variances across groups are equal for the dependent variable of RRCT since the related statistics is not significant.

After meeting the assumptions, ANOVA was performed to examine whether a significant difference existed between groups in terms of students' understanding of reaction rate concept measured by RRCT for Anatolian high school. Table 5.19 presents ANOVA results.

Table 5.19 Results of One-way ANOVA for Anatolian High School

Source	df	F	Sig.	Partial Eta Squared	Observed Power
GROUP	1	23.19	0.00	0.28	0.99

The results of analysis of post-RRCT scores of students in Anatolian high school indicated that there was a significant mean difference between EG and CG in terms of students' understanding of reaction rate concept. Specifically, as shown in Table 5.17, mean score of control group was 18.10 and that of control group was 20.60. Partial $\eta 2$ of 0.28 suggests a strong relationship between treatment and dependent variable, implying that the magnitude of the difference among groups in terms of conceptual understanding in reaction rate was large. This means that, 28 % of variance on dependent variable was attributed to treatment. In addition, power, which is the probability of detecting a significant effect when the effect truly does exist in nature, was found to be 0.99. Therefore, the difference found between the groups arouses from the treatment effect and this difference had practical value (Gay & Airasian, 2000).

5.2.3 Statistical Analysis of post-RRCT Scores for Ordinary State High School

The hypothesis was tested by one-way ANCOVA where treatment was independent variable and understanding of reaction rate concept (RRCT) was dependent variable for the participants of ordinary state high school. Moreover, students' scores on SPST was assigned as covariate. Table 5.20 indicates the descriptive statistics of RRCT scores as dependent variable.

Table 5.20 Descriptive Statistics of RRCT for Ordinary State High School

Dependent variable	N		Mean		SD		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
RRCT	25	26	13.28	16.76	2.71	3.52	-0.07	-0.44	-0.85	-0.44

As seen from Table 5.20, skewness and kurtosis values are acceptable which means bivariate normality assumption is met. The

RRCT scores on each group are normally distributed for any specific value of the covariate.

Another assumption of ANCOVA is the homogeneity-of-slopes assumption which means that the covariate is linearly related to the dependent variable across groups, and slopes relating the covariate to the dependent variable are equal within groups. Results of test of homogeneity of slopes are given on Table 5.21.

Table 5.21 Results of Test of Homogeneity of Slopes for Ordinary State High School

Source	df	F	Sig.
GROUP*SPST	1	0.36	0.55

The interaction source is labed as GROUP*SPST in Table 5.21. The results suggest that the interaction between the covariate and the factor in prediction of dependent variable (RRCT) is not significant, which means there is no interaction between covariate (SPST) and the factor (GROUP). Therefore, it is possible to proceed to ANCOVA.

Moreover, in order to check homogeneity of variance assumption, Levene's Test of Equality of Error Variances is used. Table 5.22 indicates the results of Levene's test for 0.05 significance level.

Table 5.22 Levene's Test of Equality of Error Variances for All Groups in Two Schools

Dependent Variable	F	df1	df2	Sig.
RRCT	5.45	1	49	0.02

Table 5.22 shows that population variances across groups are not equal for the dependent variable of RRCT when SPST scores are used as covariate since the related statistics is significant. So this assumption was not met. On the other hand, since there is nothing unusual in the distributions for measures of normality (skewness and kurtosis) and F value is not large, the significant value of it can be ignored and ANCOVA analysis can be accepted as valid for ordinary state high school (George & Mallery, 2003).

After meeting the assumptions, ANCOVA was performed to examine whether a significant difference existed between groups in terms of students' understanding of reaction rate concept measured by RRCT when SPST scores was assigned as covariate. Table 5.23 presents ANCOVA results.

Table 5.23 Results of One-way ANCOVA for Ordinary State High School

Source	df	F	Sig.	Partial Eta Squared	Observed Power
SPST	1	14.55	0.000	0.23	0.96
GROUP	1	5.21	0.027	0.09	0.61

The results of analysis of post-RRCT scores of students in ordinary state high school indicated that there was a significant mean difference between EG and CG in terms of students' understanding of reaction rate concept when SPST scores were used as covariate. Specifically, as shown in Table 5.20, mean score of control group was 13.28 and that of experimental group was 16.76. Partial $\eta 2$ of 0.09 suggests a moderately large relationship between treatment and dependent variable, implying that the magnitude of the difference among groups was not small. This means that, 9 % of variance on dependent variable was attributed to treatment. In addition, power, which is the probability of detecting a significant effect when the effect truly does exist in nature, was found to be 0.61. Similarly, partial $\eta 2$ of 0.23 suggests a strong relationship between treatment and covariate. This means that, 23 % of variance, which is a large value, on dependent variable was explained by science process skills of the students in ordinary state high school. As a result, the effect of science process skills of students on their understanding in reaction rate concept can not be underestimated.

When the effect of cooperative learning based on conceptual change conditions on students' understanding in reaction rate is compared at two different schools (Anatolian high school and ordinary state school), it can be concluded that this method improved students' understanding of reaction rate in Anatolian high school more than it did in ordinary state high school because the magnitude of difference between EG and CG in Anatolian high school is larger.

Hypothesis 2:

There is no significant mean difference between 11th grade students who are taught by cooperative learning based on conceptual change conditions and traditionally designed instruction in terms of their motivation to chemistry as a school subject (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety).

This hypothesis was tested by performing one-way MANOVA where treatment was independent variable and intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety were dependent variables for two schools together and for each school separately.

5.2.4 Statistical Analysis of post-MSLQ Scores for all Groups in Two Schools

Descriptive statistics for the dependent variables across EG and CG were presented in Table 5.24.

Table 5.24 Descriptive statistics for IGO, EGO, TV, CLB, SELP, and TA for All Groups in Two Schools

	N		Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
IGO	54	56	17.75	19.69	4.86	4.22	-0.12	-0.14	-0.16	-0.45
EGO	54	56	20.96	22.21	4.73	4.22	-1.23	-0.92	2.24	1.43
TV	54	56	29.85	30.64	6.91	7.18	-0.74	-0.74	1.45	0.09
CLB	54	56	22.88	22.83	3.78	3.61	-0.68	-1.13	0.72	1.68
SELP	54	56	42.25	45.21	8.04	6.98	-0.78	-0.31	0.54	-0.87
TA	54	56	19.11	20.23	6.14	6.10	-0.04	-0.27	0.07	-0.15

Table 5.24 revealed that experimental group (EG) had the highest mean score on some variables such as IGO, EGO, TV, SELP, and TA. Also, skewness and kurtosis values implied that univariate normality which is a sign of multivariate normality assumption was satisfied. Furthermore, Box's Test of equality of covariances result was significant which means covariance matrices of the groups on dependent variables were not equal, $F(21, 42777) = 1.85$, $p = 0.01$. On the other hand, since the sample size was large enough and the group sizes were approximately equal, actual α value was kept very close to the level of significance (preventing Type I error), and so the test was conservative (Hakstian, Roed & Lind, 1979). As a result, it was not necessary to be concerned for significant Box test and the assumption was satisfied. Results of Levene's Test to check equality of variances on dependent variables across groups were given in Table 5.25.

Table 5.25 Levene's Test of Equality of Error Variances for all groups in two schools

Dependent Variables	F	df1	df2	Sig.
IGO	1.90	1	108	0.17
EGO	0.05	1	108	0.82
TV	0.37	1	108	0.54
CLB	0.22	1	108	0.63
SELP	0.10	1	108	0.75
TA	0.00	1	108	0.99

Table 5.25 revealed that population variances across groups were equal for the dependent variables of IGO, EGO, TV, CLB, SELP, and TA since the related statistics was not significant. Therefore, equality of variances assumption was met. Having satisfied all

assumptions, one-way MANOVA was performed to see the effect of cooperative learning based on conceptual change conditions on students' motivation (IGO, EGO, TV, CLB, SELP, and TA). Results of MANOVA for all groups in two schools were shown in Table 5.26.

Table 5.26 Results of MANOVA for the dependent variables of IGO, EGO, TV, CLB, SELP, and TA for all groups in two schools

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
GROUP	0.87	2.49	6.00	103.00	0.027	0.13	0.82

The results indicated that there was a significant mean difference between experimental and control group in terms of collective dependent variables. Partial Eta Squared (η_2) value was not small, 0.13, meaning that the magnitude of the difference between the groups was moderately large (Green, Sulkind & Akey, 2000). In other words, 13% of variance of dependent variables was explained by the treatment. Furthermore, power, which is the probability of detecting a significant effect when the effect truly does exist in nature, was found to be high, 0.82. Therefore, it can be concluded that difference between experimental and control group arose from the treatment effect and this difference had the practical value.

To determine the effect of treatment on each dependent variable, univariate ANOVA's were proceeded. Table 5.27 indicates the results of univariate ANOVAs for all groups in two schools.

Table 5.27 The results of univariate ANOVA's for All Groups in Two Schools

Source	Dependent Variable	df	F	Sig.	Partial Eta Squared	Observed Power
GROUP	IGO	1	4.992	0.028	0.044	0.60
	EGO	1	2.143	0.146	0.019	0.30
	TV	1	0.342	0.558	0.003	0.09
	CLB	1	0.005	0.944	0.000	0.051
	SELP	1	4.242	0.042	0.038	0.532
	TA	1	0.921	0.339	0.008	0.158

As seen from Table 5.27, concerning treatment, the univariate ANOVAs for the dependent variables of intrinsic goal orientation and self-efficacy for learning and performance were significant ($p < 0.05$). In other words, there was a statistically significant mean difference between EG and CG in terms of these variables. When the means of groups on intrinsic goal orientation and self-efficacy for learning and performance were checked in Table 5.24, EG students had higher scores than CG students. Mean scores of EG and CG students on IGO were 19.69 and 17.75; and on SELP were 45.21 and 42.25, respectively.

Percentages of agreement with the selected items in the intrinsic goal orientation scale (item 16 and 24) and self-efficacy for learning and performance scale (item 5, 6, 12, 20, 21, 29) across groups were presented in Table 5.28.

Table 5.28 Percentages of responses to selected items of the IGO and the SELP scale

Scale	Item No	Groups	1 (%)	2 (%)	3(%)	4 (%)	5 (%)	6 (%)	7 (%)
IGO	16	CG	13	7.4	25.9	16.7	11.1	5.6	20.4
		EG	7.1	3.6	17.9	14.3	16.1	23.2	17.9
	24	CG	7.4	9.3	14.8	27.8	9.3	13.0	18.5
		EG	7.1	0	3.6	28.6	16.1	30.4	14.3
SELP	5	CG	3.7	1.9	9.3	18.5	25.9	24.1	16.7
		EG	0	0	1.8	10.7	23.2	33.9	30.4
	6	CG	5.6	9.3	7.4	18.5	31.5	14.8	13.0
		EG	1.8	1.8	5.4	17.9	26.8	25.0	21.4
	12	CG	0	1.9	0	9.3	22.2	29.6	37.0
		EG	0	0	0	12.5	10.7	37.5	39.3
	20	CG	5.6	1.9	3.7	14.8	29.6	31.5	13.0
		EG	0	0	1.8	23.2	21.4	25.0	28.6
	21	CG	1.9	1.9	0	14.8	24.1	25.9	31.5
		EG	0	0	1.8	5.4	19.6	41.1	32.1
	29	CG	0	5.6	5.6	13.0	35.2	25.9	14.8
		EG	0	1.8	5.4	16.1	19.6	30.4	26.8

Higher scores on items related to intrinsic goal orientation means that students in experimental group participated in chemistry lesson for reasons of challenge, curiosity, and mastery instead of grades or evaluation by others. For example, in item 16, it is stated that “In chemistry lessons, I prefer course material that arouses my curiosity, even if it is difficult to learn”. This item was rated as 6 and7 by 41.1 % of experimental group students while 26 % of control group students rated that as 6 and 7 which indicates the agreement of this statement. Moreover, 44.7 % of experimental group students agreed with item 24 stating “When I have the opportunity in chemistry lesson, I choose course assignments that I can learn from even if they don't guarantee a good grade” while 31.5 % of students in control group agreed with it. In addition, students in experimental group had higher scores of self-efficacy for learning and performance that is; they have higher expectancy for success and self-efficacy which means one's confidence in having the skills necessary to perform a task compared to the control group. For instance, the item 5 stating "I believe I will receive an excellent grade in chemistry lesson" was rated 6 and 7 indicating agreement by 64.3 % of students in experimental group while 40.8 % of control group students agreed with it. In addition, the statement of "I'm certain I can understand the most difficult material presented in the readings for chemistry lesson" (item 6) was agreed by 46.4 % of experimental group students whereas 27.8 % of control group students agreed with it. Similarly, the statement of "I'm confident I can learn the basic concepts taught in chemistry lesson" (item 12) was agreed by 76.8 % of students in experimental group and by 66.6 % of control group students. Item 20 stating "I'm confident I can do an excellent job on the assignments and tests in chemistry lesson" was agreed by 53.6 % of students in experimental group and by 44.5 % of students in control group. Item 21 stating "I expect to do well in chemistry lesson" was agreed by 73.2 % of experimental group students and by 44.5 % of control group students. Furthermore, item 29 stating "I'm certain I can master the skills being taught in chemistry lesson" was agreed by 57.2 % of experimental group students and by 40.7 % of control group students.

In contrast, the results showed that there was no significant mean difference between groups in terms of extrinsic goal orientation, control of learning beliefs, task value and test anxiety when post-MSLQ scores of students from both schools were analyzed together.

5.2.5 Statistical Analysis of post-MSLQ Scores for Anatolian High School

Descriptive statistics for the dependent variables across EG and CG were presented in Table 5.29.

Table 5.29 Descriptive statistics for IGO, EGO, TV, CLB, SELP, and TA for Anatolian High School

	N		Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
IGO	29	30	18.06	18.66	5.07	4.24	0.17	0.26	-1.09	-0.71
EGO	29	30	21.48	21.96	4.70	3.35	-0.67	0.24	-0.21	-0.90
TV	29	30	29.62	31.20	6.49	6.91	0.02	-0.66	-0.16	0.17
CLB	29	30	21.86	22.33	4.04	3.30	-0.41	-1.10	0.63	1.94
SELP	29	30	42.13	46.50	9.34	6.66	-0.90	-0.28	0.42	-1.27
TA	29	30	19.24	20.30	6.37	6.30	0.16	-0.28	-0.01	-0.25

Table 5.29 revealed that experimental group (EG) in Anatolian high school had the highest mean score on some variables such as TV, CLB, SELP, and TA. Also, skewness and kurtosis values implied that univariate normality which is a sign of multivariate normality assumption was satisfied. Furthermore, Box's Test of equality of covariances result was not significant which means covariance matrices of the groups on dependent variables were equal, $F(21, 11919) = 1.02$, $p = 0.42$, $p > 0.05$ and the assumption was satisfied. Results of Levene's Test to check equality of variances on dependent variables across groups were given in Table 5.30.

Table 5.30 Levene's Test of Equality of Error Variances for Anatolian High School

Dependent Variables	F	df1	df2	Sig.
IGO	2.11	1	57	0.15
EGO	2.84	1	57	0.09
TV	0.59	1	57	0.44
CLB	0.68	1	57	0.41
SELP	1.37	1	57	0.24
TA	0.00	1	57	0.98

Table 5.30 revealed that population variances across groups were equal for all dependent variables since the related statistics were not significant, which means that population variances for groups are equal with these dependent variables.

Having satisfied all assumptions, one-way MANOVA was performed to see the effect of cooperative learning based on conceptual change conditions on students' motivation (IGO, EGO, TV, CLB, SELP, and TA) in Anatolian high school. Results of MANOVA for Anatolian high school were shown in Table 5.31.

Table 5.31 Results of MANOVA for the Dependent Variables of IGO, EGO, TV, CLB, SELP, and TA for Anatolian High School

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
GROUP	0.90	0.94	6.00	52.00	0.04	0.09	0.34

The results indicated that there was a significant mean difference between experimental and control group in terms of collective dependent variables. Partial Eta Squared (η_2) value was not small, 0.09, meaning that the magnitude of the difference between the groups was moderately large (Green, Sulkind & Akey, 2000). In other words, 9 % of variance of dependent variables was explained by the treatment.

To determine the effect of treatment on each dependent variable, univariate ANOVA's were proceeded. Table 5.32 indicates the results of univariate ANOVAs for Anatolian high school.

Table 5.32 The results of univariate ANOVA's for Antolian High School

Source	Dependent Variable	df	F	Sig.	Partial Eta Squared	Observed Power
GROUP	IGO	1	0.241	0.625	0.004	0.07
	EGO	1	0.208	0.650	0.004	0.07
	TV	1	0.816	0.370	0.014	0.14
	CLB	1	0.241	0.635	0.004	0.07
	SELP	1	4.280	0.043	0.070	0.52
	TA	1	0.411	0.524	0.007	0.09

As seen from Table 5.32, concerning treatment, the univariate ANOVAs for the dependent variable of self-efficacy for learning and performance were significant ($p < 0.05$). In other words, there was a statistically significant mean difference between EG and CG in terms of students' self-efficacy for learning and performance. When the means of groups on self-efficacy for learning and performance were checked in Table 5.29, EG students had higher scores than CG students. Mean scores of EG and CG students on SELP were 42.13 and 46.50, respectively.

5.2.6 Statistical Analysis of post-MSLQ Scores for Ordinary State High School

Descriptive statistics for the dependent variables across EG and CG were presented in Table 5.33.

Table 5.33 Descriptive statistics for IGO, EGO, TV, CLB, SELP, and TA for Ordinary State High School

	N		Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
IGO	25	26	17.40	20.88	4.67	3.94	-0.64	-0.63	1.30	1.27
EGO	25	26	20.36	22.50	4.79	5.10	-1.98	-1.39	5.10	1.83
TV	25	26	30.12	30.00	7.50	7.57	-1.39	-0.83	3.11	0.10
CLB	25	26	24.08	23.42	3.78	3.61	-0.91	-1.39	1.55	1.40
SELP	25	26	42.40	43.73	3.13	3.93	-0.17	-0.30	-0.93	-0.70
TA	25	26	18.96	20.15	6.39	7.16	-0.36	-0.70	0.45	0.23

Table 5.33 revealed that experimental group (EG) had the highest mean score on some variables such as IGO, EGO, SELP, and TA. Skewness and kurtosis values are acceptable except for kurtosis values of EGO and TV in CG, which were 5.10 and 3.11 respectively. On the other hand, Stevens (2002) stated that the effects of kurtosis on level of significance tend to be slight and deviation from normality for only two variables is not so important to be concerned with. Therefore, it can be claimed that univariate normality assumption which may be the indicator of multivariate normality (Stevens, 2002) is

met. Furthermore, Box's Test of equality of covariances result was significant which means covariance matrices of the groups on dependent variables were not equal, $F(21, 8800) = 2.05$, $p = 0.003$. On the other hand, since the sample size was large enough and the group sizes were approximately equal, actual α value was kept very close to the level of significance (preventing Type I error), and so the test was conservative (Hakstian, Roed & Lind, 1979). As a result, it was not necessary to be concerned for significant Box test and the assumption was satisfied. Results of Levene's Test to check equality of variances on dependent variables across groups were given in Table 5.34.

Table 5.34 Levene's Test of Equality of Error Variances for Ordinary State High School

Dependent Variables	F	df1	df2	Sig.
IGO	1.90	1	49	0.33
EGO	0.05	1	49	0.46
TV	0.37	1	49	0.82
CLB	0.22	1	49	0.43
SELP	0.10	1	49	0.51
TA	0.00	1	49	0.95

Table 5.34 revealed that population variances across groups were equal for all dependent variables since the related statistics was not significant. Therefore, equality of variances assumption was met. Having satisfied all assumptions, one-way MANOVA was performed to see the effect of cooperative learning based on conceptual change conditions on students' motivation (IGO, EGO, TV, CLB, SELP, and TA) in ordinary state high school. Results of MANOVA for ordinary state high school are shown in Table 5.35.

Table 5.35 Results of MANOVA for the Dependent Variables of IGO, EGO, TV, CLB, SELP, and TA for Ordinary State High School

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
GROUP	0.69	3.25	6.00	44.00	0.010	0.30	0.89

The results indicated that there was a significant mean difference between experimental and control group in terms of collective dependent variables in ordinary state high school. Partial Eta Squared (η_2) value was large, 0.30, meaning that the magnitude of the difference between the groups was large (Green, Sulkind & Akey, 2000). In other words, 30% of variance of dependent variables which reflect students' motivation was explained by the treatment. Furthermore, power, which is the probability of detecting a significant effect when the effect truly does exist in nature, was found to be high, 0.89. Therefore, it can be concluded that difference between experimental and control group arose from the treatment effect and this difference had the practical value.

To determine the effect of treatment on each dependent variable, univariate ANOVA's were proceeded. Table 5.36 indicates the results of univariate ANOVAs for ordinary state high school.

Table 5.36 The results of univariate ANOVA's for Ordinary State High School

Source	Dependent Variable	df	F	Sig.	Partial Eta Squared	Observed Power
GROUP	IGO	1	8.309	0.006	0.145	0.80
	EGO	1	2.379	0.129	0.046	0.32
	TV	1	0.003	0.955	0.000	0.05
	CLB	1	0.433	0.514	0.009	0.09
	SELP	1	0.488	0.488	0.010	0.10
	TA	1	0.506	0.506	0.010	0.10

As seen from Table 5.36, concerning treatment, the univariate ANOVAs for the dependent variable of intrinsic goal orientation was significant ($p < 0.05$). In other words, there was a statistically significant mean difference between EG and CG in terms of students' intrinsic goal orientation. When the means of groups on intrinsic goal orientation were checked in Table 5.32, EG students had higher scores than CG students. Mean scores of EG and CG students on IGO were 20.88 and 17.40, respectively.

As a summary, the results showed that cooperative learning based on conceptual change conditions improved students' intrinsic goal orientation in ordinary state school and self-efficacy for learning and performance in Anatolian high school. Therefore, when post-MSLQ scores of participants from both schools were analyzed together, it was found that cooperative learning based on conceptual change conditions improved students' intrinsic goal orientation and self-efficacy for learning and performance.

5.3 Students' Misconception on Reaction Rate Concept

As stated before, RRCT was administered to both EG and CG students before and after the instruction. It was prepared to identify several misconceptions related to reaction rate concept including: (1) rate of chemical reactions (2) activation energy (3) heat of reaction (4) reaction mechanisms (5) rate equations (6) factors affecting reaction rate (concentration, temperature, catalyst, surface area). Cooperative learning based on conceptual change conditions resulted in better results in terms of students' motivation to chemistry lesson and coping with students' misconceptions about reaction rate compared to the traditional instruction. Students' misconceptions included in RRCT were given in Chapter 4, Table 4.2. In the following sections, those misconceptions were investigated in detail by analyzing their answers to RRCT and by interviews.

5.3.1 Analysis of Students' Responses to RRCT

There was a difference in responses between the experimental and control group students to the items in RRCT. Items 1, 2, 5, 9, 12, 14, 17, 18, 21, 22 where the most striking differences were observed between groups in their misconceptions, were selected to discuss in this section. Means of correct responses to each question in the pos-RRCT for EG and CG are given in Figure 5.1.

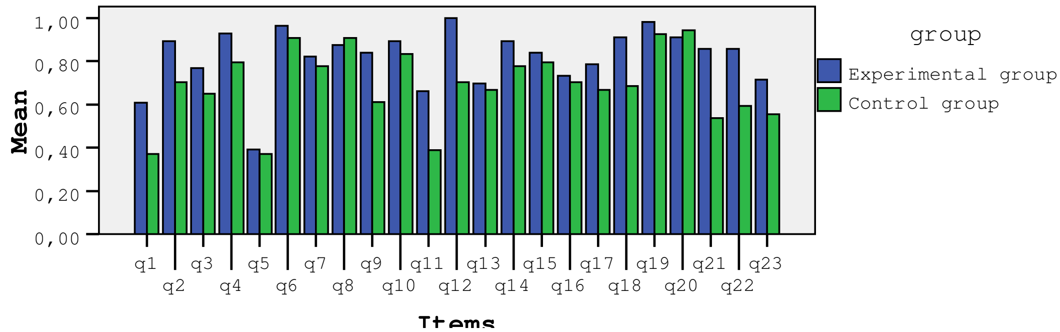


Figure 5.1 Mean of Correct Responses versus Post-RRCT Items for EG and CG

Item 1 was prepared to measure students' misconceptions about what reaction rate is. 60.7 % of EG students answered both part of this question correctly whereas 37 % of CG students answered this item correctly by stating that reaction rate is the change in the concentrations of reactants per unit time at constant temperature. The most common misconception in both EG (32.1 %) and CG (53.7 %) was that *reaction rate is the amount of substance turning into products per unit time at constant temperature and concentration* which was also revealed by Nakiboğlu et al. (2002). They overlooked the fact that the concentration of reactants can not be constant during a reaction. Although this misconception was discussed within cooperative groups in EG, it could not be removed completely. Anyhow, number of students in EG having this misconception was much less than the ones in CG. Moreover, students had another misconception which was *reaction rate is the time required for reactants to form products* though its frequency was low. Percentage of this misconception in EG was 3.6 % and in CG was 7.4 %. The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 1 are given in Table 5.37.

Table 5.37 Percentages of Students' Selection of Alternatives for Item1

Rate of a chemical reaction is calculated by measuring the amount of substance consumed or produced per unit time.	Percentage of students' responses (%)	
***(I)** TRUE **(II)** FALSE **Reason**	EG	CG
*A) Reaction rate is the change in the concentrations of reactants per unit time at constant temperature	64.3	37.0
B) Reaction rate is the time required for reactants to form products.	3.6	7.4
C) Rate of forward reaction is always equal to rate of reverse reaction.	0	1.9
D) Reaction rate is the amount of substance turning into products per unit time at constant temperature and concentration. * Correct Alternative	32.1	53.7

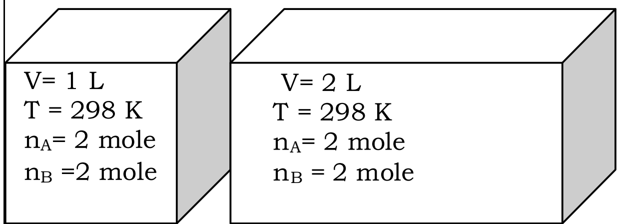
In item 2, students were asked how a zero-order reaction rate changes over time. 91.1 % of EG students answered both part of this question correctly whereas 70.4 % of CG students answered this item correctly by stating that rate of this reaction is constant since it does not depend on number of molecules of A. Before instruction, 11.3 % of EG students and 14.8 % of CG students associated the change in zero-order reaction rate with the change in the amount of products during reaction. After instruction, no student in EG had this misconception while 5.6 % of CG students had it. The students in CG were confused the reaction rate with the amount of product as also stated in the study of Çakmakçı (2005). In addition, percentage of students who gave the statement that *collision frequency of molecules decreases since the number of A molecules decreases with time for a zero-order reaction* as reason for the answer of the first part of the question was 24.1 % in CG and 8.9 % in EG. In fact, the students overgeneralized that rate of reactions always decreases as the reaction proceeds without considering the order of the reaction as supported by Çakmakçı (2005). The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 2 are given in Table 5.38.

Table 5.38 Percentages of Students' Selection of Alternatives for Item2

A $\rightarrow$ B + C **The rate equation of the reaction above is found experimentally as V = k [A]^0 = k According to this equation, rate of this reaction;**	Percentage of students' responses (%)	
(I) increases **(II)** decreases ***(III)** is constant **as the reaction proceeds.** **Reason**	EG	CG
A) Collision frequency of molecules decreases since the number of A molecules decreases with time.	8.9	24.1
B) Amount of products (number of B and C molecules) increases over time.	0	5.6
C) Interaction between molecules increases as the reaction proceeds.	0	0
*D) Rate of this reaction does not depend on the number of A molecules * Correct Alternative	91.1	70.4

Item 5 aimed to investigate whether the students are aware of the fact that the rate of reaction depends on the volume. This question is problematic for both groups because 39.3 % of EG students and 37 % of CG students answered both part of this item correctly by selecting related alternatives stating "the rate of the reaction in the first condition is greater than that of second condition since the concentration of reactants are greater in the first vessel than in the second vessel". As understood from the percentages, more than half of the students in both groups gave incorrect answers. In fact, in this question, students were expected to conclude that effect of volume is related to its effect on concentration of reactants. However, in both groups, students associated volume of the container with the kinetic energy of the molecules. Actually, 60.7 % of EG students and 51.9 % of CG students selected the alternative C which states that *although the number of reactant molecules is the same for both conditions, the kinetic energy of molecules in the first vessel is greater since the volume of the vessel is smaller* as the reason of higher reaction rate in the first vessel. They might think that as the volume of molecules decreases, the particles move at higher speeds since they more frequently collide with each other. In addition, no student in EG and 3.7 % of students in CG selected the alternative which states that *rate of reaction does not depend on volume; rate of reactions for both conditions are the same since the initial amounts of reactants and the temperatures are the same.* It can be concluded that, students in EG and majority of students in CG knew that rate of reaction depends on volume as opposed to the results of Çakmakçı (2005). However, students in both groups had difficulty in understanding the effect of volume on reaction rate even after the treatment. The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 5 are given in Table 5.39.

Table 5.39 Percentages of Students' Selection of Alternatives for Item5

	Percentage of students' responses (%)	
1. Condition 2. Condition **The reaction of A(g) + B(g) → C(g) + D(g) is performed in both vessels given above with the given amounts, volume and temperature. The rate of reaction in 1. Condition is greater than the rate of reaction in 2. Condition.** ***(I)** TRUE **(II)** FALSE **Reason**	EG	CG
*A) Concentration of reactants in 1. Condition is greater than the concentration of reactants in 2. Condition.	39.3	38.9
B) Rate of reaction does not depend on volume; rate of reactions for both conditions are the same since the initial amaounts of reactatns and the temperatures are the same.	0	3.7
C) Although the number of reactant molecules is the same for both conditions, the kinetic energy of molecules in the first vessel is greater since the volume of the vessel is smaller.	60.7	51.9
D) The particles in 2. Condition move more easily and probability of effective collision increases. * Correct Alternative	0	5.6

Item 9 was prepared to measure students' understanding related to effect of surface area on reaction rate. Before instruction, 80.4 % of EG students and 75.5 % of CG students gave correct answer for the first part indicating that most of them knew the effect of surface area on reaction rate. On the other hand, 14.3 % of EG students and 18.9 % of CG students selected the third alternative of the first part before instruction, which states that “rate of reactions in both containers are the same”. After the instruction, no student in EG selected this alternative though 5.6 % of CG students selected that alternative. This indicates that, some of the students in CG still had the misconception that *surface area of reactants does not affect reaction rate.* Similarly, 5.4 % of EG students and 5.7 % of CG students selected the first alternative of the first part before instruction, which states that “rate of reaction in first container is greater”. After the instruction, no student in EG selected this alternative though 5.6 % (almost the same with the percentage before instruction) of CG students did. Altough the surface area of reactants in the first container is less than the second one, students thought that rate of reaction in first container is greater. This may be because of the fact that students thought the surface area of solid MgO is greater than that of powdered MgO. Based on the percentages, it can be concluded that this misconception could not be removed in CG after the instruction. Although all of the students in EG (100 %) selected the correct alternative for the first part, which indicates that they could interpreted the effect of surface area of reactants on reaction rate by examining two conditions, 83.9 % of students in EG could gave the correct reason of their answers in the first part by stating that “since the surface area of MgO(s) is greater in second container, number of collisions and effective collisions of reactants increase”. 16.1 % of them stated that “since the molecules of solid MgO (s) are more strongly bonded than those of powdered MgO (s), they react hardly compared to the powdered one”. Moreover, 31.5 % of students in CG gave the same reason for their answers in the first part. This means that, 31.5 % of CG students had the misconception that *since the molecules of solid MgO (s) are more strongly bonded than* *those of powdered MgO (s), they react hardly compared to the powdered one* after the instruction. 61.1 % of students in CG answered both part of the question correctly. The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 9 are given in Table 5.40.

Table 5.40 Percentages of Students' Selection of Alternatives for Item9

<table>
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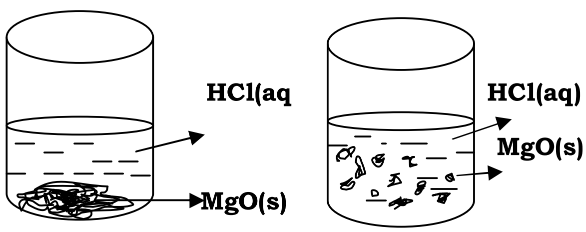
<td rowspan="2">

I   II
100 ml HCl(aq)   100 ml HCl(aq)
10 gr solid MgO(s)   10 gr powdered MgO(s)

There are two identical reaction vessels containing 100 ml of HCl (aq) in each. 10 g of solid MgO(s) is added to the first vessel and 10 gr of powdered MgO(s) is added to the second one, and the reaction below is performed:

$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O\ (l)$
Based on the the information given above:

(I) The reaction in the first vessel occurs faster than the second one.
*(II) The reaction in the second vessel occurs faster than the first one.
(III) Rates of bothe reactions are equal.

Reason</td>
<td colspan="2">Percentage of students' responses (%)</td>
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<tr>
<td>EG</td>
<td>CG</td>
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Table 5.40 (Contunied)

*A) Since the surface area of MgO(s) in second container is greater than the first one, number of collisions and effective collisions of reactants increase.	83.9	63
B) Rates of reactions in both containers are equal since the amount of reactants and the volumes are equal.	0	3.7
C) Since surface area does not affect reaction rate, rates of reactions in both containers are equal.	0	1.9
D) Since the molecules of solid MgO (s) are more strongly bonded than those of powdered MgO (s), they react hardly compared to the powdered one * Correct Alternative	16.1	31.5

Item 12 was related to the effect of temperature and volume on reaction rate. Students were expected to compare the rates of reactions at different temperatures and volumes. While 64.3 % of students in EG gave correct answers for both part of this question before instruction, all of them (100 %) answered correctly after instruction. On the other hand, 70 % of CG students gave correct answers to both parts after instruction. 16.7 % of CG students selected the third alternative in the second part, which states that" increase in temperature decreases the activation energy, therefore, fastest reaction is the third one and rates of reactions in first and second vessels are equal since their temperatures are the same". According to this result, students in CG had the misconception that *increasing temperature decreases the activation energy of the reaction.* Furthermore, 7.4 % of CG students selected the first alternative in the second part, which indicated that these students overlooked the effect of temperature on reaction rate and just considered the effect of volume. The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 12 are given in Table 5.41.

Table 5.41 Percentages of Students' Selection of Alternatives for Item12

$X(g) + 3Y(g) \rightarrow 2Z(g)$ **The reaction given above is performed in three different vessels by using 1 mole of X(g) and 3 moles of Y(g) in each at three different conditions given below:** **(I)** 5 L vessel at 100 ^{0}C **(II)** 10 L vessel at 100 ^{0}C **(III)** 5 L vessel at 200 ^{0}C **Which of the comparisons is correct related to the rate f formation of Z(g)?** ***I)** III > I > II **II)** I = II > III **III)** III > I = II **Reason**	Percentage of students' responses (%) EG	 CG
A) Concentrations of particles in vessel I and III are equal, and particle concentration is less in vessel II, so does the collision frequency. As a result, rates of formation of Z(g) are equal in vessel I and III, and greater than vessel II.	0	7.4
B) When temperature is changed, changing concentration has no effect on reaction rate. Therefore, rate of formation of Z(g) is higest in vessel III in which the temperature is highest and that of Z(g) is equal in vessel I and II.	0	5.6
C) Increase in temperature decreases the activation energy, therefore, fastest reaction is the third one and rates of reactions in first and second vessels are equal since their temperatures are the same.	0	16.7
*D) Increasing temperature increases the kinetic energy and so effective collisions of particles. Incresing concentration increases number of molecules per unit volume and so does collision frequency. However, increasing temperature has more effect on rate than concentration so the ranking will be III > I > II. * Correct Alternative	100	70.4

Item 14 was prepared to measure the students' understanding of effect of catalyst on reaction rate. While 89.3 % of EG students answered both part of the question correctly, 77.8 % of CG students did. All of the students (100 %) in EG stated that "catalyst changes the energy of activated complex" which is the correct answer for the first part while 88.9 % of CG students selected this statement. Furthermore, 9.3 % of students in CG had the misconception that *catalyst changes the yield of reaction* since they selected the first alternative of the first part. They might have this misconception because they might think that catalyst affects forward and reverse reaction rates differently. About the answers given to the second part, 91.1 % of EG students provided the correct reason for their answers in the first part, which denoted that "since catalyst decreases the activation energy, it also changes the energy of activated complex". On the other hand, 79.6 % of CG students gave correct reason for the answer of the first part. 9.3 % of them had the misconception that *energy of activated complex increases because catalyst increases the average speed of molecules.* Correspondingly, in EG, 8.9 % of students had the same misconception. Furthermore, 5.6 % of CG students had the following misconception: *since the catalyst decreases the activation energy of only forward reaction, reaction enthalpy changes according to* $\Delta H = Ea_f - Ea_r$. Similarly, 5.6 % of them had the misconception that *since the catalyst affects forward and reverse reaction rate differently, it chages the yield of products.* The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 14 are given in Table 5.42.

Table 5.42 Percentages of Students' Selection of Alternatives for Item 14

When a catalyst is used in a chemical reaction, which one of the followings changes? **(I)** Yield of reaction **(II)** Enthalpy of reaction ***(III)** Energy of activated complex **Reason**	Percentage of students' responses (%)	
	EG	CG
A) Since the catalyst decreases the activation energy of only forward reaction, reaction enthalpy changes according to $\Delta H = Ea_f - Ea_r$.	0	5.6
B) Since the catalyst affects forward and reverse reaction rate differently, it chages the yield of products.	0	5.6
*C) Since catalyst decreases the activation energy, it also changes the energy of activated complex.	91.1	79.6
D) Energy of activated complex increases because catalyst increase the average speed of molecules. * Correct Alternative	8.9	9.3

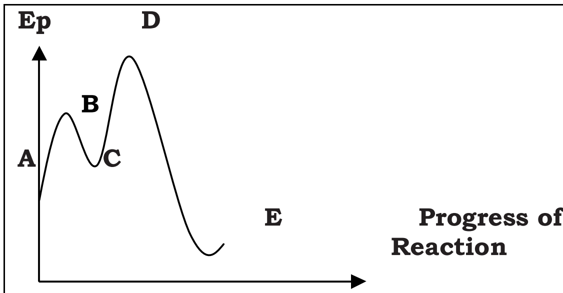
Item 17 was a multiple choice type question and related to how catalyst affects reaction rate like the item 14. Altough percentages of correct answers (58.9 % of EG and 57.4 % of CG) to this item before instruction were almost the same, percentage of students in EG (78.6 %) was greater than that of students in CG (66.7 %) after instruction. It is interesting that while 1.8 % of students in EG had the misconception that *catalyst does not change the mechanism of reaction,* 13 % of CG students had it. In fact, percentage of students in CG with this misconception increased after instruction from 5.6 % to 13 %. A common misconception, c*atalyst does not react with any of the reactants or products*, revealed by some studies (İcik, 2003; Bozkoyun, 2004; Çakmakçı, 2005) was also observed among both experimental and control group students with 8.9 % and 7.4 %, respectively. The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 17 are given in Table 5.43.

Table 5.43 Percentages of Students' Selection of Alternatives for Item 17

Which of the followings is correct related to catalyst?	Percentage of students' responses (%)	
	EG	CG
*A) Catalyst increases both reverse and forward reaction rate because it lowers activation energies of both equally.	78.6	66.7
B) Catalyst facilitates collision of particles by interposing them.	5.4	7.4
C) Catalyst does not chage the mechanism of the reaction.	1.8	13
D) Catalyst does not affect the reaction rate if reactants are in liquid or solid phase.	5.4	5.6
E) Catalyst does not react with any of the reactants or products.	8.9	7.4
* Correct Alternative		

Item 18 aimed to measure students' understanding of energy diagrams of reactions taking place in several steps. They were expected to interpret reaction intermediate, activated complex, heat of reaction and slow step of the reaction on the curve. Bozkoyun (2004) stated that students confused reaction intermediate with catalyst. So this item was prepared to check whether the participants of this study had the same confusion. It was a multiple choice type item. Before instruction, only 30.4 % of students in EG and 24.1 % students in CG answered correctly this question. On the other hand, while 91.1 % of EG students selected correct alternative, only 68.5 % of CG students did selected after instruction. When the percentages of selection of alternatives were examined, it was revealed that 16.7 % of CG students selected the second alternative which satates that "B and D are catalysts". This indicated that students confused activated complex with catalyst on the graph. However, in EG, no student selected this alternative meaning that they could distinguish between activated complex, catalyst, and reaction intermediate. Moreover, since no student in EG selected fourth alternative which was related to the mechanism of the reaction, it can be claimed that all students in EG could decide on the number of steps of the reaction by interpreting the potential energy curve. Furthermore, it was revealed that some students in CG had difficulty in identifying a reaction taking place in more than one step as exothermic or endothermic by examinig the potential enegy curve because 7.4 % of them selected the fourth alternative. The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 18 are given in Table 5.44.

Table 5.44 Percentages of Students' Selection of Alternatives of Item 18

 **Given the plot for the potential energy versus progress of reaction, which of the following is correct?**	Percentage of students' responses (%)	
	EG	CG
A) A → C is the rate determinig step.	5.4	3.7
B) B and D are catalysts.	0	16.7
*C) C is the reaction intermediate.	91.1	68.5
D) $\Delta H > 0$ for the reaction of A → E.	3.6	7.4
E) The reaction takes place in 3 steps.	0	3.7
* Correct Alternative		

Item 21 was prepared to identify students' misconceptions related to activation energy. 85.7 % of EG students answered this item correctly whereas only 53.7 % of CG students did after instruction. Selection of alternative E by 14.3 % of EG students indicated that some students had the following misconception: *Activation energy of exothermic reactions is lower than that of endothermic reactions* which was also found by Çakmakçı (2005). Although this misconception was discussed in cooperative groups, the students still had it. This proves that some misconceptions are persistent. However, when this percentage was compared to the one in CG (35.2 %), it can be concluded that cooperative learning based on conceptual change conditions was effective to remove this misconception. Furthermore, no student in EG had the misconception that *the bigger the activation* *energy, the faster a reaction occurs.* Conversely, 7.4 % of students in CG had this misconception. The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 21 are given in Table 5.45.

Table 5.45 Percentages of Students' Selection of Alternatives for Item 21

Given three statements for activation energy; **I.** The bigger the activation energy, the faster a reaction occurs. **II.** Activation energy of exothermic reactions is lower than that of endothermic reactions. **III.** Number of particles exceeding activation energy increases at high temperature. **Which of the following(s) is/are <u>correct</u>?**	Percentage of students' responses (%)	
	EG	CG
A) Only I	0	7.4
B) I and II	0	1.9
*C) Only III	85.7	53.7
D) I, II and III	0	1.9
E) II and III	14.3	35.2
* Correct Alternative		

Item 22 was related to interpretation of how to change the rate of a reaction taking place in more than one step. According to the results, 85.7 % of EG students and 59.3 % of CG students answered this item correctly. The most common misconception among both groups was that *catalyst increases reaction rate without changing mechanism*. This finding was also supported by Çakmakçı (2005). On the other hand, there were more students having this misconception in CG (27.8 %) than in EG (10.7%). In addition, some students in CG

(5.6%) stated that *decreasing temperature increases the reaction rate without changing mechanism* and some of them (5.6 %) denoted that *decreasing pressure increases the reaction rate without changing mechanism.* The percentages of experimental and control group students' selection of alternatives in the post-RRCT for item 22 are given in Table 5.46.

Table 5.46 Percentages of Students' Selection of Alternatives for Item 22

The mechanism for the reaction $X_2 (g) + Y_3 (g) \rightarrow X_2Y_3 (g)$ is given below: $Y_3(g) \rightarrow Y_2(g) + Y (g)$ (Slow) $X_2 (g) + Y_2 (g) \rightarrow X_2Y_2(g)$ (Fast) $X_2Y_2(g) + Y(g) \rightarrow X_2Y_3(g)$ (Fast) **Which of the following increases the rate of this reaction <u>without changing its mechanism</u>?**	Percentage of students' responses (%)	
	EG	CG
A) Adding X_2 to the medium	0	1.9
*B) Adding Y_2 to the medium	85.7	59.3
C) Decreasing temperature	1.8	5.6
D) Decreasing pressure	1.8	5.6
E) Adding a catalyst to the medium	10.7	27.8
* Correct Alternative		

To conclude, the above findings indicated that the number of students who removed their misconceptions related to rate of reaction in EG was greater than the number of students in CG after instruction. Therefore, it can be claimed that cooperative learning based on conceptual change conditions was efficient to deal with students' misconceptions about reaction rate concepts and it resulted in a significantly better understanding of reaction rate concepts than traditional instruction for all participants in this study. However, when Figure 5.1 was examined, it could be seen that the differences between scores of students in EG and CG on the items of 3, 4, 6, 7, 8, 10, 13, 15, 19, 20 were not so great. This indicates the resistance of misconceptions despite the instruction.

The percentages of experimental and control group students' correct responses to each question in post-RRCT are presented in Appendix J.

5.3.2 Interviews

In this study, interviews were conducted with twelve 11th grade students from both experimental and control group. The purpose of interviews was to obtain detailed information about students' reasoning of reaction rate concepts. Six students from experimental group and six students from control group were selected depending on their scores of post-RRCT. Specifically, two high achievers, two middle achievers and low achievers were selected from each group for the interviews. Interview questions were prepared based on students' responses given to post-RRTC. Students 1 to 6 were from experimental group and students 7 to 12 were from control group. Selected examples of excerpts from interviews are given below:

Students' Ideas about Reaction Rate

Interviewer: In the first part of the first question of RRCT, it is stated that "rate of a reaction is calculated by measuring amount of substance consumed or produced per unit time". What do you think? Is it correct or not?

Student 2: It is correct.

Student 4: It is correct.

Student 5: Correct.

Student 11: Correct.

Student 12: Correct.

Interviewer: You selected the statement that "reaction rate is the amount of substance turning into products per unit time at constant temperature and concentration"as the reason of your answer in the first part for the first item. Why at constant concentration?

Student 4: Because we write the rate law according to the concentrations.

Student 5: I think, it means that the rate depends only on the concentrations of reactants... Umm.. On the other hand, the concentrations of reactants cannot be constant during the reaction.. I must have selected the wrong reason..

Interviewer: You selected the statement that "forward reaction rate always equals to the reverse reaction rate"as the reason of your answer in the first part of first question on RRCT. Can you explain more?

Student 12: They are equal because forward reaction rate + reverse reaction rate = ΔH.

Interviewer: Can I say that reaction rate is the time necessary for a reaction to be completed?

Student 12: Yes, you can.. Correct.

Interviewer: Can you define reaction rate?

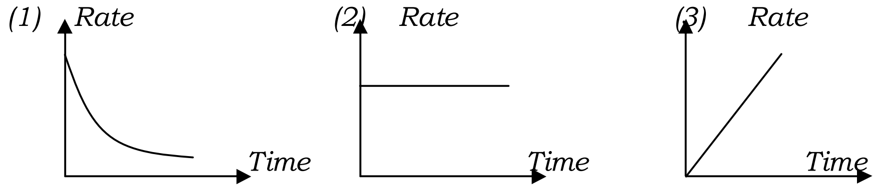
Student 2: I know but, I can't make a sentence... Reaction of reactants or formation of products in a unit period of time..

As understood from the answers, although most of the students knew that rate of a reaction is calculated by measuring amount of substance consumed or produced per unit time they still had some misconceptions concerning what reaction rate is. When they were asked to give detail, they had difficulty in making sentence because they were not used to making interpretations; instead, they were expected to solve algorithmic problems or select from alternatives. Students in both experimental and control group did not have an accurate definition of reaction rate in their minds. Following misconception was detected in a student of control group (Student 12): *forward reaction rate + reverse reaction rate = ΔH.* Furthermore, the same student had the misconception that r*eaction rate is the time necessary for a reaction to be completed* which was also identified by Kousathana andTsaparlis, (2002); Nakiboğlu, et al., (2002); İcik (2003) and Çakmakçı (2005).

Change of Reaction Rate with Time

Interviewer: Look at the question 16 of RRCT.

$A(g) + B(k) \rightarrow C(g)$
Select the curve of Reaction Rate versus Time for the reaction above, which occurs in one step? Explain why.



Student 1: The first one because concentration of A decreases and amount of products increases with time therefore the rate of the reaction will decreases.

Student 4: The first one because the amount of reactants decrases with time.

Student 5: The first one because reactants turn into products and the concentration decrases. As a result, the rate decreases.

Student 6: The first one because A is a reactant and continuosly produces the products. Therefore, the concentration of it decreases with time so does the rate.

Student 7: Third one because the rate of the reaction increases at the beginning of the reaction. When reactants are consumed, the reaction rate drops, and at the end of the reaction, the rate becomes zero… if this reaction was an equilibrium reaction, the rate will be zero at the end.

Student 8: The first one. The rate of the reaction decreases with time because A is consumed and so the amount of it decreases.

Student 11: The third one.. The rate of the reaction increases with time because the amount of products increases.

Student 12: The third one. The rate increases at the beginning, and then decreases while the reaction reaches equilibrium and becomes zero when the reaction is at equilibrium.

The interviews with the students showed that most of the experimental group students understood how rate of reaction changes with time depending on the concentrations of reactants and they could be able to interpret what they knew on the related graph. On the other hand, students in control group had great difficulty in understanding change of rate with time and they had also problems with interpretations of related graph. They confused the rate of one-way reaction with the rate of equilibrium reactions during the reaction proceeds. Student 7 and Student 12 had the misconception that *the rate of the reaction increases at the beginning of the reaction; when reactants are consumed, the reaction rate drops, and at the end of the reaction, the rate becomes zero*, which was also found out by Çakmakçı (2005). In addition, some of them stated that *the rate of the reaction increases with time because the amount of products increases* as also supported by the study of Garnett et al., (1995) and Çakmakçı (2005). Similarly, some students from control group (Student 7 and Student 12) had the following misconception: *rate of a reaction is zero when it is at equilibrium.*

Zero-order Reactions

Interviewer: For the second question of RRCT:

$A \rightarrow B + C$

The rate equation of the reaction above is found experimentally as $V = k\,[A]^0 = k$ *According to this equation, how does the rate of this reaction changes with time?*

Student 1: The rate of the reaction stays constant during the reaction.

Student 5: The rate is constant during the reaction.

Student 7: The rate which is equal to k is constant during the reaction.

Student 11: The rate increases during the reaction because the kind of products increases.

Interviewer: If the rate law was first order, how would the rate change during reaction?

Student 11: It would stay constant.

Interviewer: What is the meaning of first order reaction?

Student 11: That means the reaction occurs in one step.

Interviewer: What does the rate depends on here?

Student 5: Concentration, but it only depends on k constant here.

Interviewer: What does k depends on?

Student 7: Temperature, concentration and volume of the reactants.

Interviewer: Why is the rate constant during the reaction?

Student 1: A must be a solid or a liquid so it is not written in the rate equation. The rate of the reaction does not depend on the number of A molecules.

Student 5: Rate of this reaction does not depend on the number of A molecules whether it is in gas or solid phase.

Student 7: I think A must be a solid because its exponent is zero in the rate equation. Normally, the exponent of A would be one, but since it is zero, it must be a solid. We only take the gases not the solids to calculate the rate.

Interviewer: The net reaction equation is given in the question. We don't know the mechanism of the reaction or how it proceeds. So based on your answer (student 7), if A was a gas, the rate law would be like $V = k[A]$.

Student 7: Exactly..

Interviewer: Why are solids not written on the rate law equation?

Student 7: Because, they are not gases.

Interviewer: Why are gases written on the rate law equation?

Student 7: If we heat a gas, the rate will increase but if we heat a solid, the rate will not affected. However, if a solid and a gas were together, the rate would change.

The dialogues related to zero-order reactions indicated that students in experimental group had better understanding of zero-order reactions than the students in control group did. Experimental group students learned that rate of a zero-order reaction does not depend on the concentrations of reactants independent of their phases. On the other hand, during the interview, a student from control group (Student 11) claimed that *rate of a zero-order reaction increases with time if the "kinds" of products increase.* Another student (Student 7) claimed that *if the reactants of a zero-order reaction were in gas phase, they would be written in the rate equation.* She also had the misconception that *if a gaseous reaction is heated, the rate of the reaction will increase, however, if reactants which are in solid phase are heated, the reaction rate will remain constant during the reaction.* Another misconception revealed by this interview was *rate constant (k) depends on temperature, concentration, and volume of the reactants.*

Activation Energy

Interviewer: Related to the third question in RRCT:

I. $K(g) + L(g) \rightarrow M(g)$ $\quad$ $Ea = 98\ kj$, $\Delta H > 0$
II. $N(g) + P(g) \rightarrow R(g)$ $\quad$ $Ea = 360\ kj$, $\Delta H < 0$
Compare the rates of the reactions above. Explain your answer.

Student 2: First reaction is faster than the second one because there is no substance difference.. I mean, all reactants are in gas phase. There is no solid.

Interviewer: What if one of the reactants was solid?

Student 2: Then we would check ΔH *values. We can say that endothermic reactions proceed and end faster than exothermic reactions do.*

Student 3: The reaction with lower activation energy occurs faster. Therefore, the first one is faster.

Student 4: Second one is faster because it is exothermic. Exothermic reactions are faster than endothermic reactions because exothermic reactions occur spontaneously.

Student 5: The first one is faster. Activation energy is the minimum energy required for a reaction to reach activated complex therefore, the lower the activation energy, the faster the reaction.

Student 6: First one is faster than the second one. I decided based on the activation energies. When the activation energy is lower, number of particles exceeding it will be higher and so the reaction will be faster.

Student 9: First one is faster because the activation energy of it is lower.

Student 10: The first one is faster but I don't know why.

Student 12: The first one is faster than the second one because the activation energy is lower… I don't know how the activation energy affects the rate..

Interviewer: Do ΔH values provide any information related to the rate of the reaction?

Student 5: No.

Student 6: They have no effect on the rates.

Student 9: Yes, but I don't know how.

Interviewer: Can I say that endothermic reactions are faster than exothermic ones or vice versa?

Student 5: No, we cannot make this overgeneralization.

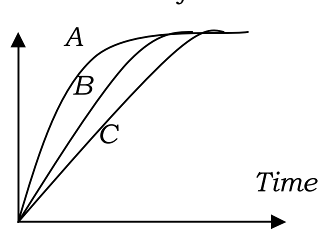
Student 10: Yes, exothermic reactions are faster than endothermic reactions because they evolve heat.

The answers indicated that students in both groups learned that lower the activation energy is, faster the reaction occurs. However, most of students in control group did not know the reason. Moreover, it was observed that students in both groups were confused with ΔH values to decide on the reaction rate although the number of students confused in control group was higher. Some students stated that *endothermic reactions are faster than exothermic ones because they are spontenaous* as opposed to Çakmakçı (2005). Some of them also claimed that *exothermic reactions are faster than endothermic reactions because they evolve heat* as supported by Çakmakçı (2005).

Effect of Concentration on Reaction Rate

Interviewer: Consider the 13th item of RRCT:

Concentration of Gas Produced



Some amount of $CaCO_3$ reacts in three containers (A, B, C) with HCl in different concentrations. The amount of gas evolved per unit time is recorded and a curve above is obtained. Which is the fastest reaction? Explain your answer.

Student 1: A is the fastest reaction because when I look at the concentrations of gases produced in the same time interval on the curve, A has the greatest one.

Student 2: A is the fastest reaction because the end point of it is earlier. A is finished earlier than the others.

Student 7: A is the fastest one because amount of gas produced is highest.

Student 8: C is the fastest one because curve of C increases linearly with time and other curves increase slower with time.

Interviewer: So?

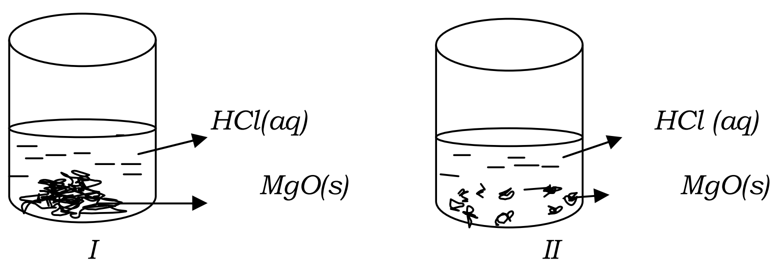
Student 8: Amount of gas produced by C per unit time is highest; therefore concentration of acid used is highest. Reaction rate increases with increasing concentration.

Student 9: A is the fastest one because the amount of gas produced in A is highest at the end of the reaction

As understood from the answers, students in experimental group could interpret a curve related to the effect of concentration on reaction rate. They could conclude that the reaction in which the biggest amount of product formed per unit time is the fastest one. On the other hand, control group students had great problems with interpreting the curve. Most of them deduced that *faster reaction produces more products.* When they were asked the effect of concentration on reaction rate, they could easily answer the question. However, they could not make interpretations on a curve by using this information. This indicated that they just memorized the fact instead of learning them meaningfully.

Effect of Surface Area on Reaction Rate

Interviewer: Look at the question nine on RRCT:



100 ml HCl(aq) *100 ml HCl(aq)*

10 gr a big piece of MgO(s) *10 gr powederd MgO(s)*

There are two identical reaction vessels containing 100 ml of HCl (aq) in each. 10 g of big piece MgO(s) is added to the first vessel and 10 gr of powdered MgO(s) is added to the second one, and the reaction below is performed:

$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O\ (l)$

Compare the rates of reactions in two conditions. Explain your answer.

Student 4: Second reaction is faster because the surface area of the reactant MgO(s) is greater. When the surface area increases, number of particles colliding with each other increases.

Student 5: Second reaction is faster. When we increase the surface area, particles collide more and the reaction occurs faster. Number of collisions increases.

Student 7: Second reaction is faster. I compared this question with melting of sugar in tea..The two events are the same. Powedered sugar melts faster than the cube one in tea… Surface area of the powdered MgO(s) is greater.

Interviewer: Why does increasing surface area increase reaction rate?

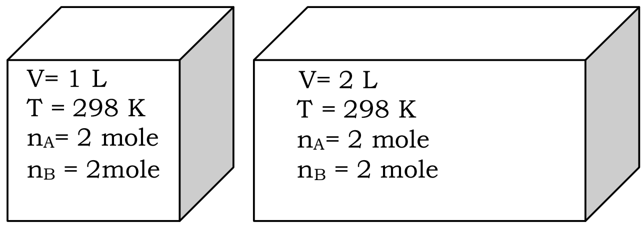
Student 7: I don't know why.. I just know that it increases..

Student 11: Second one is faster. Since the crumbled substances reacts faster, reaction rate increases. Crumbled substances move faster..

The interviews related to the effect of surface area on reaction rate showed that students in experimental group had better understanding. They comprehended that increasing surface area increases the number of collisions so the reaction rate increases by interpreting on the visual representations of the reaction vessels. Conversely, control group students had some misconceptions related to the effect of surface area. For example, one student stated that *powedered sugar melts faster than the cube one in tea.* He confused melting with dissolving. He also compared this physical event with a chemical reaction to find out the effect of surface area on reaction rate. Another student had the misconception that *crumbled substances move and so react faster than a big piece of a substance.* As a result, students in control group failed to reason their answers.

Effect of Volume on Reaction Rate

Interviewer: Look at the fifth item of RRCT:



I *II*

The reaction of A(g) + B(g) → C(g) + D(g) is performed in both vessels given above with the given amounts, volume and temperature. Compare the rates of reactions for two conditions. Explain your answer.

Student 1: First reaction is faster than the second one. When the volume is increased, concentration decreases. Therefore, the first one is faster…

Student 3: First reaction is faster than the second one. In a lower volume, particles' frequency of collision increases. As a result, the lower the volume is, the faster the reaction is.

Student 5: Volume and the concentration are inversely proportional. When the volume increases, concentration decreases. When the concentration decreases, rate of reaction decreases. As a result, the reaction with lower volume is faster than the other.

Student 7: Second one is faster than the first one. When the volume increases, frequency of collisions increases.

Student 9: First one is faster because the concentration is higher.

Student 11: Second one is faster than the first one because the volume of it is greater.

Interviwer: How is the kinetic energy of molecules affected from change of volume?

Student 1: If volume decreases, number of collisions and so the kinetic energy of particles inceases.

Student 3: It has no effect on kinetic energy. Kinetic energies of molecules in two conditions cannot be compared by looking at their volumes.

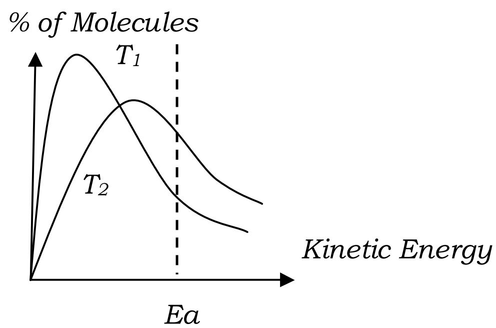
Student 5: Particles in lower volume have greater speed than the ones in higher volume and so they collide more.. In lower volume, particles move faster and they have higher kinetic energy.

Student 9: Smaller the volume, greater the kinetic energies of molecules and so they move faster. As a result, number of effective collisions increases.

As understood from the interviews, experimental group students had better understanding of effect of volume on reaction rate than the students in control group. They could come to the conclusion that change in volume affects the concentration of reactants and so does the reaction rate. The smaller the volume is, the greater the reaction rate is. However, some of them related change in volume with the kinetic energy of molecules (Student 1, Student 5, and Student 9). This revealed a misconception: *If volume decreases, number of collisions and so the kinetic energy of particles incease.* Another misconception by experimental group students was: *Particles in lower volume have greater speed than the ones in higher volume.* Most of the students in control group didn't understand the effect of volume on reaction rate. They provided wrong answers or wrong reasonings for their answers. Similarly, they also made a connection between change in volume and the kinetic energies of the molecules. Therefore, similar misconceptions were also observed in control group students.

Effect of Temperature on Reaction Rate

Interviewer: Consider the tenth question of RRCT:



The curve shows % of Molecules versus Kinetic Energy of Molecules at two diferent temperatures. Based on this curve, compare the temperatures. Explain your answer.

Student 1: T_2 > T_1. The area below the curve after Ea is greater at T_2.

Student 2: T_1 > T_2. The reaction at T_1 is faster than the one at T_2 because the peak point of the curve at T_1 is higher than that of curve at T_2. Moreover, The curve of T_1 ends earlier than that of T_2.

Student 3: $T_2 > T_1$. The area under the curve after Ea is greater at T_2.

Student 6: $T_2 > T_1$. We decide according to the area under the curve after Ea. The area at T_2 is greater than the area at T_1.

Student 7: $T_2 > T_1$. Since the area under the curve at T_2 is greater, T_2 is greater.

Student 11: T_2 is greater. When we look at the area under the curve, it is more at T_2. Therefore, amount of substance reacting is greater at T_2.

Interviewer: What does the area under the curve after Ea mean to you?

Student 1: Amount of products formed at T_2 is greater.

Student 3: It indicates that number of particles exceeding activation energy is greater.

Student 6: This area shows number of particles exceeding activation energy.

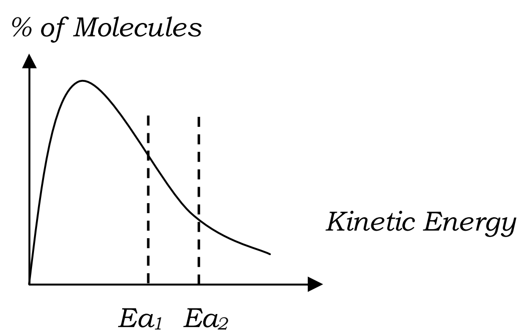
Student 7: Number of particles exceeding activation energy..

Student 11: I don't remember..

The answers indicated that most of the students in experimental group could make correct interpretations on a curve which is related to the effect of temperature on reaction rate. They also could reason their answers. Nevertheless, a student (Student 2) provided incorrect explanations for his answer like *(a) the peak point of the curve at T_1 is higher than that of curve at T_2 (b) The curve of T_1 ends earlier than that of T_2.* This shows that the student decided on the rate and so the temperature by checking the point that the curve ends. He might think that the curve ending earlier shows the faster reaction which is also indicator of higher temperature. Moreover, he was confused with the height of peaks and the number of molecules reacting at different temperatures. Another student in expeirmental group (Student 1) had the misconception that *the higher the temperature is, the more the amount of products formed is*, which was also revealed by the study of Kousathana and Tsaparlis, (2002). On the other hand, experimental group students could reason their answers better than control group students could. As understood, control group students memorized the fact without questionning the reason behind it.

Effect of Catalyst on Reaction Rate

Interviewer: Look at the seventh question of RRCT:



The curve shows the distribution of energies of particles in a reaction and two different activation energies for that reaction. In order to pass from Ea_2 to Ea_1, what could be done? Explain answer.

Student 3: To pass from Ea_2 to Ea_1, which means decreasing the activation energy of the reaction, we should use a catalyst.

Student 6: Passing from Ea_2 to Ea_1 can be done by using a catalyst. Catalyst decreases the activation energy.

Student 11: To decrease the activation energy, catalyst is used.

Intrviewer: How does a catalyst increase the rate of the reaction?

Student 12: Catalyst gives energy to the reaction and so increases the activation energy and the rate of the reaction… Catalyst increases the average speed of molecules.

The interviews indicated that students both in experimental group and control group understood the effect of catalyst on reation rate. They could use their information to interpret the curve related to the effect of the catalyst on reaction rate. However, a student in control group (Student 12) had a misconception that *catalyst gives energy to the reaction and so increases the activation energy and the rate of the reaction* as supported by Çakmakçı (2005). She also stated that *catalyst increases the average speed of molecules* as also identified by Kıngır and Geban, (2006).

Reaction Mechanisms

Interviewer: Consider 15th question of RRCT:

$2Cu^{+2} + 2I^{-} \rightarrow 2Cu^{+} + I_2$ *(fast)*

$Cu^{+} + S_2O_8^{-2} \rightarrow CuSO_4^{+} + SO_4^{-2}$ *(slow)*

$Cu^{+} + CuSO_4^{+} \rightarrow 2Cu^{+2} + SO_4^{-2}$ *(fast)*

Given the mechanism of a reaction, find the reaction intermediate. Explain your answer.

Student 3: $CuSO_4^+$ is the reaction intermediate because it is produced in one step and consumed in the following.

Student 4: $CuSO_4^+$, because it is produced and then consumed during the reaction. So it is not in reactants' or products' side in net chemical equation.

Student 7: $CuSO_4^+$ is the reaction intermediate because it does not exist at the begining but produced later and not written in the net chemical equation.

Student 11: $CuSO_4^+$. Reaction intermediate appears first in products and then the eractants. It must be produced in one reaction and consumed in another.

Interviewer: Why is the reaction intermediate not written in the net equation?

Student 7: Because it exists both in reactants and products and so cancel each other.

Interviewer: What is the difference between reaction intermediate and the catalyst?

Student 4: Catalyst enters the reaction and then comes out. It only speeds up the reaction and does no effect on the formation of reaction.

Interviewer: What do you mean by not affecting the formation of reaction?

Student 4: I mean, it does not change the reaction. The same products would be formed if the catalyst was not used.

Interviewer: Is there a catalyst in the mechanism?

Student 3: Yes, Cu^{+2} *is the catalyst because it is consumed in on step and produced in another.*

Student 7: Yes, Cu^{+2} *is the catalyst.*

Student 11: Yes, Cu^{+2} *is the catalyst.*

As understood from the interviews related to reaction mechanism, students in both experimental and control group could identify reaction intermediate from the reaction mechanism and also they could distinguish between the reaction intermediate and the catalyst, which was also supported by the analysis of post-RRCT scores that was given in Appendix J.

In general, the interviews which were conducted to get deeper information related to the experimental and control group students' understanding of reaction rate indicated that experimental group students performed better in RRCT and they could provide better reasoning for their answers. However, some of the misconceptions could not be removed in both groups after instruction, which supports the idea that misconceptions are persistent and resistant to change (Novak, 1988).

5.4 Students' Opinions about Cooperative Learning

Feedback Form for Cooperative Learning was given to 51 experimental group students after the treatment in order to obtain deeper information about students' thoughts and suggestions on cooperative learning method. The questions in the instrument and selected responses of the students are given below:

Q1. How do you describe Cooperative Learning Model? In your opinion, what characteristics best describe Cooperative Learning?

Student 3: It is a learning model in which everybody in the group can understand the topic by working together and by assistance of friends who know the content better to the ones who are lacking of related content. The most distinctive characteristic is to comprehend the concepts through mutual dialogues.

Student 5: Fun, learning, discussion, transferring our knowledge to each other. It helped us learn our mistakes.

Student 6: It provides opportunity to the students who don't know the content well to be involved in decisions as much as it does to the students who are more knowledgeable.

Student 8: Cooperative Learning Method is a system in which everybody have a discussion with each other and as a result learn the topic substantially. The most distinctive characteristic is that everybody in the group learn the subject completely and interdependently.

Student 9: I think it as learning by helping one another. The most distinctive characteristic is learning cooperatively and in collaboration with each other. Knowledge is continually renewed because everything is done collectively and quizzes are given continuously. Since the students are exposed to remember topics continually, this provides the opportunity of practice and repetition and not to overlook important points.

The aim of the first question was to find out students' views of the cooperative learning. Responses to this question indicated that students specified interdependence, mutual discussions, helping each others' learning and providing everybody with learning the topic completely as key elements of the cooperative learning. Some of them stated that learning in cooperative groups is enjoyable and most of them denoted that high achievers helped others' learning and group activities provided them with practice of what teacher taught. Furthermore, they liked the characteristic that low achievers had opportunity to be closely involved in decisions as much as high achievers.

Q2. Which of these characteristics contributed most to your learning?

Student 3: mutual dialogues and opportunity to be able to ask a friend for explanations of questions that I couldn't understand.

Student 4: discussions of questions together and noticing our mistakes.

Student 9: application of quizzes continually and answering questions cooperatively through discussions.

Student 12: discussions and learning others' perspectives.

Srudent 19: everybody's reflection of his/her ideas, discussing the task completely till everybody is satisfied or persuaded, being enjoyable, improving our speaking, ability of persuasion and expressing ourselves.

Student 20: having right to speak, working in groups cooperatively, and opportunity to participate in the lesson for everbody.

Students' answers to second question revealed that mutual discussions, working cooperatively, opportunity to get help from friends, having right to speak, being able to see from others' perspectives, involving in the lesson more actively, having fun, improving their speaking and persuasion abilities contributed most to their learning.

Q 3: What aspects of Cooperative Learning Model would you definitely change?

Student 1: It is good in this way.

Student 3: All features were good enough so I wouldn't change any of them.

Student 9: Number of questions to be discussed in groups could be increased.Out of this, everything was ok.

Student 10: I wish the teacher intervened in the group works less.

Student 14: The number of students in groups might be less.

Student 41: It would be more efficient if group size was decreased and number of groups was increased.

Student 48: the groups could be quieter.

According to students, they were generally satisfied with cooperative group works. On the other hand, some of them stated that the group size could be decreased, the teacher should have interfered with the groups less, number of group works could be increased. Moreover, some students reflected that the groups could be quieter. This might be because of the fact that they were used to listening the teacher quietly during the lessons so some of them might have found this atmosphere strange.

Q 4: What features of Cooperative Learning Method would you definitely keep?

Student 12: composing homogeneous groups in terms of academic achievement.

Student 14: dealing with students more by teacher, organizing lessons being accord with students' needs and, rewarding.

Student 23: teacher's guidance to the groups by walking around, being able to express ideas by each group member.

Student 30: Learning by discussion.

Student 32: This system does not fit Turkey.

Student 35: Solutions found by group members were more reliable because four students' ideas were taken instead of one. This feature should be kept.

Student 37: tolerance, kindness, and following up each student.

Student39: group works and quizzes.

Student 41: group work, involving everybody in discussions and opportunity to demand help from teacher when no consensus is reached.

The students stated that composing homogeneous groups in terms of academic achievement, learning by discussion, teacher's guidance to the groups by walking around, tolerance in groups, working in groups cooperatively, applications of quizzes, opportunity to get help from teacher when needed, teacher's guidance, and rewards must be definitely kept. One student stated that this method is not suitable for Turkey. He might think so because the students in Turkey are not accustomed to student centered methods; instead, they are always passive listeners and treated by teacher lecturing in the lessons.

Q 5: What problems were faced with during the implementation of Cooperative Learning Method?

Student 5: Sometimes we faced with disagreements on some questions.

Student 7: I didn't face with any problems.

Student 9: It was suitable for me. I didn't face with any difficulties except for time limitation. More time was necessary for some questions.

Student 11: Some of our group members didn't know how to behave in the group.

Student 12: At the begining, we faced with difficulty becase we were not respectful to each other but later, we solved this problem.

Student 18: We had difficulty in deciding on answers of some questions.

Student 22: I had difficulty in making sentences.

Student 33: There was some noise in the classroom.

Most of the students denoted that they didn't face with any problems during the implementation of Cooperative Learning Method. On the other hand, some of them stated following problems: disagreements in group members, time limitations, lack of social skills in some students, making sentences or interpretations and noise in the classroom. This was the first time these students participated in cooperative learning classroom environment. Therefore, they needed to practice social skills necessary for cooperative group work more. In addition, the students were used to solving algorithmic problems, selecting among alternatives instead of making interpretations, expressing themselves and being involved in discussions. For this reason, most of them had difficulty in making sentences, telling their ideas about questions, and expressing themselves during group works. Furthermore, as stated before, they found little noise in the class strange and some of them perceived this as lack of teacher control or discipline.

Q 6: How would you describe the ideal teacher for cooperative learning environment? (Science background, knowledge of group process, level of participation/guidance, etc.)

Student 1: patient, concerned, and providing guidance when necessary.

Student 4: knowledgeable in his/her subject area, being able to teach what he/she knows, patient, and helpful.

Student 12: being able to communicate well with students and teach what he/she knows well.

Student 14: knowledgeable in his/her subject area, being able to respond students' needs and understand students by talking with them.

Student 17: being able to discipline the classroom and motivate students during group works.

Student 27: Authoritative.

Student 36: patient, cheerful, and loving students.

The answers for this question indicated that the students were aware of features of a good facilitator. They stated that the ideal teacher for cooperative learning environment should have good communication skills, be patient, cheerful, authoritative and knowledgeable, as well as consider students' needs. They specify providing discipline or authority in the classroom as an important characteristic of a good teacher. They expect teacher to make students to keep quiet during the lesson. They perceived the noise in the class as a sign of lack in discipline.

Q 7: Do you think that any of skills you acquired in Cooperative Learning Method have made a contribution to you academically or socially? If so, please explain?

Student 3: I learned the points that I had difficulty before and I didn't forget the topics because of continual practice. I improved my dialogues with my friend.

Student 7: I can inerpret the topics of chemistry and I think chemistry course is more enjoyable comared to l ast semester.

Student 9: Sometimes learning from friends instead of teacher was more efficient. I learned most parts of reaction rate concept completely.

Student 13: I actively participated in group works, and I was relaxed. Iit improved my communication skills.

Student 16: It helped me increase my grade.

Student 19: I realized that chemistry could be enjoyable.

Student 28: I gained the skill of being able to see from different perspectives.

Student 30: To be able to discuss, speak and listen to others' ideas.
Student 36: working in groups cooperatively, leading the group, ability to interpret, and sharing.

Generally, most students thought that Cooperative Learning Method contributed them academically and socially. Specifically, it helped them not forget the topics by practice, improve their ability to interpret issues related to chemistry, learn the concept better, increase their grades, improve their social and communication skills with friends, and their ability to view from others' perspectives.

As a summary, students' responses to cooperative learning feedback form indicated that most students noticed the main characteristics of cooperative learning such as, working interdependently in groups, providing every member to learn the material, listening others' ideas, being respectful and democratic, making each member to participate in the group activity. They stated that working in groups cooperatively contributed to improve their social skills, understanding of the concept, ability to view from others' perspectives, ability to interpret the concepts and participate in discussions, express themselves and it also increased their grades. They also found the lesson enjoyable. On the other hand, they sometimes had difficulty in dealing with disagreements and contradictions. They wanted more teacher authorization and discipline because of noise in the classroom. This might be because they were used to listening to the teacher quietly and passively with almost no interaction with their classmates. In addition, they were satisfied with teacher's guidance and help when needed.

5.5 Conclusions

The conclusions drawn from this study are given below:

1. The analysis of pre-RRCT indicated that the students in control and experimental group had similar misconceptions before instruction. That means, there was no significant mean difference between experimental and control group students in terms of their pre-knowledge on reaction rate concept.

2. The analysis of pre-SPST showed that there was a significant difference between experimental and control group students in terms of their science process skills in favor of experimental group students. Therefore, science process skills of students were controlled during the analysis of post-RRCT scores.
3. The analysis of pre-MSLQ revealed that there was no significant difference between experimental and control group students with respect to intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance and test anxiety. That means, students' motivational characteristics were similar in experimental and control group before instruction.
4. Cooperative learning based on conceptual change conditions resulted in significantly better gaining of scientific conceptions about rate of reactions concept and elimination of misconceptions compared to traditionally designed instruction. It remedied most of students' misconceptions in experimental group compared to students in control group.
5. Altough cooperative learning based on conceptual change conditions removed most of students' misconceptions, some of them still existed even after the instruction.
6. Cooperative learning based on conceptual change conditions improved students' understanding of reaction rate in Anatolian high school more than it did in ordinary state high school.
7. Cooperative learning based on conceptual change conditions had no effect on students' perceived extrinsic goal orientation, task value, control of learning beliefs, and test anxiety when mean scores of experimental and control

groups were compared for both schools (Anatolian high school and ordinary state school together).

8. Cooperative learning based on conceptual change conditions improved students' perceived intrinsic goal orientation and self-efficacy for learning and performance when mean scores of experimental and control group students were compared for both schools. That means; students in experimental group participated in chemistry lesson for reasons of challenge, curiosity, and mastery instead of grades and evaluation by others and they had higher expectancy for success, and self-efficacy meaning one's confidence in having the skills necessary to perform a task.
9. Cooperative learning based on conceptual change conditions improved students' perceived intrinsic goal orientation in ordinary state high school and self-efficacy for learning and performance in Anatolian high school.
10. Cooperative learning based on conceptual change conditions contributed to improve students' social skills, their understanding of the concept, ability to view from others' perspectives, ability to interpret the concepts and participate in discussions, express themselves and it also increased their grades. The students taught by cooperative learning based on conceptual change conditions found the lesson more enjoyable.

CHAPTER 6

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

6.1 Discussion

The main purpose of the present study was to investigate the effectiveness of cooperative learning based on conceptual change conditions on 11th grade students' understanding of reaction rate concept and their motivation (intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety).

In this study, as pretests, RRCT, MSLQ, and SPST were administered to both experimental and control group students to determine if any differences existed among groups before the instruction in terms of their pre-knowledge about reaction rate, their existing motivation, and science process skills respectively. Independent-samples t-test results revealed that there was no significant difference between EG and CG in terms of their previous conceptions of reaction rate. On the other hand, there was a significant mean difference among groups with respect to their science process skills. Because the science process skills have great influence on students' understanding of science, it was necessary to control this variable. As a result, it was assigned as a covariate. In addition, MANOVA results indicated that there was no difference between two groups with respect to students' pre-existing motivation (intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety). For the treatment, experimental group students were taught by cooperative learning based on conceptual change conditions and control group students were instructed by traditional method. According to the results, cooperative learning based on conceptual change conditions resulted in significantly better acquisition of knowledge related to reaction rate and elimination of misconceptions than the traditional instruction (EG_{mean} = 18.82; CG_{mean} = 15.87). When the effect of this method on students' conceptual understanding of reaction rate is compared among two different schools (Anatolian high school and ordinary state school), it can be concluded that it improved students' understanding of reaction rate in Anatolian high school more than it did in ordinary state high school because the magnitude of difference between EG and CG in Anatolian high school is larger. This may be because of the fact that, the students in Anatolian high school were brighter than the ones in ordinary state high school because they had higher scores on Anatolian High School Examination. Therefore, it was easier for them to grasp the concepts compared to the students in ordinary state high school. Moreover, the interviews with both experimental and control group students from two schools were conducted in order to get deep information about their conceptions of reaction rate and identify any misconceptions if existed even after the treatment. The analysis of interviews showed that cooperative learning based on conceptual change conditions dealt better with students' misconceptions and removed most of them when compared to the traditional instruction. Effectiveness of cooperative learning was also supported by other studies in the literature (e.g. Felder, 1996; Barbosa et al., 2004; Bilgin & Geban, 2006; Doymus, 2007; Acar & Tarhan, 2008).

On the other hand, the present study revealed that students had several misconceptions related to reaction rate concept even after the cooperative learning instruction based on conceptual change conditions designed to remove these misconceptions. The most frequent and persistent misconceptions which were in consistent with the previous studies (Haim, 1989; Garnett et al., 1995; Nakiboğlu et al., 2002; İcik, 2003; Bozkoyun, 2004; Çakmakçı, 2005; Balcı, 2006; Çakmakçı et al., 2006; Kıngır & Geban, 2006) are as follows:

- Reaction rate is the amount of substance turning into products per unit time at constant temperature and concentration.
- Students overgeneralized that rate of reactions always decreases as the reaction proceeds without considering the order of the reaction.
- Kinetic energy of molecules increases by decreasing volume of the vessel (The students had difficulty in understanding the effect of volume on reaction rate)
- Since the molecules of solid $MgO(s)$ are more strongly bonded than those of powdered $MgO(s)$, they react hardly compared to the powdered one.
- Activation energy of exothermic reactions is lower than that of endothermic reactions.
- Catalyst increases reaction rate without changing mechanism.

In addition to these, based on the interview results, some new ones which are given below were identified in this study:

- Forward reaction rate + reverse reaction rate = ΔH
- Rate of a reaction is zero when it is at equilibrium.
- Rate of a zero-order reaction increases with time if the "kinds" of products increase.
- If the reactant of a zero-order reaction was in gas phase, it would be written in the rate equation.

- If a gaseous reaction is heated, the rate of the reaction will increase, however, if reactants which are in solid phase are heated, the reaction rate will remain constant during the reaction.
- Rate constant (k) depends on temperature, concentration, and volume of the reactants.
- A faster reaction produces more products.
- Crumbled substances move and so react faster than a big piece of a substance.
- Particles in lower volume have greater speed than the ones in higher volume.

These results confirmed that misconceptions are persistent or resistant to change even after the instruction other than a traditional method. If the teacher does not deal with or try to remedy them, they will distort students' further learning. For example, in curriculum, chemical equilibrium chapter comes after reaction rate concept and it is strongly based on reaction rate. In other words, if students don't understand reaction rate completely, their learning of chemical equilibrium will be incomplete. Thus, the teacher should consider these misconceptions while preparing teaching materials for further lessons.

In this study, cooperative learning model was designed based on conceptual change conditions suggested by Posner et el. (1982). Posner et al.'s (1982) instructional theory requires that the learner should be dissatisfied with their existing ideas and the new concept to be taught should be intelligible, plausible, and fruitful. The group activities were prepared by considering students' misconceptions on reaction rate. The worksheets were designed to create *dissatisfaction* in students since they included misconceptions contradicting scientifically accepted knowledge. Moreover, discussions in cooperative groups provided contradiction because the students noticed that their group mates had different ideas or perspectives from their own point of views. In addition to these, the teacher asked some questions to the groups to encourage the discussions and to create contradictions. During the group work, students could ask questions to the teacher related to the points or questions that they didn't understand. After the group activity, each group explained their answers to whole class. During this phase, teacher gave feedback to the groups. After the discussions of whole class, teacher provided reasonable explanations of problematic points to make their minds clear. This was aimed to fulfill *intelligibility* and *plausibility.* Furthermore, some of the questions in worksheets were prepared to make connection between the scientific knowledge and the daily life. Also, the teacher used some additional everyday life examples while presenting the concept before group works and providing support to the groups during group works to meet the *fruitfulness* condition.

Contrary to this strategy which requires the consideration of students' existing knowledge and misconceptions to establish conceptual change, traditional instruction was strongly dependent on teacher coordination without taking students' backgrounds and needs into account. Information was directly transmitted from the teacher to the students instead of permitting students to construct their own knowledge. There was almost no student-student interaction and little student-teacher interaction. Students were not allowed to talk to each other to provide silence and authority in the classroom. They just passively listened to the teacher and copied the blackboard. As a result, traditional instruction didn't promote conceptual change.

Conversely, conceptual change model (Posner et al., 1982) has been criticized because of its deficiency to consider motivational issues. Pintrich et al. (1993) criticized the conceptual change model in terms of its lack of attention to affective, situational, and motivational factors. In fact, although dissatisfaction provides students with an affective reason to change their existing knowledge, Strike and Posner (1992) recommended that it was necessary to deal with "motives and goals and the institutional and social sources of them need to be considered" to improve the model (p. 162). Research studies about conceptual change in the 1980s and early 1990s mainly focused on three areas: (a) the effect of cognitive factors such as students' preknowledge or misconceptions on change, (b) developmental changes in young learners' knowledge representations, and (c) the instructional methods to promote change. Pintrich et al. (1993) named these predominant aspects as "cold conceptual change" because of their concentration on rational and cognitive factors by excluding extrarational or "hot" constructs. Pintrich et al. (1993) stated that "We take the constructivist position that the process of conceptual change is influenced by personal, motivational, social, and historical processes, thereby advocating a hot model of individual conceptual change" (p. 170). In spite of the fact that students may have similar existing knowledge; they may not have the goal of learning the content or motivation to resolve inconsistencies between their knowledge and the new concept. Pintrich et al. (1993) defined the motivational constructs that could affect conceptual change as mastery goals, epistemological beliefs, personal interest, values, importance, self-efficacy, and control beliefs. Moreover, Dole and Sinatra (1998) counted the *social context* as a motivator. For instance, students may engage in an activity which they were disinterested before, if their peers show an interest. The idea that social context could encourage or weaken students' motivation to be involved was supported also by Pintrich et al. (1993) by stating that "classroom contextual factors…can influence students' motivation and cognition and can either facilitate or hinder the potential for conceptual change" (p. 178).

In this study, cooperative learning environment was designed based on conceptual change conditions. Cooperative learning environment was designed to meet the deficit of conceptual change related to motivation. Kutnick (1990) suggested that cooperation in small groups must be in a situation that does not impose constraints on students, such as the authority or specific control of teachers or authoritarian peers. Slavin (1987c) has categorized this kind of work into two major theoretical perspectives: (a) developmental, and (b) motivational. He emphasized the role of group rewards for individual learning in motivating students to provide high-quality help and elaborate explanations to the other group members. The developmental perspective is founded on Piaget's (1926) and Vygotsky's (1978) theories. The basic principle of these theories is that task-focused interaction among students promotes learning by creating cognitive conflicts and by exposing students to higher-quality thinking. Interaction between children around appropriate tasks improves their control of critical concepts and skills. Incentives for group learning efforts are not necessary. On the other hand, motivational perspective emphasizes the importance of rewarding groups to promote individual learning of all group members and favouring active helping of peers. Providing an incentive for group learning efforts is critical to improve the learning outcomes. In the present study, STAD method of cooperative learning, which includes rewarding of high-performed group, was implemented. It was aimed to motivate students to provide their group mates with assistance to improve individual learning of all group members. Correspondingly, the results of this study showed that cooperative learning based on conceptual change conditions improved students' motivation in terms of IGO (intrinsic goal orientation) and SELP (self-efficacy for learning and performance). Specifically, this strategy increased students' IGO in ordinary state high school and SELP in Anatolian high school. This is a proof that students instructed by cooperative learning based on conceptual change conditions participated in chemistry lesson for challenge, curiosity, and mastery instead of grades or evaluation by others. Moreover, these students had higher perception of their ability to perform a task and expectancy for success than the students taught traditionally. Courtney, Courtney & Nicholson (1992) stated that cooperative learning improves low-achieving students' level of achievement and self-esteem. Heterogeneous composition of the groups provides students with the feeling of being empowered as a result of group support and pooling of skills. Also, intrinsic motivation of them is improved since most students think that working together is more enjoyable than working individually. Courtney et al. (1992) also declared that a student's self-efficacy increases through repeated experiences of success of specific tasks. Schunk (1985) claimed that self-efficacy increases when students are provided with feedback of their progress toward mastery. Students focus on the mastery of task instead of relative success or failure in comparison to their group mates in cooperative learning environment (Crooks, 1988). Task mastery is strongly related to self-efficacy and intrinsic motivation (Ames, 1984).

The findings of the present study concerning the improvement in motivation were supported by some research studies. For example, Blaney, Stephan, Rosenfield, Aronson and Sikes (1977, as cited in Sharan, 1980) revealed that students instructed by jigsaw cooperative learning method expressed more self-esteem and liking for school. Moreover, Courtney et al. (1992) examined the effect of cooperative learning on achievement and attitude of teachers attended in a graduate statistics course. The results indicated that cooperative learning improved student motivation, self-efficacy, and sense of social cohesiveness. Reduction in anxiety about the subject matter content was also among the results. In addition, Nicholes (1996) investigated the effects of a cooperative group instruction (Student Teams Achievement Divisions) on student motivation and achievement in a high school geometry class. He found that cooperative learning instruction improved students' geometry achievement, efficacy, intrinsic value of geometry, learning goal orientation and usage of deep processing strategies. Furthermore, Hancock (2004) examined the effects of graduate students' peer orientation on achievement and motivation to learn with cooperative learning strategies in a one-semester educational research methods course. According to the results, students who had high peer orientation were significantly more motivated to learn in the cooperative learning environment than the students who had low peer orientation.

On the other hand, although this study indicated that cooperative learning based on conceptual change conditions improves students' intrinsic goal orientation and self-efficacy for learning and performance, it does not affect extrinsic goal orientation, task value, control of learning beliefs and test anxiety. This can be because of the fact that the implementation period for cooperative learning based on conceptual change conditions was only six weeks. Thus, this limited time may not be enough for participants to be aware of the usefulness or the importance of the task and to develop expectancy for positive outcomes with their efforts instead of teacher or another external factor. Furthermore, since the present study revealed that students participated in chemistry lesson for challenge, curiosity, and mastery instead of grades or evaluation by others, which are signs of extrinsic goal orientation, it can be concluded that cooperative learning based on conceptual change conditions has no effect on extrinsic goal orientation. In addition, students may worry about their performance on exams, which indicates test anxiety because the method was totally new for them and they were administered more tests than their ordinary classroom. In fact, though it was not statistically significant, post-MSLQ scores of experimental group students were higher than that of control group students showing a higher level of test anxiety in the cooperative learning group.

In traditional classrooms, the most common formal extrinsic incentives are grades. However, grades are away from ideal as incentives (Slavin, 1978a, 1986). Feedback and rewards should be given close in time to student performance, on the basis of well-defined behaviours (Brophy, 1981), and frequently (Peckham & Roe, 1977). On the other hand, grades are generally given long after the behaviours they are expected to reinforce and infrequently (every 6-9 weeks). In addition, Slavin (1987b) claimed that grades are given in competitive nature. This creates an atmosphere where students hope their classmates will fail. In this situation, they become usually happy when a classmate gives a wrong answer in class and they want to correct the error. This affects student motivation negatively. The competitive grading system complicates for many students to be successful. After a while, many students perceived that school success is not a route open to them and start to look for other routes to a positive self-image, such as delinquent or antisocial behavior (Weis & Sed-erstrom, 1981). Slavin (1987b) suggested that cooperative standards are more useful to improve student motivation than competitive standards.

This study also revealed that cooperative learning contributed students socially and academically and they liked to learn reaction rate concept through cooperative learning activities. According to students' answers to Feedback Form for Cooperative Learning, they learned how to work cooperatively because they recognized the basic elements of copperative learning by specifying *interdependence, mutual discussions, helping each others' learning and providing everybody with learning the topic completely* as key elements of the cooperative learning.. They found cooperative learning activities as enjoyable. Moreover, they liked the characteristic that low achievers had chance to be closely involved in decisions as much as high achievers. The students declared that mutual discussions, opportunity to get help from friends during the lesson, having right to speak, being able to see from others' views, participating in the lesson more actively, having fun, having chance to practice their speaking and persuasion abilities contributed most to their learning. Also, they were satisfied with the guidance of teacher during the activities. They stated that reward should be definitely kept in cooperative learning activities. This may be evidence for the fact that being rerwarded for success motivated students to achieve their goals. They also reflected that they faced situations resulting in disagreements among group members. This is important for creating dissatisfaction in students' minds and so for meeting one of conceptual change conditions. It was also found by this study that the students really had difficulty in interpreting, reasoning, and discussing the concepts because they were generally expected to solve algorithmic problems or answer multiple choice-type tests rather than essay type exams requiring them to express their ideas and interpretations in the school. Correspondingly, they stated that cooperative learning helped them improve their ability to interpret issues of chemistry and their social and communication skills.

Another finding of the present study was that science process skills of the students explained a significant portion of their conceptual understanding in reaction rate concept. Actually, science process skills accounted for 20 % of variance on dependent variable. For this reason, effect of science process skills of students on their conception of reaction rate cannot be overlooked. In order to understand complicated issues and problems in chemistry, students should be able to apply basic principles, use suitable conceptual and theoretical frameworks, and carry out chemical calculations. Mastery of these performances in chemistry entails a variety of science process skills such as, identifying and defining variables, identifying appropriate hypotheses, interpreting data and designing experiments (Carin & Sund, 1989). That is to say, science process skills of participants should always be considered while investigating their conceptions or achievements in science.

In this study, although cooperative learning based on conceptual change conditions improved students' understanding of reaction rate and motivation, it was observed that implementation of this method in classrooms requires caution. Integrating cooperative learning in science and mathematics classrooms brings about some challenges. Students and teachers have to deal with several problems. Zakaria and Iksan (2007) stated five potential problems related to implementation of cooperative learning strategies in classrooms. First one is *the need to prepare extra materials for class use*. The teachers need to prepare related materials which require a lot of work to be used in group activities and other parts of the class. This entails a burden for them to prepare these extra materials. In fact, for this study, during the meetings of the teachers from different schools in Ankara, some of them abstained from the implementation of cooperative learning in their classes because of this work load. Although the researcher had prepared all the materials needed in the class, teachers were expected to endeavor more than they did in their ordinary classrooms. The teacher was supposed to facilitate groups, make connection between the scientific concept and the daily usage of the theories, answer the questions asked by the groups, provide contradicting questions to the groups in order to encourage the discussions, and evaluate and grade the quizzes given, which are not necessary to be performed in traditional classrooms. Secondly, *fear of the loss of content coverage* is another problem. Implementation of cooperative learning in class requires more time than traditional instruction. Teachers may conclude that it is a waste of time. Actually, they have to catch up with a time schedule for the application of curriculum. However, high schools are increased from three to four year period to relieve the load of curriculum in Turkey. On the other hand, there are common exams which are administered to all classrooms at the same time in a school for each chapter of the program in a semester. These common exams are conducted to provide synchronization among classrooms in terms of content coverage. As a result, teachers have to finish related content until the common exam. This limits their usage of time for lessons. In addition to common exams, "*dersane*" which is a special institution for education intending to support lessons in state schools in Turkey affects the teachers' time usage in their classrooms because they prefer to go with them. In fact, most of the students in high schools attend these institutions. Because of these reasons, during the application of cooperative learning, time limitation was a problem for teachers. In my opinion, "*dersane*"s should follow the state schools, not vice versa because they aim to support the students to be more successful in their lessons. Indeed, if the teaching strategies are improved and moved from teacher-centered to student-centered methods in high schools in Turkey, there will be no need to these special institutions called "*dersane*". Thirdly, Zakaria and Iksan (2007) claimed that *teachers do not trust students in gaining knowledge by themselves.* Teachers think that they must tell the students what and how to learn. Only the teachers have the knowledge and proficiency. Fourthly, *lack of familiarity with cooperative learning methods* is another problem for the implementation of cooperative learning in the classroom. Cooperative learning is new to some teachers so they need time to be familiar with the new method. In the present study, the teachers were informed about the basic principles and implementation of cooperative learning in their classrooms but it would be better for them to try this method in another classroom before the study. In fact, teachers are used to instructing traditionally and not familiar with student-centered methods in Turkey. Although the teachers had some difficulties in applying cooperative learning in their classrooms at the beginning of the study, they learned to deal with problems and achieved to carry out and finish the instruction. They can be good at this method with more practice. As a fifth problem, Zakaria and Iksan (2007) claimed that *students do not have the skills to work in groups.* Teachers often deal with students' participation in group activities. They think that students are deficient in the necessary skills to work in group. Nevertheless, according to Ong and Yeam (2000), teachers should teach the missing skills and reinforce the skills that students need. In this study, some of the groups had difficulty in coping with contradictions and providing democratic environment in their groups at the beginning of the study although the teacher taught necessary skills to work in groups cooperatively before study. However, they learned to deal with these issues with more experience and help of the teacher when needed.

To sum up, contributing to progress of science learning is a sore process. Student-centered methods which provide students with construction of their own knowledge require more efforts than teacher-centered methods. Only presenting a new concept or explaining the learners that their ideas are wrong does not bring about improving the students' understanding of the scientific knowledge as traditional methods do. However, teacher strategies where the students are actively involved in their learning process promote meaningful learning.

6.2 Implications

The results of this study have some important implications which are given below for science teachers, educators, and researchers:

1. Many of students have several misconceptions about reaction rate concept and they distort students' learning seriously. Thus, teachers should consider these misconceptions while designing their teaching strategies. The instructional strategy must be designed so that the learner is convinced that scientific conception is more valuable and useful than the existing misconception. In addition, since teachers are counted among the sources of misconceptions, examination of these misconceptions can be useful for them to identify possible misconceptions they can have.

2. Students' pre-knowledge strongly influences their learning. Misconceptions result from their failure to use prior knowledge in learning situations since the students construct their knowledge by connecting existing knowledge and new information. As a result, teachers should allow time to identify students' prior knowledge.
3. Connection between daily life and scientific concept should be made. This also help link between pre-knowledge and new information.
4. Well prepared materials meeting conceptual change conditions can create dissatisfaction which gives rise to conceptual change and reconstruction. For this reason, teachers should design teaching materials producing contradiction and dissatisfaction in students' minds.
5. Cooperative learning based on conceptual change conditions can be used to remove misconceptions and improve students' understanding of science concepts. Cooperative group works based on conceptual change conditions produce contradiction since students face with different perspectives of their group mates and worksheets for group activities are prepared to activate students' misconceptions. Therefore, cooperative learning based on conceptual change conditions should be integrated into curriculum.
6. Besides to cognitive factors, affective factors should also be taken into account during science instruction. Students' motivation strongly influences their learning. Therefore, teaching methods affecting motiavation to learn positively should be used. In this study, rewarding of the most successful group members was important part of the method, which might be most likely to motivate the

students. Thus, cooperative learning methods including reward should be preferred to increase students' motivation.

7. Teachers should be trained about the implementation of cooperative learning based on conceptual change conditions including basic elements of cooperative learning, formation of groups, preparation of group activities and quizzes, role of the teacher, rewarding process and meeting conceptual change conditions.
8. During the implementation of cooperative learning activities, some unpredicted situations inevitably may arise and should be concerned because student's active involvement and discussions in cooperative groups are basic characteristics of this method. Hence, teachers should figure out effective classroom management strategies in cooperative learning classrooms.
9. Teaching strategies are designed so that the students are expected to explain and discuss their ideas instead of selecting among alternatives.
10. Science process skills of students explain important portion of variance in understanding of science. Therefore, teachers should prepare teaching strategies improving science process skills of the students.

6.3 Recommendations

Based on the result of this study, the researcher recommends that:

1. This study can be conducted at different grade levels and other concepts of chemistry.
2. Number of participants and the type of schools can be increased to increase generalizability.

3. Effect of cooperative learning based on conceptual change conditions on students' understanding of scientific concepts and their motivation can be investigated in other disciplines such as, mathematics or physics.
4. Effect of cooperative learning on students' achievement of reaction rate concept can be examined.
5. Effects of cooperative learning integrated with other constructivist methods on students' understanding of scientific concepts and motivation can be investigated.
6. Teachers' behaviours and ideas related to cooperative learning in a chemistry course can be investigated instead of students.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

Cognitive Domain

1. To define reaction rate.
2. To explain how reaction rate is measured.
3. To distinguish the conditions for successful collision.
4. To explain collision theory.
5. To state activation energy.
6. To relate activation energy with the rate of reaction.
7. To interpret potential energy diagrams.
8. To identify activation energy from potential energy diagram.
9. To identify heat of reaction from potential energy diagram.
10. To predict whether a reaction is exothermic or endothermic from potential energy diagram.
11. To predict rate law for a given reaction mechanism.
12. To predict order of reaction from rate law.
13. To predict rate determining step for a given reaction mechanism.
14. To interpret the reaction mechanism of a reaction on a given potential energy diagram.
15. To name the factors affecting reaction rate.
16. To relate the collision theory and the effect of concentration on reaction rate.
17. To relate the collision theory and the effect of volume on reaction rate.
18. To relate the collision theory and pressure on eraction rate.

19. To relate the collision theory and the effect of temperature on reaction rate.
20. To interpret the graphs related to effect of temperature on reaction rate.
21. To relate the collision theory and the effect of surface area on reaction rate.
22. To explain the effect of catalyst on reaction rate.
23. To interpret the graphs related to the effect of catalyst on reaction rate.

Affective Domain

1. To listen to group mates with respect.
2. To ask questions to group mates.
3. To assist the group mates when necessary.
4. To answer to the questions of group mates.
5. To discusses the given questions on the worksheets with group mates.
6. To invite the group mates to the discussions when they are passive and isolated from the discussion.
7. To report the agreed solution of the problem on worksheets to the whole class.

APPENDIX B

TEPKİME HIZI KAVRAM TESTİ

BÖLÜM 1

Bölüm 1'de tepkime hızıyla ilgili bilginizi ölçen 16 adet soru bulunmaktadır. Her soru *cevaplama bölümü* ve *sebep bölümü* olmak üzere iki bölümden oluşur. Cevaplama bölümünde verilen 2 veya 3 seçenekten birini işaretlemeniz, sebep bölümünde cevabınızın sebebini açıklayan seçeneği işaretlemeniz beklenmektedir. Her soruda iki bölüme de doğru yanıt verdiğiniz takdirde cevabınız doğru kabul edilecektir.

1) Bir tepkimenin hızı birim zamanda harcanan ya da oluşan madde miktarı ölçülerek hesaplanır.

(1) DOĞRU (2) YANLIŞ

Çünkü

A) Tepkime hızı belli sıcaklıkta, birim zamanda girenlerin ya da ürünlerin derişimindeki değişime eşittir.
B) Tepkime hızı girenlerin ürünlere dönüşme süresidir.
C) İleri yöndeki tepkime hızı her zaman geri yöndeki tepkimenin hızına eşittir.
D) Tepkime hızı sabit sıcaklıkta ve derişimde; birim zamanda ürüne dönüşen madde miktarıdır.

2) $A \rightarrow B + C$
Yapılan deneyler sonucunda yukarıdaki tepkimenin hız denklemi HIZ = $k [A]^0 = k$ olarak bulunmuştur. Bu verilere göre tepkime ilerledikçe hızı

(1) Artar (2) Azalır (3) Değişmez

Çünkü

A) Zamanla A molekülleri sayısı azaldığı için çarpışma sıklığı azalır.
B) Zamanla oluşan ürün miktarı (B ve C molekülleri sayısı) artar.
C) Tepkime ilerledikçe moleküller arasındaki etkileşim artar.
D) Tepkimenin hızı A moleküllerinin sayısına bağlı değildir.

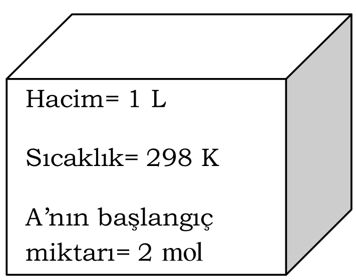
3) I. K(g) + L(g) → M(g) Ea = 98 kj , ΔH > 0
II. N(g) + P(g) → R(g) Ea = 360 kj , ΔH < 0
Yukarıdaki tepkimelerden I.' si II.' sinden daha hızlı gerçekleşir.
(1) DOĞRU (2) YANLIŞ

Çünkü
A) Ekzotermik tepkimeler endotermik tepkimelerden daha hızlıdır.
B) Eşik enerjisi küçük olan tepkimeler daha hızlı gerçekleşir.
C) Tepkime ne kadar hızlıysa o kadar çok enerji açığa çıkar.
D) II. durumda tepkimeye giren moleküllerin kinetik enerjisi daha fazladır.

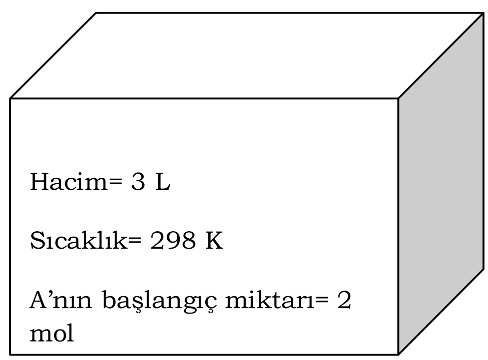
4) A(g) + B(g) → 2C(g) + D(g) ΔH < 0
Yukarıdaki tepkimede sıcaklık arttırılırsa tepkime hızı nasıl değişir?
(1) Artar (2) Azalır (3) Değişmez

Çünkü
A) Ekzotermik tepkimelerde sıcaklık arttıkça ileri yöndeki tepkime hızı azalır.
B) Sıcaklık arttırıldığında taneciklerin kinetik enerjileri ve dolayısıyla etkin çarpışma sayısı hem ileri hem de geri yöndeki tepkime hızı artar.
C) Ekzotermik tepkimler sonucu ısı açığa çıktığından bu tepkimeler devam etmek için enerjiye ihtiyaç duymaz ve dolayısıyla sıcaklık artışı hızı etkilemez.
D) Tepkime hızı sadece hız sabitine ve girenlerin derişimine bağlı olduğu için sıcaklık artışı etkilemez.

5)



I. Durum



II. Durum

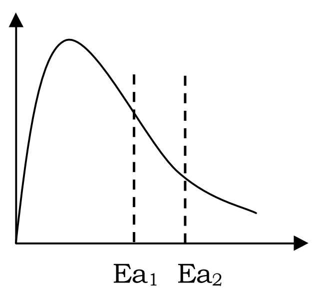
A(g) + B(g) → C(g) + D(g) tepkimesi yukarıdaki gibi iki farklı kapta gerçekleştiriliyor. Verilenlere göre I. durumdaki tepkime II. durumdaki tepkimeden daha hızlı gerçekleşir.
(1) DOĞRU (2) YANLIŞ

Çünkü
A) İlk durumda tepkimeye girenlerin derişimi II. durumdakine kıyasla daha fazladır.
B) Tepkime hızı hacme bağlı değildir; her iki durumda da girenlerin başlangıç miktarları ve sıcaklık aynı olduğu için tepkime hızları eşittir.
C) Tepkimeye giren moleküllerin sayısı her iki durumda da aynı olmasına rağmen 1. durumdaki moleküller daha küçük bir hacimde olduğundan kinetik enerjileri daha fazladır.
D) İkinci durumda tanecikler daha kolay hareket ederler ve etkin çarpışma olasılıkları artar.

6) Bir tepkimede katalizör kullanmak tepkime hızını
(1) Azaltır (2) Arttırır (3) Değiştirmez

Çünkü
A) Katalizör kullanıldığında daha çok madde tepkimeye girer.
B) Katalizör tepkimeye enerji verir ve sonuçta aktivasyon enerjisini arttırır.
C) Katalizör sadece tepkimeyi başlatmak için gereklidir.
D) Katalizör eşik enerjisini düşürerek etkin çarpışma sayısını arttırır.

7) Molekül Kesri



Yandaki şekilde bir tepkimeye ait taneciklerin enerji dağılım eğrisi ve bu tepkimeye ait iki farklı eşik enerjisi gösterilmektedir. Ea_2'den Ea_1'e geçiş için;

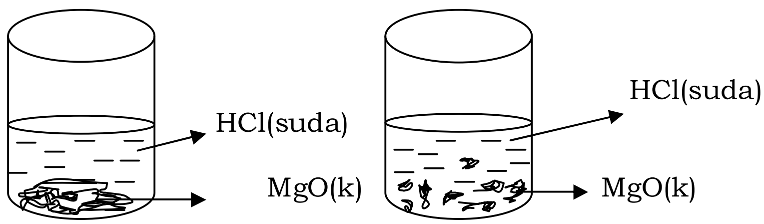
(1) Sıcaklık düşürülmelidir. (2) Katalizör kullanılmalıdır.

Çünkü
A) Sıcaklık düşürüldüğünde eşik enerjisi azalır.
B) Sıcaklık düşürüldüğünde taneciklerin ortalama kinetik enerjisi azalır.
C) Katalizör eklemek taneciklerin ortalama kinetik enerjisini düşürür.
D) Katalizör bir tepkimenin eşik enerjisini düşürür.

8) $A(g) + 2B(g) \rightarrow C(g) + D(g)$ (yavaş)
$2X(g) + C(g) \rightarrow Z(g) + P(g)$ (hızlı)
Mekanizmasına sahip bir tepkimede ortama X(g) eklemek tepkime hızını arttırır.
(1) DOĞRU (2) YANLIŞ

Çünkü
A) Tepkime hızı derişimle doğru orantılı olduğundan derişim arttıkça tepkime hızı artar.
B) Mekanizmalı tepkimelerde hızı belirleyen, yavaş adımdır ve X(g) tepkimenin yavaş adımında bulunmadığı için ortama X(g) eklemek tepkimenin hızını artırmaz.
C) Tepkimeye girenlerin derişimi arttıkça reaksiyonun gerçekleşme süresi artar.
D) Tepkime hızına derişimin etkisi yoktur.

9)



I
100 ml HCl(suda)
10 gr iri bir parça MgO(k)

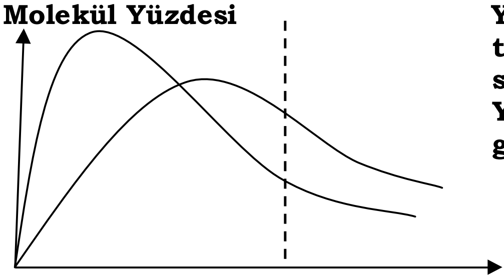
II
100 ml HCl (suda)
10 gr ufalanmış MgO(k)

Şekildeki gibi 2 ayrı özdeş kaba 100'er ml HCl(suda) konuyor. Daha sonra I. kaba 10gr iri bir parça MgO(k), II. kaba 10gr ufalanmış MgO(k) eklenerek
$MgO + 2HCl \rightarrow MgCl_2 + H_2O$ tepkimesi gerçekleştiriliyor. Buna göre

(1) I. kaptaki tepkime daha hızlı gerçekleşir
(2) II. kaptaki tepkime daha hızlı gerçekleşir.
(3) Her iki kaptaki tepkimenin de hızı birbirine eşittir.

Çünkü
A) II. kapta MgO(k)'nun yüzey alanı daha büyük olduğundan tepkimeye girenler arasındaki çarpışma sayısı ve etkin çarpışma sayısı artar.
B) Her iki durum için de maddelerin miktarları ve hacimler eşit olduğundan tepkime hızları eşittir.
C) Temas yüzeyinin tepkime hızına etkisi olmadığı için her iki kaptaki tepkimenin de hızı birbirine eşittir.
D) İri parçalar halindeki MgO(k) molekülleri pudralanmış haline kıyasla birbirine daha kuvvetli bağlıdır ve tepkimeye girmesi daha zordur.

10) Molekül Yüzdesi



Kinetik Enerji

Ea (Eşik Enerjisi)

Yandaki şekilde bir tepkime için T_1 ve T_2 sıcaklıklarındaki "Molekül Yüzdesi-Kinetik Enerji" grafiği verilmiştir.

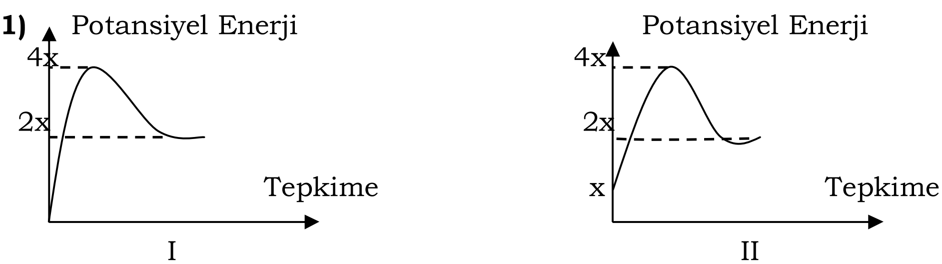
Buna göre;

(1) $T_1 > T_2$ (2) $T_2 > T_1$

Çünkü

A) T_1 sıcaklığında moleküllerin ortalama kinetik enerjisi daha büyüktür.
B) T_2 sıcaklığında Ea değerini aşan molekül sayısı daha fazladır.
C) T_2 sıcaklığında tepkimenin Ea değeri daha büyüktür.
D) T_1 sıcaklığında tepkimenin Ea değeri daha büyüktür.

11)



2 ayrı tepkimenin potansiyel enerji diyagramları veriliyor. Buna göre

(1) Her iki tepkimenin de hızı eşittir.
(2) II. tepkime daha hızlıdır.

Çünkü

A) Her iki tepkimedeki aktifleşmiş komplekslerin enerjileri birbirine eşittir.
B) II. tepkime ekzotermiktir.
C) II. tepkimenin eşik enerjisi daha düşüktür.
D) $\Delta H_1 > \Delta H_2$' dir.

12) . $X(g) + 3Y(g) \rightarrow 2Z(g)$

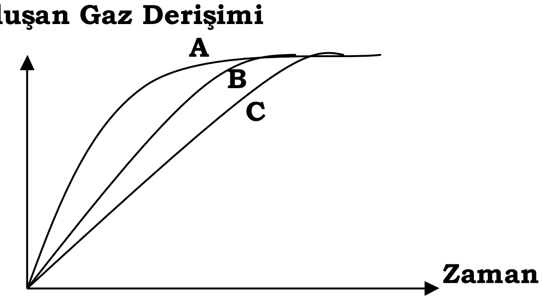
Tepkimesi üç ayrı kapta 1'er mol X(g) ve 3'er mol Y(g) kullanılarak aşağıdaki koşullarda gerçekleştiriliyor.

I. 5 litrelik kapta, 100 °C de
II. 10 litrelik kapta, 100 °C de
III. 5 litrelik kapta 200 °C de

Buna göre, Z'nin kaplardaki ortalama oluşma hızı arasındaki ilişki için hangisi doğrudur?
(1) III > I > II (2) I = III > II (3) III > I = II

Çünkü
A) I . ve III . kaplardaki tanecik derişimleri aynıdır. II . kaptaki tanecik derişimi daha azdır; dolayısıyla çarpışma sayısı da azdır. Sonuçta I . ve III . kaplardaki Z(g) oluşma hızı birbirine eşit ve II . kaptan büyük olacaktır.
B) Sıcaklık söz konusu olduğunda derişimin tepkime hızına etkisi yoktur. Sıcaklığı yüksek III . kaptaki Z(g) oluşum hızı en yüksek olacaktır. I . ve II . kapların sıcaklıkları aynı olduğundan bu kaplardaki Z(g) oluşum hızı aynıdır.
C) Sıcaklık arttığında tepkimenin eşik enerjisi düşer ve hızı artar. Bu durumda en hızlı tepkime III . kapta gerçekleşir. I . ve II . kapların sıcaklıkları aynı olduğundan bu Z(g) oluşum hızı aynıdır.
D) Sıcaklık arttığında taneciklerin kinetik enerjisi artar ve dolayısıyla etkin çarpışma sayısı artar. Derişim arttıkça birim hacimdeki molekül sayısı arttığından çarpışma sayısı artar. Ancak sıcaklıktaki artışın hız üzerine etkisi daha fazla olacağından en hızlı tepkime III . kapta, daha sonra I .'de ve en yavaşı da II . kapta gerçekleşir.

13) Oluşan Gaz Derişimi



Bir miktar $CaCO_3$ ve HCl tepkimeye sokuluyor. Tepkime 3 defa ve her seferinde farklı kuvvette asit kullanılarak gerçekleştiriliyor. Belli bir zaman aralığında açığa çıkan gaz miktarı kaydediliyor ve yukarıdaki gibi bir grafik elde ediliyor. Grafiğe göre en hızlı tepkime
(1) A 'dır (2) B'dir (3) C'dir

Çünkü
A) A tepkimesinde oluşan gaz miktarı en fazladır.
B) A tepkimesinde birim zamanda açığa çıkan gaz miktarı en fazla olduğundan kullanılan asit derişimi de en yüksektir; derişim arttıkça hız artar.
C) B tepkimesinde kullanılan asit miktarı en fazladır.
D) C tepkimesinde birim zamanda açığa çıkan gaz miktarı en fazla olduğundan kullanılan asit derişimi de en yüksektir; derişim arttıkça hız artar.

14) Kimyasal bir tepkimede katalizör kullanılırsa aşağıdakilerden hangisi değişir?
(1) Tepkimenin ürün verimi
(2) Tepkime entalpisi
(3) Aktifleşmiş kompleksin enerjisi

Çünkü
A) Katalizör sadece ileri yöndeki tepkimenin eşik enerjisini düşürdüğünden $\Delta H = Ea_i - Ea_g$ 'ye göre tepkime entalpisi değişir.
B) Katalizör ileri ve geri tepkimenin hızını farklı şekilde etkilediğinden ürün verimini değiştirir.
C) Katalizör tepkimenin eşik enerjisini düşürdüğünden aktifleşmiş kompleksin enerjisini de değiştirmiş olur.
D) Katalizör moleküllerin ortalama hızını arttırdığından aktifleşmiş kompleksin enerjisi artar.

15) $2Cu^{+2} + 2I^{-} \rightarrow 2Cu^{+} + I_2$ **(hızlı)**

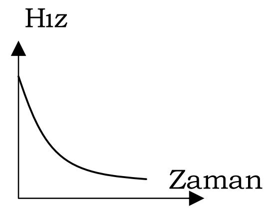
$Cu^{+} + S_2O_8^{-2} \rightarrow CuSO_4^{+} + SO_4^{-2}$ **(yavaş)**

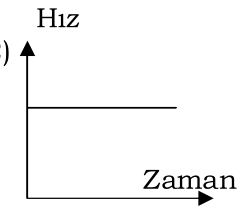
$Cu^{+} + CuSO_4^{+} \rightarrow 2Cu^{+2} + SO_4^{-2}$ **(hızlı)**

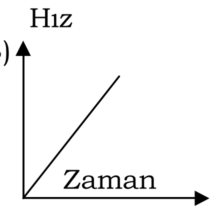
Yukarıda mekanizması verilen tepkimede ara ürün hangisidir?
(1) Cu^{+2} (2) $CuSO_4^{+}$

Çünkü
A) Tepkime sırasında oluşmuş ve tüketilmiştir.
B) Tepkime sonunda hiçbir değişikliğe uğramadan yeniden oluşmuştur.
C) Hızı belirleyen adımda oluşan bir üründür.
D) Hız denkleminde yer almaz.

16) A(g) + B(k) $\rightarrow$ C(g)
Tek adımda gerçekleşen yukarıdaki tepkime için A(g) 'nın derişiminin zamanla değişimine göre Hız – Zaman grafiği aşağıdakilerden hangisi gibi olur?

(1)


(2)


(3)


Çünkü
A) Belli etmenler (derişim, sıcaklık, katalizör, vb..) değiştirilmediği sürece tepkime boyunca hız sabit kalır.
B) Zamanla A derişimi azaldığından tepkime boyunca hız azalır.
C) Tepkime boyunca ürün miktarı arttığından tepkime hızı artar.
D) Başlangıçta tepkime hızı artar, girenler tükendikçe düşmeye başlar ve tepkime sonunda sıfır olur.

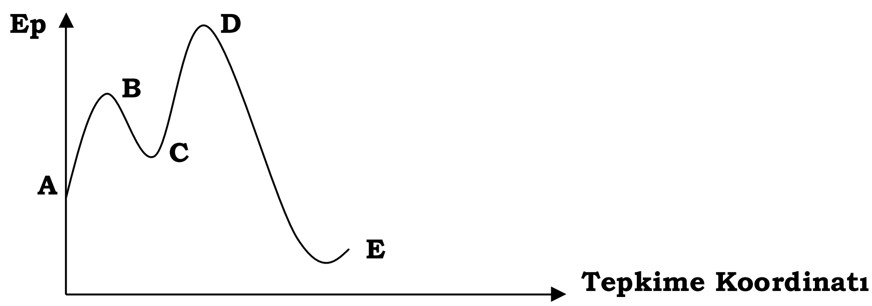
BÖLÜM 2

Bölüm 2'de tepkime hızıyla ilgili bilgilerinizi ölçen 7 adet çoktan seçmeli soru bulunmaktadır. Seçeneklerden doğru olanı işaretlemeniz beklenmektedir.

17) Katalizörle ilgili aşağıda verilenlerden hangisi doğrudur?

A) Katalizör ileri ve geri tepkimenin aktivasyon enerjisini eşit miktarda düşürerek hem ileri hem de geri tepkimeyi hızlandırır.
B) Katalizör maddelerin arasına girerek çarpışmalarına yardımcı olur.
C) Katalizör tepkime mekanizmasını (izlenen yolu) değiştirmez
D) Tepkimeye girenler katı ya da sıvı haldeyse katalizör tepkimenin hızını etkilemez.
E) Katalizör tepkimeye girmez.

18)



Yukarıda "Potansiyel Enerji- Tepkime Koordinatı" grafiği verilen tepkime için aşağıdakilerden hangisi doğrudur?

A) A → C tepkimesi hızı belirleyen adımdır.
B) B ve D katalizördür.
C) C ara üründür.
D) A → E tepkimesi için $\Delta H > 0$ 'dır.
E) Tepkime 3 adımda gerçekleşir.

19) Tepkime hızıyla ilgili aşağıda verilenlerden hangisi doğrudur?

A) Hız denklemi net tepkime denklemine göre yazılır.
B) Kimyasal tepkimelerin hızı her zaman, giren maddelerin derişimleri çarpımına eşittir.
C) Tepkime Hızı = $\Delta H_{ürünler} - \Delta H_{girenler}$
D) Mekanizmalı tepkimelerde hızı belirleyen basamak en yavaş basamaktır.
E) Tepkimenin başlangıcından bitimine kadar geçen süreye tepkime hızı denir.

20) Aşağıdakilerden hangisi katalizörü <u>en iyi</u> tanımlar?

A) Kimyasal tepkimelerde ürün verimini arttıran maddedir.
B) Tepkimeye girerek hiçbir değişikliğe uğramadan tekrar oluşan ve tepkimenin hızını arttıran maddedir.
C) Kimyasal tepkimelerin hızını arttıran maddedir.
D) Sadece ileri yöndeki tepkimenin hızını arttıran maddedir.
E) Tepkimeye girmeden tepkimenin hızını arttıran maddedir.

21) Aşağıda aktifleşme enerjisine ilişkin üç ifade veriliyor.

I. Aktifleşme enerjisi ne kadar büyük olursa tepkime o kadar hızlı olur.
II. Ekzotermik tepkimelerin aktifleşme enerjisi endotermik tepkimelerden daha düşüktür.
III. Yüksek sıcaklıkta aktifleşme enerjisini aşan tanecik sayısı artar.

Bunlardan hangisi ya da hangileri <u>doğrudur</u>?

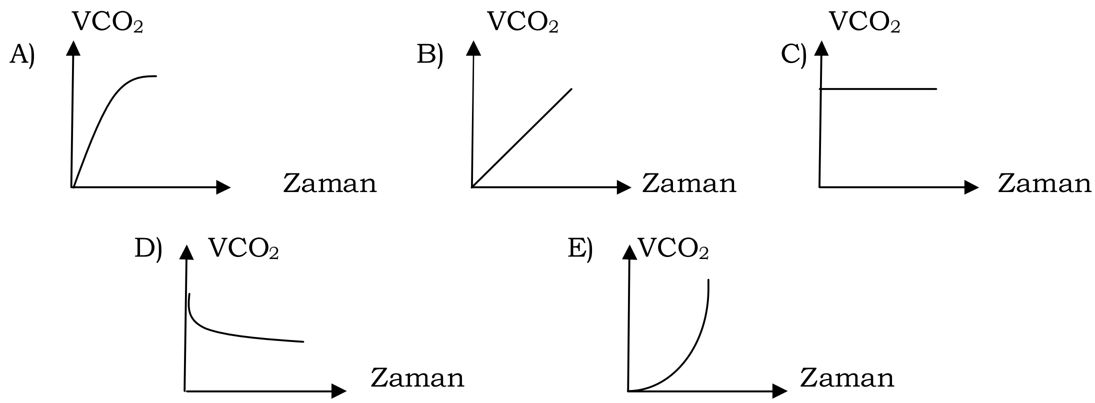
A) Yalnız I B) I ve II C) Yalnız III D) I, II ve III E) II ve III

22) X_2 (g) + Y_3 (g) → X_2Y_3 (g) tepkimesinin mekanizması aşağıda verilmiştir;

$Y_3(g) \rightarrow Y_2(g) + Y(g)$ (Yavaş)
$X_2(g) + Y_2(g) \rightarrow X_2Y_2(g)$ (Hızlı)
$X_2Y_2(g) + Y(g) \rightarrow X_2Y_3(g)$ (Hızlı)

Aşağıdakilerden hangisi bu tepkimenin hızını <u>mekanizmayı değiştirmeden arttırır</u>?
A) Ortama X_2 katılması
B) Ortama Y_3 katılması
C) Sıcaklığın düşürülmesi
D) Basıncın düşürülmesi
E) Bir katalizör katılması

23) $CaCO_3$(k) + 2HCl(suda) → $CaCl_2$(suda) + H_2O(s) + CO_2(g)
Yukarıdaki tepkimede oluşan CO_2 gazının toplam hacmi ile zaman arasındaki ilişkiyi gösteren grafik hangisidir?



APPENDIX C

ÖĞRENMEDE GÜDÜSEL STRATEJİLER ANKETİ

Değerli Öğrenci,
Bu ölçek kimya dersine yönelik öğrenme stratejilerini ve öğrenme güdülenmenizi belirlemek amacıyla hazırlanmıştır. Ölçekte yer alan sorulara verdiğiniz yanıtlar, kesinlikle **size not vermek** ya da sizi **eleştirmek** amacıyla **kullanılmayacaktır**. Bu soruların herkes için geçerli **doğru yanıtları bulunmamaktadır**. Bu nedenle lütfen aşağıda verilen tüm soruları dikkatle okuyarak yanıtınızı, ifadenin karşısındaki seçeneklerden sizin için en uygun olanı işaretleyerek belirtiniz.

Soruları yanıtlamak için aşağıdaki ölçütleri kullanın. Soruda geçen ifade sizin için **kesinlikle doğru ise (7)**'yi; sizinle ilgili **kesinlikle yanlışsa (1)**'i işaretleyin. Eğer ifadenin size göre doğruluğu bunlardan farklı ise sizin için en uygun düzeyi gösteren (1) ile (7) arasındaki rakamı işaretleyin.

Benim için Kesinlikle Yanlış.	**1 2 3 4 5 6 7**	**Benim için Kesinlikle Doğru.**

Soru No	**GÜDÜLENME (MOTİVASYON)**	
1	Kimya dersinde yeni bilgiler öğrenebilmek için büyük bir çaba gerektiren sınıf çalışmalarını tercih ederim.	(1) (2) (3) (4) (5) (6)(7)
2	Eğer uygun şekilde çalışırsam, kimya dersindeki konuları öğrenebilirim.	(1) (2) (3) (4) (5) (6)(7)
3	Kimya sınavları sırasında, diğer arkadaşlarıma göre soruları ne kadar iyi yanıtlayıp yanıtlayamadığımı düşünürüm.	(1) (2) (3) (4) (5) (6)(7)
4	Kimya dersinde öğrendiklerimi başka derslerde de kullanabileceğimi düşünüyorum.	(1) (2) (3) (4) (5) (6)(7)

5	Kimya dersinden çok iyi bir not alacağımı düşünüyorum.	(1) (2) (3) (4) (5) (6)(7)
6	Kimya dersi ile ilgili okumalarda yer alan en zor konuyu bile anlayabileceğimden eminim.	(1) (2) (3) (4) (5) (6)(7)
7	Benim için şu an kimya dersi ile ilgili en tatmin edici şey iyi bir not getirmektir.	(1) (2) (3) (4) (5) (6)(7)
8	Kimya sınavları sırasında bir soru üzerinde uğraşırken, aklım sınavın diğer kısımlarında yer alan cevaplayamadığım sorularda olur.	(1) (2) (3) (4) (5) (6)(7)
9	Kimya dersindeki konuları **öğrenemezsem** bu benim hatamdır.	(1) (2) (3) (4) (5) (6)(7)
10	Kimya dersindeki konuları öğrenmek benim için önemlidir.	(1) (2) (3) (4) (5) (6)(7)
11	Genel not ortalamamı yükseltmek şu an benim için en önemli şeydir, bu nedenle kimya dersindeki temel amacım iyi bir not getirmektir.	(1) (2) (3) (4) (5) (6)(7)
12	Kimya dersinde öğretilen temel kavramları öğrenebileceğimden eminim.	(1) (2) (3) (4) (5) (6)(7)
13	Eğer başarabilirsem, kimya dersinde sınıftaki pek çok öğrenciden daha iyi bir not getirmek isterim.	(1) (2) (3) (4) (5) (6)(7)
14	Kimya sınavları sırasında bu dersten başarısız olmanın sonuçlarını aklımdan geçiririm.	(1) (2) (3) (4) (5) (6)(7)
15	Kimya dersinde, öğretmenin anlattığı en karmaşık konuyu anlayabileceğimden eminim.	(1) (2) (3) (4) (5) (6)(7)
16	Kimya derslerinde öğrenmesi zor olsa bile, bende merak uyandıran sınıf çalışmalarını tercih ederim.	(1) (2) (3) (4) (5) (6)(7)
17	Kimya dersinin kapsamında yer alan konular çok ilgimi çekiyor.	(1) (2) (3) (4) (5) (6)(7)
18	Yeterince sıkı çalışırsam kimya dersinde başarılı olurum.	(1) (2) (3) (4) (5) (6)(7)
19	Kimya sınavlarında kendimi mutsuz ve huzursuz hissederim.	(1) (2) (3) (4) (5) (6)(7)
20	Kimya dersinde verilen sınav ve ödevleri en iyi şekilde yapabileceğimden eminim.	(1) (2) (3) (4) (5) (6)(7)
21	Kimya dersinde çok başarılı olacağımı umuyorum.	(1) (2) (3) (4) (5) (6)(7)

22	Kimya dersinde beni en çok tatmin eden şey, konuları mümkün olduğunca iyi öğrenmeye çalışmaktır.	(1) (2) (3) (4) (5) (6)(7)
23	Kimya dersinde öğrendiklerimin benim için faydalı olduğunu düşünüyorum.	(1) (2) (3) (4) (5) (6)(7)
24	Kimya dersinde, iyi bir not getireceğimden emin **olmasam** bile öğrenmeme olanak sağlayacak ödevleri seçerim.	(1) (2) (3) (4) (5) (6)(7)
25	Kimya dersinde bir konuyu **anlayamazsam** bu yeterince sıkı çalışmadığım içindir.	(1) (2) (3) (4) (5) (6)(7)
26	Kimya dersindeki konulardan hoşlanıyorum.	(1) (2) (3) (4) (5) (6)(7)
27	Kimya dersindeki konuları anlamak benim için önemlidir.	(1) (2) (3) (4) (5) (6)(7)
28	Kimya sınavlarında kalbimin hızla attığını hissederim.	(1) (2) (3) (4) (5) (6)(7)
29	Kimya dersinde öğretilen becerileri iyice öğrenebileceğimden eminim.	(1) (2) (3) (4) (5) (6)(7)
30	Kimya dersinde başarılı olmak istiyorum çünkü yeteneğimi aileme, arkadaşlarıma göstermek benim için önemlidir.	(1) (2) (3) (4) (5) (6)(7)
31	Dersin zorluğu, öğretmen ve benim becerilerim göz önüne alındığında, kimya dersinde başarılı olacağımı düşünüyorum.	(1) (2) (3) (4) (5) (6)(7)

Demografik Bilgiler

Ölçeği doldurduğunuz ders :____________________

Adınız, Soyadınız :____________________

Yaşınız :____________________

Araştırma sonuçlarının gönderilmesini istiyorsanız e-posta adresiniz:_________________________

APPENDIX D

BİLİMSEL İŞLEM BECERİ TESTİ

Adı Soyadı:
Sınıf:
Okul:
Cinsiyet: Kız ☐ Erkek ☐
Yaş:

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

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

a. Her oyuncunun almış olduğu günlük vitamin miktarını.
b. Günlük ağırlık kaldırma çalışmalarının miktarını.
c. Günlük antrenman süresini.
d. Yukarıdakilerin hepsini.

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

a. Arabaların benzinleri bitinceye kadar geçen süre ile.
b. Her arabanın gittiği mesafe ile.
c. Kullanılan benzin miktarı ile.
d. Kullanılan katkı maddesinin miktarı ile.

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

a. Arabanın ağırlığı.
b. Motorun hacmi.
c. Arabanın rengi
d. a ve b.

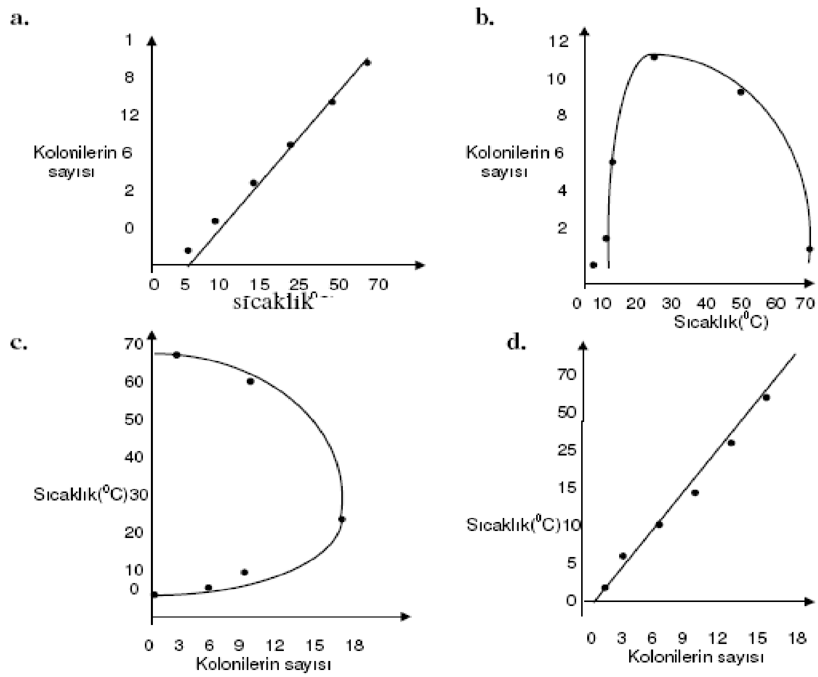
4. Ali Bey, evini ısıtmak için komşularından daha çok para ödenmesinin sebeplerini
merak etmektedir. Isınma giderlerini etkileyen faktörleri araştırmak için bir hipotez kurar. Aşağıdakilerden hangisi bu araştırmada sınanmaya uygun bir hipotez değildir?

a. Evin çevresindeki ağaç sayısı ne kadar az ise ısınma gideri o kadar fazladır.
b. Evde ne kadar çok pencere ve kapı varsa, ısınma gideri de o kadar fazla olur.
c. Büyük evlerin ısınma giderleri fazladır.
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

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

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?



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.

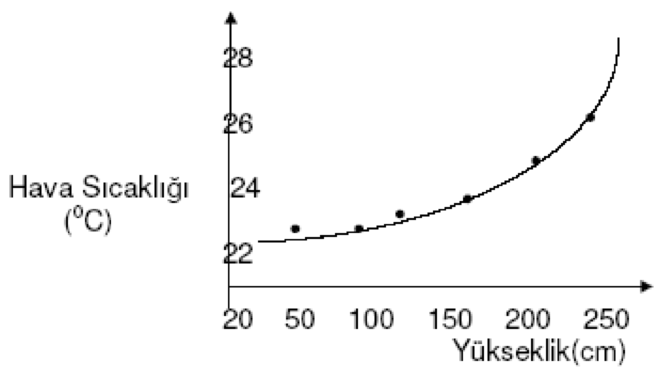
7. Bir fen sınıfında, tekerlek yüzeyi genişliğinin tekerleğin daha kolay yuvarlanması üzerine etkisi araştırılmaktadır. Bir oyuncak arabaya geniş yüzeyli tekerlekler takılır, önce bir rampadan (eğik düzlem) aşağı bırakılır ve daha sonra düz bir zemin üzerinde gitmesi sağlanır. Deney, aynı arabaya daha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

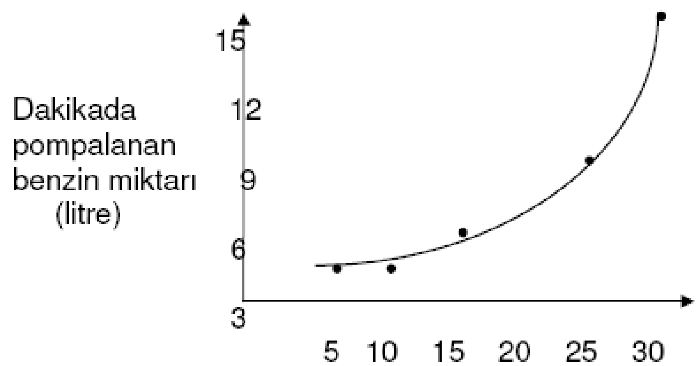


a. Yükseklik arttıkça sıcaklık azalır.
b. Yükseklik arttıkça sıcaklık artar.
c. Sıcaklık arttıkça yükseklik azalır.
d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

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

a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.
b. İçlerinde farlı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.
c. İçlerinde aynı miktarlarda hava olan topları, zeminle farklı açılardan yere vurur.
d. İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

a. Hortumun çapı genişledikçe dakikada pompalanan benzin miktarı da artar.
b. Dakikada pompalanan benzin miktarı arttıkça, daha fazla zaman gerekir.
c. Hortumun çapı küçüldükçe dakikada pompalanan benzin miktarı da artar.
d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

Önce aşağıdaki açıklamayı okuyunuz ve daha sonra 12, 13, 14 ve 15 inci soruları açıklama kısmından sonra verilen paragrafı okuyarak cevaplayınız.
Açıklama: Bir araştırmada, bağımlı değişken birtakım faktörlere bağımlı olarak gelişim gösteren değişkendir. Bağımsız değişkenler ise bağımlı değişkene etki eden faktörlerdir. Örneğin, araştırmanın amacına göre kimya başarısı bağımlı bir değişken olarak alınabilir ve ona etki edebilecek faktör veya faktörler de bağımsız değişkenler olurlar.

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

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

a. Toprak ve su ne kadar çok güneş ışığı alırlarsa, o kadar ısınırlar.
b. Toprak ve su güneş altında ne kadar fazla kalırlarsa, o kadar çok ısınırlar.
c. Güneş farklı maddeleri farklı derecelerde ısıtır.
d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Her bir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?

a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Her bir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?

a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Her bir kovanın güneş altında kalma süresi.

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

a. Hava sıcakken çim biçmek zordur.
b. Bahçeye atılan gürenin miktarı önemlidir.
c. Daha çok sulanan bahçedeki çimenler daha uzun olur.
d. Bahçe ne kadar engebeliyse çimenleri kesmekte o kadar zor olur.

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

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

17. Bu araştırmada sınanan hipotez hangisidir?

a. Şeker ne kadar çok suda karıştırılırsa o kadar çok çözünür.
b. Ne kadar çok şeker çözünürse, su o kadar tatlı olur.
c. Sıcaklık ne kadar yüksek olursa, çözünen şekerin miktarı o kadar fazla olur.
d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

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

a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.
b. Her sulamadan bir gün sonra domates bitkisinin boyunu ölçer.
c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.
d. Her alana ektiği tohum sayısına bakar.

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

a. Kullanılan toz yada spreyin miktarı ölçülür.
b. Toz yada spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.
c. Her fidede oluşan kabağın ağırlığı ölçülür.
d. Bitkilerin üzerinde kalan bitler sayılır.

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

a. 10 dakika sonra suyun sıcaklığında meydana gelen değişmeyi kaydeder.
b. 10 dakika sonra suyun hacminde meydana gelen değişmeyi ölçer.
c. 10 dakika sonra alevin sıcaklığını ölçer.
d. Bir litre suyun kaynaması için geçen zamanı ölçer.

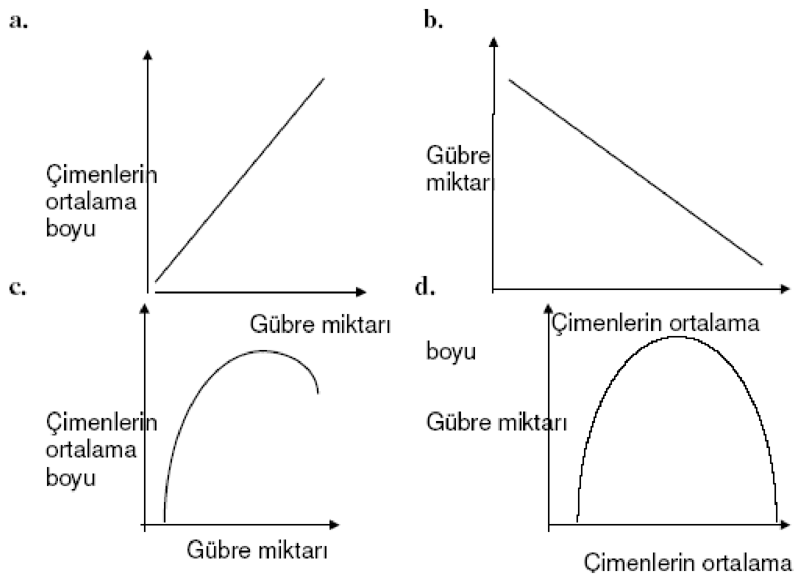
24. Ahmet, buz parçacıklarının erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarının büyüklüğü, odanın sıcaklığı ve buz parçalarının şekli gibi faktörlerin erime süresini etkileyebileceğini düşünür. Daha sonra şu hipotezi sınamaya karar verir: Buz parçalarının şekli erime süresini etkiler.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

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



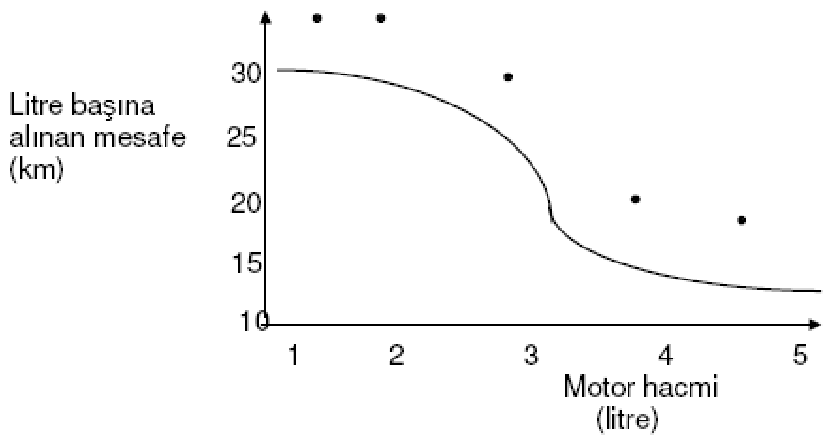
26. Bir biyolog şu hipotezi test etmek ister: Farelere ne kadar çok vitamin verilirse o kadar hızlı büyürler. Biyolog farelerin büyüme hızını nasıl ölçebilir?

a. Farelerin hızını ölçer.
b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.
c. Her gün fareleri tartar.
d. Her gün farelerin yiyeceği vitaminleri tartar.

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

a. Daha fazla şekeri çözmek için daha fazla su gereklidir.
b. Su soğudukça, şekeri çözebilmek için daha fazla karıştırmak gerekir.
c. Su ne kadar sıcaksa, o kadar çok şeker çözünecektir.
d. Su ısındıkça şeker daha uzun sürede çözünür.

28. Bir araştırma grubu, değişik hacimli motorları olan arabaların randımanlarını ölçer. Elde edilen sonuçların grafiği aşağıdaki gibidir:



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

Toprağa karıştırılan yaprakların domates üretimine etkisi araştırılmaktadır. Araştırmada dört büyük saksıya aynı miktarda ve tipte toprak konulmuştur. Fakat birinci saksıdaki torağa 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 torak 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 torak miktarı.
d. Çürümüş yaprak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki torak 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?

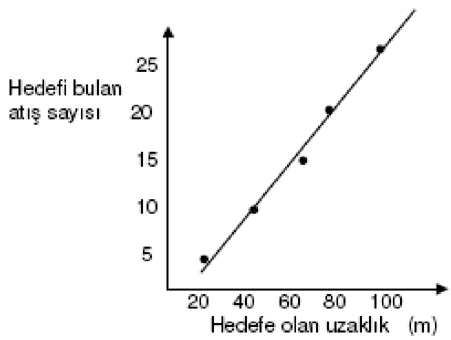
a. Kullanılan mıknatısın büyüklüğü ile.
b. Demir tozlarını çeken mıknatısın ağırlığı ile.
c. Kullanılan mıknatısın şekli ile.
d. Çekilen demir tozlarının ağırlığı ile.

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

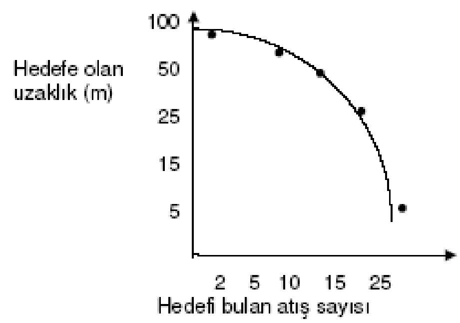
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

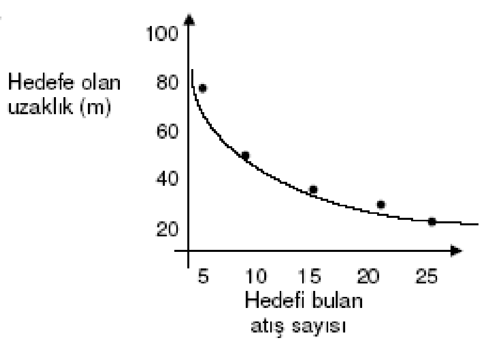
a.



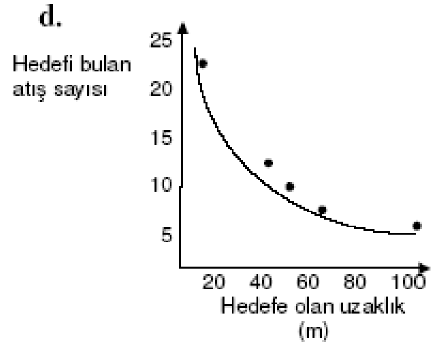
b.



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.

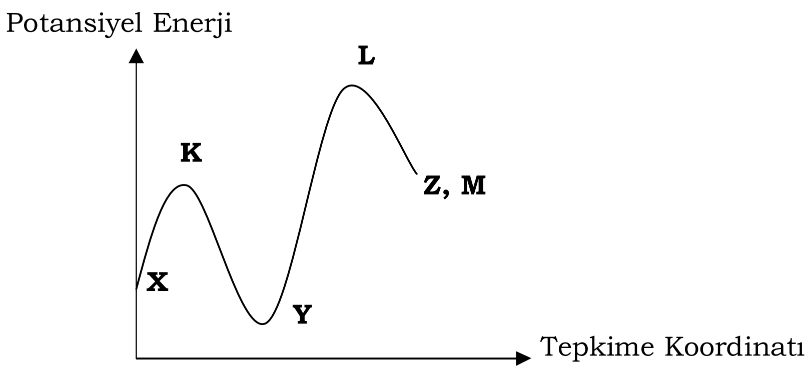
36. Murat Bey'in evinde birçok elektrikli alet vardır. Fazla gelen elektrik faturaları dikkatini çeker. Kullanılan elektrik miktarını etkileyen faktörleri araştırmaya karar verir. Aşağıdaki değişkenlerden hangisi kullanılan elektrik enerjisi miktarını etkileyebilir?

a. TV nin açık kaldığı süre.
b. Elektrik sayacının yeri.
c. Çamaşır makinesinin kullanma sıklığı.
d. a ve c.

APPENDIX E

GRUP TARTIŞMA SORULARINA BAZI ÖRNEKLER

1.



Cihan yukarıdaki grafiğe bakarak ara ürün(ler)i bulmaya çalışıyor. Net tepkime denkleminin $X \rightarrow Z + M$ olduğuna karar verip K, Y ve L'nin ara ürün olduğunu düşünüyor.

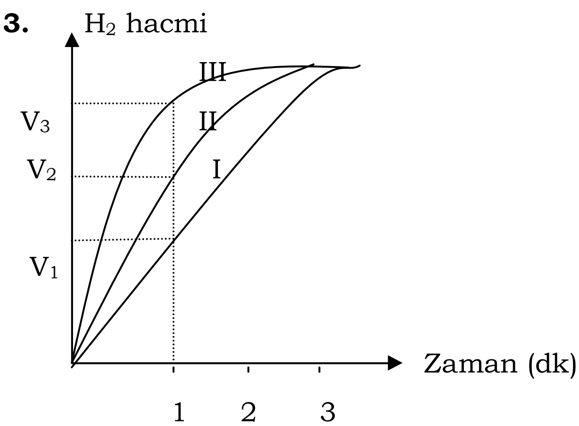
Cevabını kontrol etmek için arkadaşı Ozan'a soruyor. Ozan da K ve L'nin aktifleşmiş kompleks, Y'nin ise katalizör olduğunu söylüyor. Ancak her ikisi de cevaplarının doğruluğundan emin olamıyorlar.

Net tepkime denklemini ve ara ürün(ler)i bulmalarında Cihan ve Ozan'a cevaplarının doğruluğunu ya da yanlışlığını tartışarak yardımcı olunuz.

2. Sindirim ağızda çiğnemeyle başlar. Çiğneme; besinleri küçük parçalara ayırarak yutulmalarını kolaylaştırır; ağızda sindirim için gerekli tükürük salgılanmasını, tükürük ve mide suyu enzimlerinin daha etkili olmalarını sağlar. Nişastalı besinlerin sindirimi ağızda olur.

Buna göre çiğneme işleminin tükürük ve mide suyu enzimlerinin etkisini arttırmasını nasıl açıklarsınız? (*İpucu: tepkime hızını etkileyen faktörleri göz önüne alınız.*

3.



Ece tepkime hızına etki eden faktörlerden yüzey alanının etkisini anlayabilmek için bir dizi deney yapıyor. Aynı kütlede büyük parça, küçük parça ve toz halindeki çinko örneklerini, hacimleri ve molar derişimleri aynı olan HCl çözeltilerine ayrı ayrı koyuyor. Oluşan H_2 hacminin zamanla değişimini grafik üzerinde, yukarıdaki gibi çiziyor. Buna göre I, II ve III eğrilerinin hangisini toz, hangisini küçük parça, hangisini büyük parça için çizmiştir? Cevabınızı açıklayınız.

$2HCl\ (suda) + Zn(k) \rightarrow H_2\ (g) + ZnCl_2$

4. Sedef, Ezgi, Didem ve Emrah sıcaklığın kimyasal tepkimelerin hızına etkisine örnekler vermektedir. Hangisinin/hangilerinin verdiği örnekler doğru kabul edilebilir? Neden doğru ya da neden yanlış olduklarını açıklayınız.

Sedef: “Suyun ısıtılınca daha çabuk buharlaşması”

Ezgi: “ Şekerin sıcak suda soğuk suya kıyasla daha çabuk çözünmesi”

Didem: “ Pillerin kullanılmadığı zamanlarda buzdolabında saklandığında kullanım kapasitesinin daha fazla olması”

Emrah: “ Yemeklerin düdüklü tencerede daha çabuk pişmesi”

5. Katalizörle ilgili aşağıda verilen ifadelerin doğruluğunu tartışınız. Verdiğiniz cevapları mümkün olduğunca detaylı olarak açıklayınız.

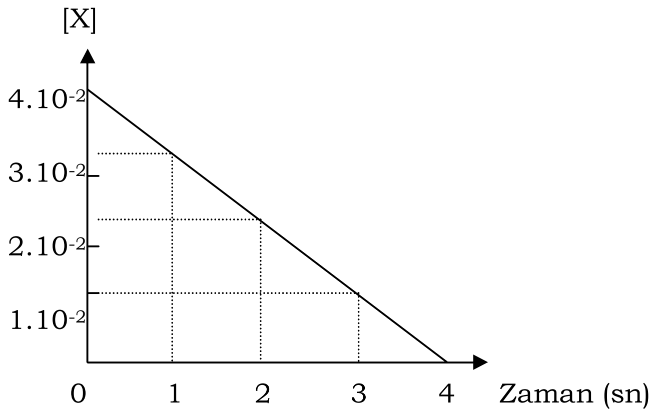
a. Katalizör tepkimeye girmeden tepkimenin hızını arttırır.

b. Katalizör sadece ileri yöndeki tepkimenin aktifleşme enerjisini düşürerek hızlandırdığı için tepkime verimini (oluşan ürün miktarını) arttırır.

c. Tek adımda gerçekleştiği bilinen bir tepkimede katalizör kullanılırsa yine tek adımda gerçekleşir; yani tepkime mekanizması değişmez.

d. Katalizör sadece ileri yöndeki tepkimenin aktifleşme enerjisini düşürdüğünden $\Delta H = Ea_i - Ea_g$ 'ye göre tepkime entalpisi değişir.

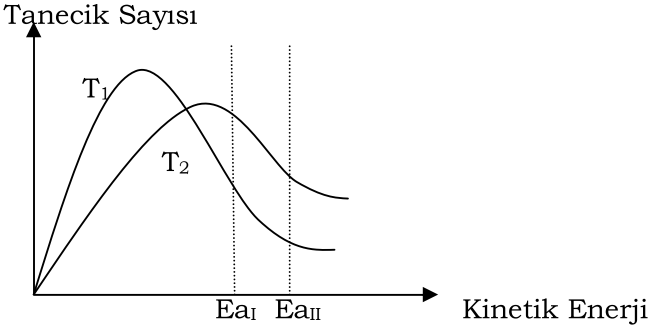
6.



a. X $\rightarrow$ Y + Z tepkimesi için yapılan deneyler sonucu X derişiminin zamanla değişim grafiği yukarıdaki gibi bulunmuştur. Grafikte verilenleri kullanarak tepkimenin hız denklemini ve derecesini bulunuz.

b. Tepkimenin hızının zamanla değişimi ile ilgili ne söyleyebilirsiniz? Cevabınızı açıklayınız.

7. Tanecik Sayısı



I ve II, gaz halinde gerçekleşen iki ayrı tepkimedir. Bu iki ayrı tepkimeye ilişkin tepkimeye giren taneciklerin T_1 ve T_2 sıcaklıklarındaki kinetik enerji dağılımı yukarıdaki grafikte gösterilmektedir. Buna göre aşağıdaki ifadelerin doğruluğunu tartışınız:

a. Aynı sıcaklıkta Hız $_I$, Hız $_{II}$ ‘den büyüktür.

b. T_1 , T_2 'ye göre düşük bir sıcaklıktır.

c. Her iki reaksiyonun da T_1 sıcaklığındaki hızı, T_2 sıcaklığındakinden büyüktür.

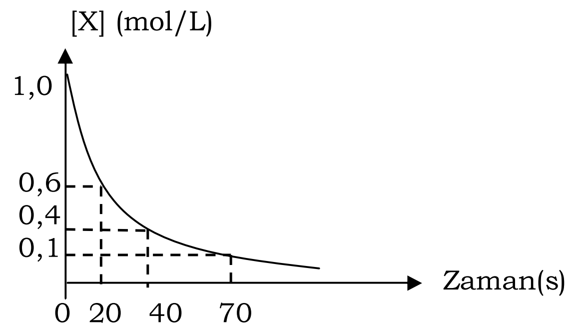
d. Her iki reaksiyon için de T_2 sıcaklığında aktif kompleks sayısı, T_1 sıcaklığındakinden daha çoktur.

APPENDIX F

QUIZZES GIVEN TO EXPERIMENTAL GROUP STUDENTS

QUIZ 1

1.



Tek basamakta gerçekleşen $2X(g) + Y(g) \rightarrow Z(g)$ tepkimesinde X(g)'nin derişiminin zamanla değişimi grafikteki gibidir. Buna göre 40. ve 70. saniyeler arasında X(g)'in ortalama tükenme hızı kaç mol/L.s'dir?

A) 0,001 B) 0,2 C) 0,1 D) 0,01 E) 0,02

2. $2A + B \rightarrow 4C$ tepkimesinde 2 lt'lik kapta A miktarı 5 saniyede 0,12 molden 0,02 mole düşüyor. Buna göre C'nin oluşum hızı kaç mol/lt.sn'dir?

3. Aşağıda verilen ifadedeki boşlukları doldurunuz:

$A(g) \rightarrow B(g)$ tepkimesinin hızı zamanla ………………. çünkü
……………………………………………………………………………………………
……………………………………………………………………………………………

4. Aşağıdaki ifadelerin doğru ya da yanlış olduğunu uygun yere çarpı işareti (X) koyarak gösteriniz.

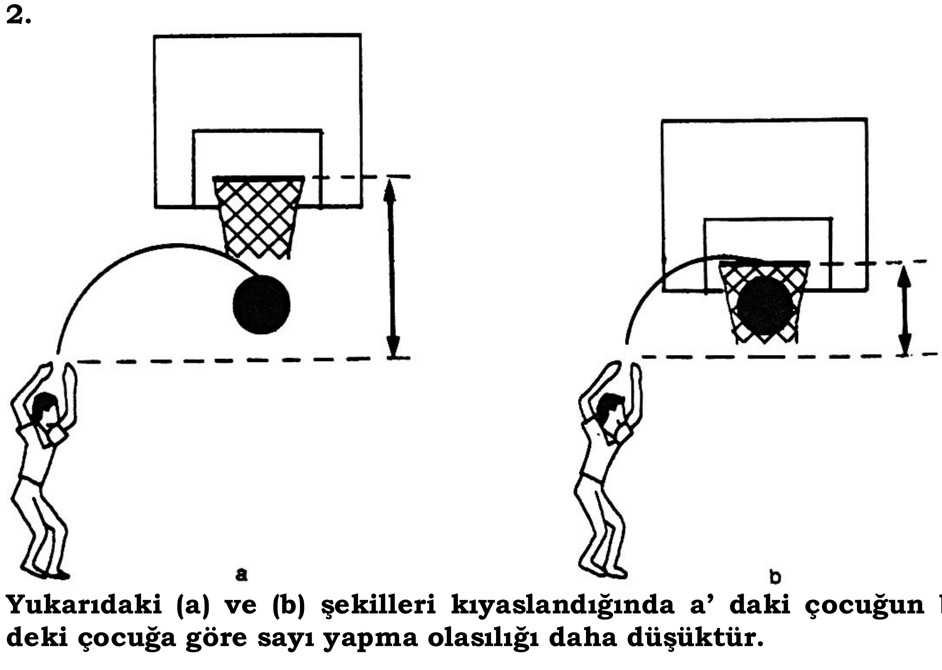
	DOĞRU	**YANLIŞ**
a. Tepkime hızı birim zamanda madde miktarındaki değişmedir.	....	....
b. Tepkime hızı tepkimenin başlangıcından bitimine kadar geçen zaman sürecidir.	....	....
c. Aynı sıcaklık ve basınçta bütün tepkimeler aynı hızda gerçekleşir.	....	....
d. Tepkime hızı sadece girenlerle ifade edilir.	....	....

QUIZ 2

1. Aktivasyon enerjisi 45 kkal/mol olan aşağıdaki reaksiyon için, tepkimeye girenleri ve ürünleri uygun yerlere yazarak potansiyel enerji diyagramını çiziniz. (Ea ve ΔH'ı grafik üzerinde gösteriniz)

$2XYZ \rightarrow 2XY + Z_2 \quad \Delta H = 20$ kkal/mol

2.



Yukarıdaki (a) ve (b) şekilleri kıyaslandığında a' daki çocuğun b' deki çocuğa göre sayı yapma olasılığı daha düşüktür.

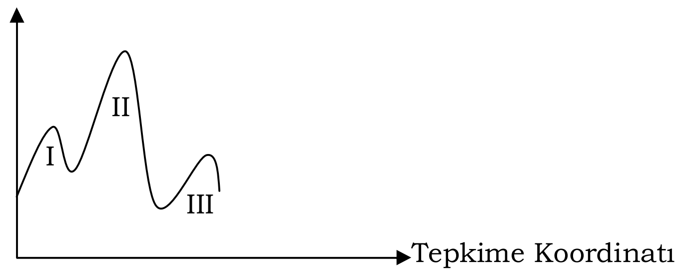
Bu örneği tepkime hızı konusundaki hangi kavramlarla benzeştirebilirsiniz? *(İpucu: a ve b' yi iki farklı tepkime olarak düşününüz)*

3. Aşağıdaki ifadelerin doğru ya da yanlış olduğunu uygun yere çarpı işareti (X) koyarak gösteriniz.

	DOĞRU	**YANLIŞ**
a. Ekzotermik tepkimeler endotermik tepkimelerden daha hızlı gerçekleşir.	………..	………..
b. Endotermik tepkimelerde ürünlerin potansiyel enerjisi girenlerinkinden daha büyüktür.	………..	………..
c. Ara ürün net tepkimede girenlerden ya da ürünlerden biridir.	………..	………..
d. Reaksiyon hız eşitlikleri doğrudan kimyasal denkleme bakılarak yazılır.	………..	………..
e. Bir tepkimenin hızını mekanizmasındaki en hızlı basamak belirler.	………..	………..
f. Ekzotermik bir tepkimede geri aktivasyon enerjisi ileri aktivasyon enerjisinden büyüktür.	………..	………..

4. Aşağıdaki ifadelerden hangisi "Çarpışma Teorisi" ne aykırıdır?
A) Tepkime için taneciklerin çarpışması gerekir.
B) Uygun geometride çarpışmış tüm tanecikler tepkime verirler.
C) Çarpışan tanecikler, yeterli kinetik enerjiye sahip olmalıdır.
D) Çarpışmalar sırasında kinetik enerji azalır, potansiyel enerji artar.
E) Birim zamandaki etkin çarpışma sayısı tepkime hızını belirler.

5. Potansiyel Enerji



Enerji değişim grafiği yukarıdaki gibi olan $4HBr(g) + O_2(g) \rightarrow 2H_2O + 2Br_2(g)$ tepkimesi 3 adımlıdır.

I. adım: $HBr + O_2 \rightarrow HOOBr$
II. adım: $HOOBr + HBr \rightarrow 2HOBr$
III. adım: $HOBr + HBr \rightarrow H_2O + Br_2$

şeklindedir. Buna göre tepkimenin hız bağıntısını yazınız. Nedenini açıklayınız.

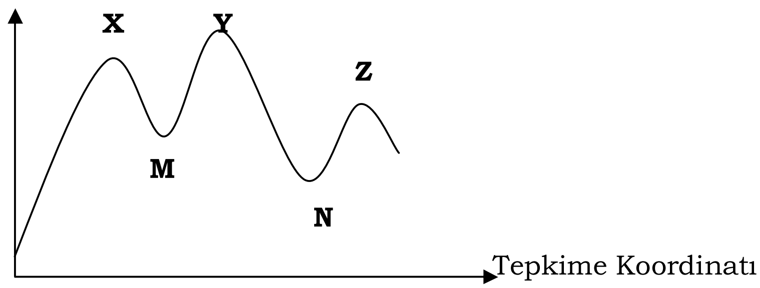
QUIZ 3

1. $A + 2B + 3C \rightarrow 2K + 3Z$
Tepkimesi için, aynı sıcaklıkta A, B ve C'nin farklı derişimleriyle deneyler yapılarak aşağıdaki veriler elde edilmiştir.

Deney	Başlangıç [A]	Başlangıç [B]	Başlangıç [C]	Hız (mol/lt.sn)
1	1	1	1	2.10^{-3}
2	1	2	2	16.10^{-3}
3	2	1	2	8.10^{-3}
4	2	2	1	16.10^{-3}

Buna göre tepkimenin hız bağıntısı nedir?
A) $k.[A]^2[B]^2[C]^2$
B) $k.[A]^3[B]$
C) $k.[A]^2[B][C]^2$
D) $k.[A][B]^2[C]$
E) $k.[A][C]^3$

2. Potansiyel Enerji



Yukarıda "Potansiyel Enerji- Tepkime Koordinatı" grafiği verilen tepkime için aşağıdakilerden hangisi doğrudur?

A) Tepkime iki basamaklıdır.
B) Net tepkime ekzotermiktir.
C) Tepkime hızını 3. basamak belirler.
D) X, Y ve Z ara ürünlerdir.
E) M ve N ara ürünlerdir.

3. $2X(g) + Z(g) \rightarrow X_2Z(g)$ (Yavaş)
$X_2Z(g) + Y(g) \rightarrow X_2Y(g) + Z(g)$ (Hızlı)

Mekanizması yukarıda verilen tepkime için aşağıdaki ifadelerin doğru ya da yanlış olduğunu uygun yere çarpı işareti (X) koyarak gösteriniz.

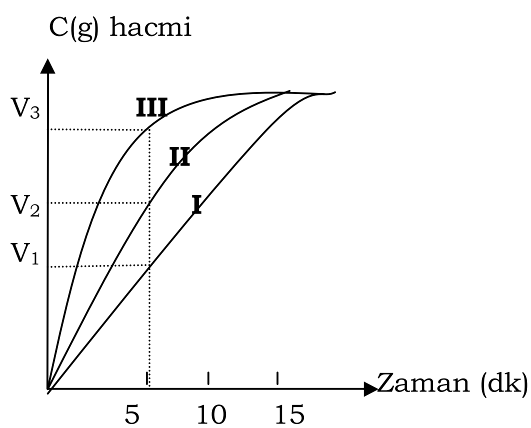
	DOĞRU	**YANLIŞ**
a. $X_2Z(g)$ ara üründür.	....	....
b. Z(g) katalizördür.	....	....
c. Ortama Y(g) ilave edilirse tepkime hızı artar.	....	....
d. Ortama $X_2Z(g)$ ilave edilirse tepkime hızı artar.	....	....

4. Tepkimeye giren bir katının toz haline getirilmesi tepkimenin hızını arttırır. Bunun nedeni aşağıdakilerden hangisidir?

A) Tepkimenin aktifleşme enerjisinin düşmesi
B) Taneciklerin kinetik enerjisinin artması
C) Taneciklerin daha hızlı hareket etmeleri
D) Taneciklerin çarpışma olasılığının artması.
E) Hacmin artması

5. A (suda) + B(k) $\rightarrow$ C (g) + D(suda)

Yukarıdaki tepkime A (suda)'nın başlangıç derişimleri sabit tutularak 3 ayrı kapta gerçekleştiriliyor. Oluşan C gazının hacminin zamanla değişim grafiği aşağıdaki gibidir.

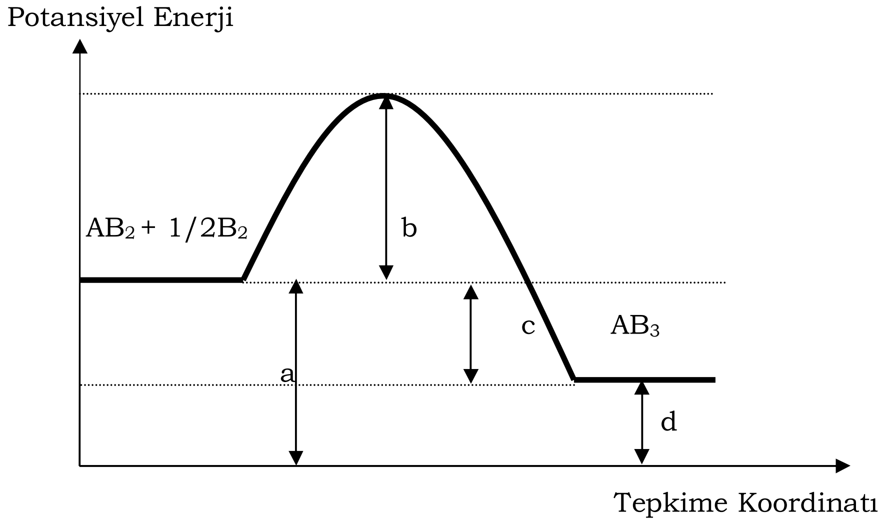


Buna göre aşağıdaki ifadelerin doğru ya da yanlış olduğunu uygun yere çarpı işareti (X) koyarak gösteriniz.

	DOĞRU	**YANLIŞ**
a. $[B]_{III} > [B]_{II} > [B]_{I}$	....	....
b. Tepkime sonunda üç kapta da farklı hacimde C(g) oluşur.	....	....
c. III. kaptaki B toz halinde, I. kaptaki B ise iri parçalar halindedir.	....	....

QUIZ 4

1.



AB_2 (g) + 1/2 B_2(g) → AB_3(g) tepkimesine ilişkin potansiyel enerji diyagramı yukarıda verilmiştir. Reaksiyon ortamına katalizör ilavesi halinde verilen değerlerden hangisi veya hangileri **değişir?**

A) Yalnız a B) Yalnız b C) a ile b D) b ile c E) a ile d

2. Aşağıdaki ifadelerin doğru ya da yanlış olduğunu uygun yere çarpı işareti (X) koyarak gösteriniz.

	DOĞRU	**YANLIŞ**
a. Sıcaklık arttırıldığında ekzotermik tepkimelerin hızı azalır.	……….	………..
b. Katalizör hız sabitinin (k) değerini değiştirir.	……….	………..
c. Katalizör tepkimenin eşik enerjisini değiştirir.	……….	………..
d. Katalizör tepkimenin mekanizmasındaki adımları değiştirir.	……….	………..
e. Katalizör tepkimenin ΔH'ını değiştirir.	……….	………..
f. Katalizör reaktiflerle beraber tepkimeye girer.	……….	………..
g. Sıcaklık değişikliğinin hıza etkisi, girenlerin derişiminin değiştirilmesinin etkisinden daha fazladır.	………	…………

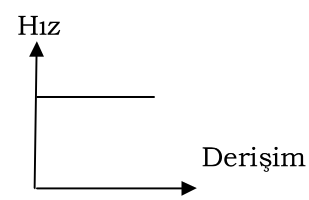
3. Aşağıda verilen ifadelerde boşlukları doldurunuz:

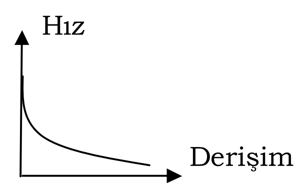
a. Sıcaklığın artması aktifleşme enerjisinin değerini ....
b. Sıcaklık arttırıldığında etkin çarpışma sayısı artar çünkü ....
c. Sıcaklığın artması tepkimenin hız sabitini (k) ....
d. Tepkimeye girenlerin derişimini arttırmak .... arttırdığından tepkimenin hızını ....

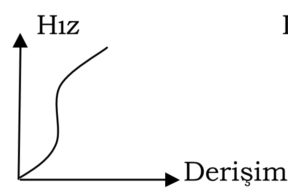
4. $2H_2O(s) + O_2(g) \rightarrow 2H_2O_2(s)$ tepkimesi tek basamakta gerçekleştiğine göre , tepkime kabının hacmi yarıya düşürülürse, tepkime hızı nasıl değişir?

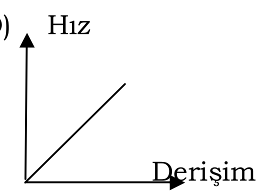
A) 2 kat azalır. B) 4 kat azalır. C) 8 kat azalır. D) 4 kat artar. E) 2 kat artar.

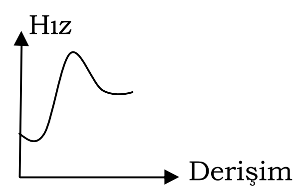
5. Sıfırıncı dereceden bir tepkime için sabit sıcaklıkta bir dizi deney yapılıyor. Başlangıç derişimleri arttırılarak tepkimelerin hızlarındaki değişim gözleniyor. Elde edilen verilere göre tepkime hızının derişime göre değişimini gösteren grafik aşağıdakilerden hangisidir?

A) 

B) 

C) 

D) 

E) 

APPENDIX G

GRUP DEĞERLENDİRME FORMU

AÇIKLAMA: Bu form, grupları değerlendirmek amacıyla öğretmen tarafından, her grup için ayrı ayrı doldurulacaktır. Aşağıda öğrencilerin grup içindeki sosyal becerilerini ölçen cümleler ve "Hiçbir Zaman", "Nadiren", "Bazen" , "Genellikle" ve "Her Zaman" seçenekleri verilmiştir. Verilen cümleleri dikkatle okuduktan sonra sizce doğru olan seçeneği işaretleyiniz.

GRUP NUMARASI: ……

	Hiçbir Zaman	**Nadiren**	**Bazen**	**Genellikle**	**Her zaman**
1. Grubun tüm üyeleri öğrenme etkinliğine dahil oluyor ve katkı sağlıyor.					
2. Öğrenciler gruplarındaki diğer arkadaşlarının fikirlerine saygı gösteriyorlar.					
3. Grup üyeleri anlayamadıkları yerleri birbirlerine sorarak anlamaya çalışıyor.					
4. Grup üyelerinden biri kendi fikrini açıklarken diğerleri onu dinliyor.					
5. Öğrenciler gruplarındaki arkadaşlarına, verilen etkinliği anlamalarında yardımcı oluyorlar.					
6. Grup üyeleri, etkinliği bitirmeden önce gruptaki herkesin tüm soruları cevaplayabildiğinden emin oluyor.					
7. Öğrenciler etkinlikler sonunda grup üyelerinin ve kendilerinin performanslarını değerlendiriyorlar.					

APPENDIX H

İŞBİRLİKÇİ ÖĞRENME MODELİ'NE İLİŞKİN GERİBİLDİRİM FORMU

Ad Soyad:
Sınıf:
Okul:

Aşağıda verilen sorular İşbirlikçi Öğrenme Modeline ilişkin görüşlerinizi belirlemek için hazırlanmıştır. Görüşleriniz, bu model doğrultusunda yeni ders planları hazırlanırken göz önüne alınacaktır. Bu nedenle verdiğiniz cevaplar işbirlikçi öğrenme modelinin ileride etkili bir şekilde uygulanabilmesi için büyük önem taşımaktadır. Lütfen her soruyu dikkatlice okuyarak, görüşlerinizi içtenlikle belirtiniz. Teşekkürler.

1. İşbirlikçi Öğrenme Modelini nasıl tanımlarsınız? Sizce İşbirlikçi Öğrenme Modelinin en belirgin temel özellikleri nelerdir?

2. Yukarıda belirttiğiniz özelliklerden hangisinin öğrenmenize en çok katkısı oldu?

3. İşbirlikçi Öğrenme Modelindeki hangi özellikleri kesinlikle değiştirmek isterdiniz?

4. İşbirlikçi Öğrenme Modelindeki hangi özellikler kesinlikle uygulanmaya devam edilmelidir?

5. İşbirlikçi Öğrenme Modelinin uygulanması sırasında ne tür zorluklarla karsılaştınız?

6. Sizce İşbirlikçi Öğrenme Modelinde ideal bir öğretmen ne tür özellikler taşımalıdır? (Alan bilgisi, grup çalışmasına katkı vb. açılardan)

7. İşbirlikçi Öğrenme Modelinin size akademik ve sosyal açıdan neler kazandırdığını düşünüyorsunuz?

APPENDIX I

İŞBİRLİKÇİ ÖĞRENME YÖNTEMİ KONTROL CETVELİ

AÇIKLAMA: Bu ölçekte İşbirlikçi Öğrenme Yönteminin uygulanmasına ilişkin cümleler ile ilk 8 sorunu için "EVET" ve "HAYIR"; 9-20. maddeler için "Hiçbir Zaman", "Nadiren", "Bazen" , "Genellikle" ve "Her Zaman" seçenekleri verilmiştir. Verilen cümleleri dikkatle okuduktan sonra sizce doğru olan seçeneği işaretleyiniz.

	EVET	HAYIR
1. Öğrencilerin sınıftaki fiziksel konumları, grup etkinlikleri esnasında yüz yüze iletişim kurmalarına uygun mu?	☐	☐
2. Gruplar cinsiyet ve başarıya göre heterojen mi?	☐	☐
3. Gruptaki her öğrenciye öğretmen tarafından bir rol verildi mi?	☐	☐
4. Grup aktivitelerinden sonra öğrencilere bireysel quizler verildi mi?	☐	☐
5. Yapılan quizler notlandırılıp öğrencilere geri dağıtıldı mı?	☐	☐
6. Grupların ortalama quiz skorları haftalık ilan ediliyor mu?	☐	☐
7. Grup çalışması bitiminde en başarılı grup ödüllendirildi mi?	☐	☐
8. Öğretmen grup aktiviteleri başlamadan önce, öğrencilere grup içerisinde nasıl davranmaları gerektiğine dair açıklamalarda bulundu mu? (birbirlerini dinleme, öğrenme etkinliklerinin tümüne dahil olma, soru sorabilme, her üyenin grup etkinliğine katıldığından emin olma)	☐	☐

	Hiçbir Zaman	Nadiren	Bazen	Genellikle	Her zaman
9. Öğretmen öğrencilere grup içindeki çalışmalarıyla ilgili geri bildirim veriyor.					
10. Grubun tüm üyeleri öğrenme etkinliğine dahil oluyor ve katkı sağlıyor.					
11. Öğrenciler gruplarındaki diğer arkadaşlarının fikirlerine saygı gösteriyorlar.					
12. Grup üyeleri anlayamadıkları yerleri birbirlerine sorarak anlamaya çalışıyor.					
13. Grup üyelerinden biri kendi fikrini açıklarken diğerleri onu dinliyor.					
14. Öğrenciler gruplarındaki arkadaşlarına, verilen etkinliği anlamalarında yardımcı oluyorlar.					
15. Grup üyeleri, etkinliği bitirmeden önce gruptaki herkesin tüm soruları cevaplayabildiğinden emin oluyor.					
16. Öğretmen gruplar arasında gezerek öğrencilere kafalarında çelişki yaratıcı ve daha detaylı açıklama yapmalarını sağlayıcı sorular soruyor.					
17. Öğretmen grupları amaçlarına yoğunlaşmaya teşvik ediyor.					
18. Öğrenciler etkinlikler sonunda grup üyelerinin ve kendilerinin performanslarını değerlendiriyorlar.					
19. Her grubun cevaplarını sınıfa sunacak öğrenci, öğretmen tarafından rasgele seçiliyor.					
20. Öğretmen grup çalışması esnasında isteyen öğrencilere yol gösterici açıklamalarda bulunuyor.					

APPENDIX J

PERCENTAGES OF STUDENTS' RESPONSES ON POST-REACTION RATE CONCEPT TEST

Table J.1 Percentages of students' responses on RRCT

		Response Percentage (%)	
Item Number	**Alternative**	**Experimental Group**	**Control Group**
1	1*	87.5	94.4
	2	12.5	5.6
	A*	64.3	37.0
	B	3.6	7.4
	C	0	1.9
	D	32.1	53.7
2	1	1.8	3.7
	2	8.9	24.1
	3*	89.3	72.2
	A	8.9	24.1
	B	0	5.6
	C	0	0
	D*	91.1	70.4

Table J.1 (Continued)

3	1*	80.4	75.9
	2	19.6	24.1
	A	10.7	20.4
	B*	80.4	66.7
	C	1.8	5.6
	D	7.1	7.4
4	1*	98.2	87.0
	2	0	9.3
	3	1.8	3.7
	A	5.4	11.1
	B*	92.9	83.3
	C	1.8	3.7
	D	0	1.9
5	1*	98.2	90.7
	2	1.8	9.3
	A*	39.3	38.9
	B	0	3.7
	C	60.7	51.9
	D	0	5.6
6	1	0	0
	2*	100	92.6
	3	0	7.4
	A	1.8	0
	B	1.8	0
	C	0	3.7
	D*	96.4	96.3

Table J.1 (Continued)

7	1	17.9	18.5
	2*	82.1	81.5
	A	5.4	5.6
	B	12.5	5.6
	C	0	3.7
	D*	82.1	85.2
8	1	10.7	7.4
	2*	89.3	92.6
	A*	10.7	11.1
	B	87.5	88.9
	C	1.8	0
	D	0	0
9	1	0	5.6
	2	100	88.9
	3*	0	5.6
	A*	83.9	63
	B	0	3.7
	C	0	1.9
	D	16.1	31.5
10	1	5.4	9.3
	2*	94.6	90.7
	A	1.8	7.4
	B*	91.1	85.2
	C	5.4	3.7
	D	1.8	3.7

Table J.1 (Continued)

11	1	23.2	42.6
	2*	76.8	57.4
	A	21.4	42.6
	B	1.8	5.6
	C*	66.1	38.9
	D	10.7	13
12	1*	100	75.9
	2	0	5.6
	3	0	18.5
	A	0	7.4
	B	0	5.6
	C	0	16.7
	D*	100	70.4
13	1*	82.1	75.9
	2	0	1.9
	3	17.9	22.2
	A	12.5	9.3
	B*	69.6	66.7
	C	0	1.9
	D	17.9	22.2

Table J.1 (Continued)

14	1	0	9.3
	2	0	1.9
	3*	100	88.9
	A	0	5.6
	B	0	5.6
	C	91.1	79.6
	D	8.9	9.3
15	1	8.9	9.3
	2*	91.1	90.7
	A*	87.5	85.2
	B	8.9	1.9
	C	0	5.6
	D	3.6	7.4
16	1*	87.5	81.5
	2	7.1	9.3
	3	5.4	9.3
	A	7.1	9.3
	B*	73.2	72.2
	C	5.4	5.6
	D	14.3	13
17	A*	78.6	66.7
	B	5.4	7.4
	C	1.8	13
	D	5.4	5.6
	E	8.9	7.4

Table J.1 (Continued)

18	A	5.4	3.7
	B	0	16.7
	C*	91.1	68.5
	D	3.6	7.4
	E	0	3.7
19	A	0	3.7
	B	0	0
	C	1.8	5.6
	D*	98.2	90.7
	E	0	0
20	A	0	0
	B*	91.1	94.4
	C	7.1	1.9
	D	0	1.9
	E	1.8	1.9
21	A	0	7.4
	B	0	1.9
	C*	85.7	53.7
	D	0	1.9
	E	14.3	35.2
22	A	0	1.9
	B*	85.7	59.3
	C	1.8	5.6
	D	1.8	5.6
	E	10.7	27.8

Table J.1 (Continued)

23	A*	71.4	55.6
	B	1.8	14.8
	C	7.1	1.9
	D	8.9	5.6
	E	10.7	22.2

APPENDIX K

INTERVIEW QUESTIONS

1. In the first part of the first question of RRCT, it is stated that "rate of a reaction is calculated by measuring amount of substance consumed or produced per unit time". What do you think? Is it correct or not?

2. You selected the statement that "reaction rate is the amount of substance turning into products per unit time at constant temperature and concentration"as the reason of your answer in the first part for the first item. Why at constant concentration?

3. You selected the statement that "forward reaction rate always equals to the reverse reaction rate"as the reason of your answer in the first part of first question on RRCT. Can you explain more?

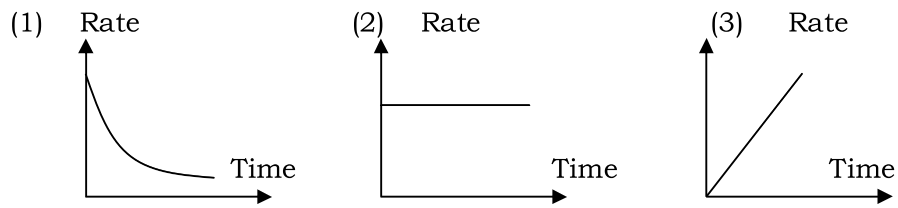
4. Can I say that reaction rate is the time necessary for a reaction to be completed?

5. Can you define reaction rate?

6. Look at the question 16 of RRCT.

   $A(g) + B(k) \rightarrow C(g)$

   Select the curve of Reaction Rate versus Time for the reaction above, which occurs in one step? Explain why.



   For the second question of RRCT:

   $A \rightarrow B + C$

   The rate equation of the reaction above is found experimentally as $V = k [A]^0 = k$ According to this equation, how does the rate of this reaction changes with time?

7. If the rate law was first order, how would the rate change during reaction?

8. What is the meaning of first order reaction?

9. What does k depends on?

10. Why is the rate constant for zero-order reaction?

11. Why are solids not written on the rate law equation?

12. Why are gases written on the rate law equation?

13. Related to the third question in RRCT:

    I. $K(g) + L(g) \rightarrow M(g)$ Ea = 98 kj , $\Delta H > 0$

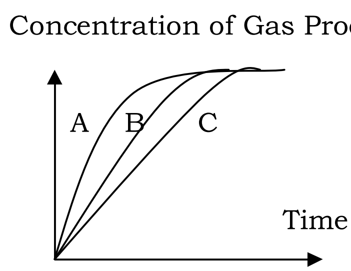
    II. $N(g) + P(g) \rightarrow R(g)$ Ea = 360 kj , $\Delta H < 0$

    Compare the rates of the reactions above. Explain your answer.

14. Do ΔH values provide any information related to the rate of the reaction?

15. Can I say that endothermic reactions are faster than exothermic ones or vice versa?

16. Consider the 13th item of RRCT:



Some amount of $CaCO_3$ reacts in three different containers (A, B, C) with HCl in different concentrations. The amount of gas evolved per unit time is recorded and a curve on the left hand side is obtained. Which is the fastest reaction? Explain your answer.

17. Look at the question nine on RRCT:

I	II
100 ml HCl(aq)	100 ml HCl(aq)
10 gr a big piece of MgO(k)	10 gr powederd MgO(k)

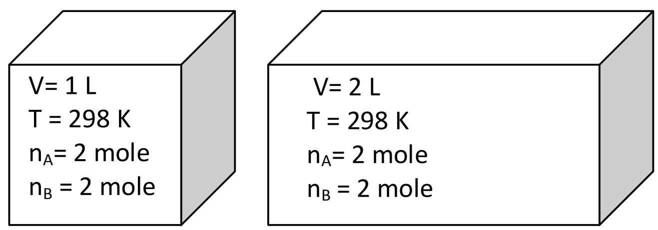
There are two identical reaction vessels containing 100 ml of HCl (aq) in each. 10 g of big piece MgO(s) is added to the first vessel and 10 gr of powdered MgO(s) is added to the second one, and the reaction below is performed:

$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O\ (l)$

Compare the rates of reactions in two conditions. Explain your answer.

18. Why does increasing surface area increase reaction rate?

19. Look at the fifth item of RRCT:

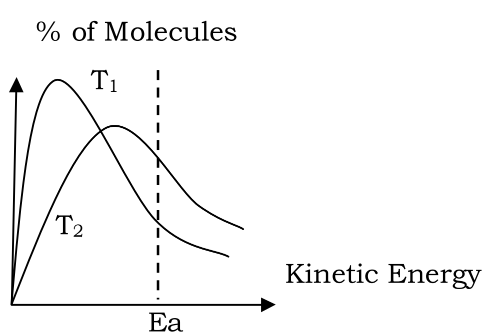


I II

The reaction of $A(g) + B(g) \rightarrow C(g) + D(g)$ is performed in both vessels given above with the given amounts, volume and temperature. Compare the rates of reactions for two conditions. Explain your answer.

20. How is the kinetic energy of molecules affected from change of volume?

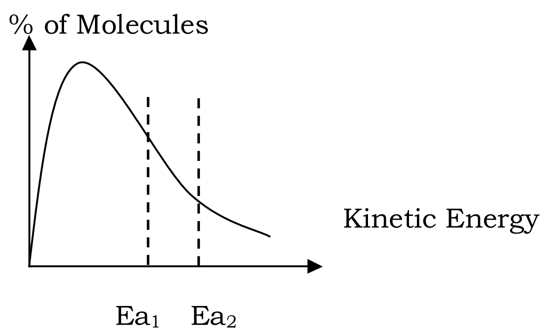
21. Consider the tenth question of RRCT:



The curve shows % of Molecules versus Kinetic Energy of Molecules at two diferent temperatures. Based on this curve, compare the temperatures. Explain your answer.

22. What does the area under the curve of % of Molecules vs Kinetic Energy after Ea mean to you?

23. Look at the seventh question of RRCT:



The curve shows the distribution of energies particles in a reaction and two different activation energies for that reaction. In order to pass from Ea_2 to Ea_1, what could be done? Explain your answer.

24. How does a catalyst increase the rate of the reaction?

25. Why is the reaction intermediate not written in the net equation?

26. What is the difference between reaction intermediate and the catalyst?

APPENDIX L

SAMPLES OF GROUP SHEETS

GRUP I

SORU 11

Sindirim ağızda çiğnemeyle başlar. Çiğneme; besinleri küçük parçalara ayırarak yutulmalarını kolaylaştırır; ağızda sindirim için gerekli tükürük salgılanmasını, tükürük ve mide suyu enzimlerinin daha etkili olmalarını sağlar. Nişastalı besinlerin sindirimi ağızda olur.

Buna göre çiğneme işleminin tükürük ve mide suyu enzimlerinin etkisini arttırmasını nasıl açıklarsınız? (*İpucu: tepkime hızını etkileyen faktörleri göz önüne alınız.)*

Temas yüzeyi ile ilgilidir.

Bir besin mideye gittiğinde eğer küçük küçük parçalar halinde ise mide onu sindirirken o kadar rahat eder. Eğer besin mideye ağızda çok çiğnemeden yutulursa mide besini sindirmek için ilk önce onu parçalamaya çalışıp, rahat sindirilebilecek konuma getirmeye, ondan sonra sindirmeye çalışacaktır. Bu işlemler sırasında mide besini küçültmekle ard zaman harcayacaktır ve besini öğütme süresi uzayacaktır.

Hem ağızda daha uzun çiğnenen besinler tükürükteki enzimler sayesinde daha kolay parçalara ayrılacağından besinin öğütülme süresini minimuma indirecektir. Dolayısıyla temas yüzeyi küçük maddelerin tepkime hızı daha yavaştır; temas yüzeyi büyük maddelerin tepkime hızı daha hızlıdır.

Figure L.1 A Sample of Group Sheet for Group 1

Grup 2

SORU 16

Sedef, Ezgi, Didem ve Emrah sıcaklığın kimyasal tepkimelerin hızına etkisine örnekler vermektedir. Hangisinin/hangilerinin verdiği örnekler doğru kabul edilebilir? Neden doğru ya da neden yanlış olduklarını açıklayınız.

Sedef: "Suyun ısıtılınca daha çabuk buharlaşması"

Ezgi: " Şekerin sıcak suda soğuk suya kıyasla daha çabuk çözünmesi" sıcaklık

Didem: " Pillerin kullanılmadığı zamanlarda buzdolabında saklandığında kullanım kapasitesinin daha fazla olması"

Emrah: " Yemeklerin düdüklü tencerede daha çabuk pişmesi" basınç

Sedef'in söylediği yanlıştır. Çünkü bu kimyasal bir tepkime değil fiziksel bir olaydır.
Ezgi'nin söylediği de kimyasal değil fiziksel bir olaydır. Bu nedenle yanlıştır.

Didem: Piller işlevini yerine getirmek için bir tepkime başlatır. Bu tepkime bittiğinde pil de biter. Pilin bitmesini geciktirmek için buzdolabına koyduğumuzda tepkimeyi yavaşlatırız. Bu madde doğrudur.

Emrah'ın söylediği doğrudur. Düdüklü tencerede yemekler daha hızlı pişer. Çünkü çok yüksek basınç sayesinde sıcaklığı iyice arttırır ve pişmeyi hızlandırır.

Figure L.2 A Sample of Group Sheet for Group 2

APPENDIX M

SAMPLE REACTION RATE LESSON IMPLEMENTED BY COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE CONDITIONS

TEPKİME HIZI VE ÖLÇÜLMESİ

1. Sınıf Sunumu

Öğretmen konuyu anlatmaya başlamadan önce günlük hayatla bağlantılı sorular sorarak öğrencilerin konuya ilgilerini çekmeye çalışır. Bu şekilde *verimlilik (fruitfulness)* koşulu sağlanmış olur.

- *Odunları tutuşturmak için büyük odun parçaları yerine küçük odun parçaları seçmemizin nedeni nedir?*
- *Yiyeceklerin oda koşullarında kısa zamanda bozulduğu halde buzdolabında daha uzun süre bozulmadan kalmasının nedeni nedir?*
- *Mutfakta kullandığımız gaz tüpleri açık unutulduğunda kendiliğinden patlamaz. Patlama için kıvılcıma ihtiyaç vardır. Nedenini açıklayınız.*

Bu soruların cevapları kısaca tartışılacak kimyasal tepkimelerin ne kadar sürede gerçekleştiğinin bilinmesinin günlük yaşantımızdaki önemi vurgulanmış olur. Daha sonra öğretmen konuyu anlatmaya başlar.

Kimyasal Tepkimeler

Bir tepkimeyi kontrol altına alabilmek için onun nasıl bir hızla meydana geldiğini ve bu hızı etkileyen faktörlerin neler olduğunu bilmek isteriz. İşte tepkime hızıyla bu nedenle ilgileniriz. Isı alış verişi, renk değişimi, iletkenlik, gaz çıkışı, çökelme, basınç, hacim değişimi, ışık salınması gibi olaylardan bir veya birkaçının varlığı kimyasal tepkimenin gerçekleştiğinin işareti sayılır. Bütan gazının yanmasında ısı ve ışık salınması, kireç taşının ısıtılması ile CO_2 gazının çıkışı, demirin paslanarak renk değiştirmesi gibi olaylar kimyasal tepkimenin gerçekleştiğini gösterir. Kimyasal tepkimelerde bu değişmeler ne kadar hızlı gerçekleşiyorsa tepkime de o kadar hızlıdır.

Tepkime Hızı ve Ölçülmesi

Bir tepkimenin hızını ifade etmek için "hızlı" veya "yavaş" gibi terimler kullanmak yeterince güvenilir ve uygun değildir çünkü bu kavramlar bağıldır, yani kişiden kişiye değişebilir. Bu sebeple tepkime hızını belirtmeye yarayan güvenilir bir yöntem bulmamız gerekir.

Kimyasal bir tepkiemede zamanla girenler tükenip ürünler oluştuğuna göre, tepkime hızı (TH) "birim zamanda tükenen ya da oluşan madde miktarındaki değişme" dir. Belirli şartlarda belirli bir tepkimenin hızı, o tepkime için belirli bir özelliktir. O halde tepkime hızını "birim zamanda, birim hacimde değişime uğrayan maddenin mol sayısı" olarak tanımlamak en doğrusu olacaktır.

$$TH = \frac{\text{Madde derişimindeki değişme}}{\text{Zaman Aralığı}}$$

$$TH = \frac{\Delta M}{\Delta t}$$

Bir tepkimenin hızı hem girenler hem de ürünler cinsinden yazılabilir. Örneğin:

$2CO(g) + O_2(g) \rightarrow 2CO_2$ tepkimesi için hız:

$$TH_{CO} = \frac{\text{CO derişimindeki azalma}}{\text{Zaman aralığı}}$$

$$TH_{O_2} = \frac{\text{O}_2\text{ derişimindeki azalma}}{\text{Zaman aralığı}}$$

$$TH_{CO_2} = \frac{\text{CO}_2\text{ derişimindeki artma}}{\text{Zaman aralığı}}$$

Tepkime denklemine göre, 2 mol karbon monoksitten 2 mol karbon dioksit oluşmaktadır. O halde, tepkimede ne kadar karbon monoksit tükeniyorsa, o kadar da karbon dioksit olşur. Buna göre karbon dioksitin oluşma hızı (TH_{CO2}), karbon monoksitin tükenme hızına (TH_{CO}) eşit olmalıdır.

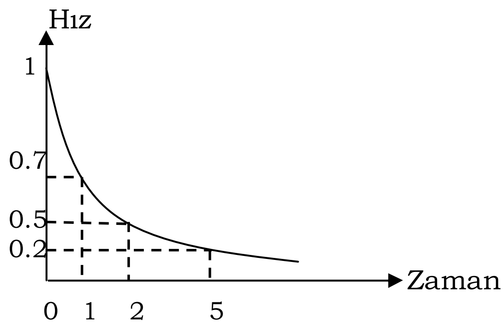
$$TH_{CO2} = TH_{CO}$$

Yine tepkime denklemine göre, 2 mol karbon monoksit tükenirken 1 mol de oksijen tükenmektedir. Bu durumda oksijenin tükenme hızı, karbon monoksitin tükenme hızının yarısına eşit olmalıdır.

$$TH_{O2} = \frac{1}{2}\, TH_{CO}$$

Buna göre her üç hız arasında $TH_{CO2} = 2TH_{O2} = TH_{CO}$ ilişkisi vardır.

Yukarda belirtilen tepkime hızı ortalama hızdır. Başlangıçta tepkimeye girenlerin derişimi en büyük değerinde olduğundan, birim zamandaki derişim değişimi de büyük yani hız büyüktür. Zamanla derişim azalacağından derişim değişimi küçük, dolayısıyla hız küçük olacaktır. Aşağıdaki şekilde bir tepkimeye ilişkin hız-zaman grafiğinde bu durum görülmektedir:



Birinci zaman aralığında (0-1 arası) derişimde, 1-0.7 = 0.3 azalma olurken, 2. zaman aralığında (1-2 arası), 0.7-0.5 = 0.2 azalma olmaktadır.

2. Grup Çalışması

Başarı ve cinsiyete göre heterojen olarak önceden oluşturulmuş dört veya beş kişilik gruplar bir araya gelir. Her grubun üyelerine okuyucu, yazıcı ve kontrolör olmak üzere görevler verilir. Grup etkinliği sonunda grubun cevabını sınıfa açıklayacak olan sözcü, etkinlik bitiminde öğretmen tarafından rastgele seçilecektir. Sıraların konumu, grup üyelerinin yüz yüze olmalarını sağlayacak şekilde ayarlanmış olmalıdır. *Çalışma Sayfası 1* ve *Çalışma Sayfası 2* gruplara dağıtılır. Her gruba herbir çalışma sayfasından 2'şer tane verilir. Bunlardan 1 tanesine yazıcı tarafından, tüm grup üyelerin fikir ve çözümleri diğerine de sorunun grupça ortak karar verilmiş çözümü yazılacaktır. Okuyucu sruyu gruba okur. Kontrolör de etkinlik boyunca herkesin tartışmaya dahil olduğundan emin olmalıdır.

Çalışma Sayfası 1

Tepkime hızı ile ilgili olarak 4 arkadaş aralarında tartışmaktadır:

Serap'a göre tepkime hızı "*Bir kimyasal tepkimede tepkimenin başlangıcından bitimine kadar geçen süredir.*"

Murat ise "*Kimyasal bir tepkime sonucu oluşan ürün miktarına o tepkimenin hızı deni*r." demektedir.

Sevim hızı şöyle tanımlar: "*Sabit sıcaklıkta, birim zamanda girenlerin ya da ürünlerin derişimindeki değişime tepkime hızı denir.*"

Ali' ye göre ise hız "*Sabit sıcaklıkta ve derişimde, birim zamanda ürüne dönüşen madde miktarıdır.*"

Bu 4 öğrenciden hangisi hızı doğru tanımlamıştır? Yanlış tanımlayanlara ifadelerinin neden yanlış olduğunu açıklayınız.

Çalışma Sayfası 1, öğrencilerin tepkime hızının tanımıyla ilgili kavram yanılgılarını içeren bir sorudan oluşmaktadır. Grup üyelerinden bu tanımların neden yanlış olduğunu tartışmaları beklenmektedir. Serap, Murat ve Ali'nin tanımları kavram yanılgıları olup Sevim'in açıklaması hızın doğru tanımını vermektedir. Tartışma sırasında grup üyeleri farklı fikirler ortaya koyup savunacağından, bu durumun öğrencilerin zihinlerinde *memnuniyetsizlik (dissatisfaction)* yaratması beklenmektedir. Ayrıca bu kavram yanılgıları ile grup üyeleri arasında *çeklişki* veya *zıtlık* (*contradiction*) oluşturularak tartışmaların kuvvetlendirilmesi amaçlanmaktadır. Öğrenciler soruyu tartışırken öğretmen gruplar arasında dolaşarak tartışmaları dinler ve gruplara yol gösterici açıklamalarda bulunur. Örneğin; kimyada bir tepkimenin hızının tanımı yapılırken fizik dersinde anlatılan hız konusuyla bağlantı kurulabilir. Bir arabanın hızından bahsederken aldığı yol ve geçen süre göz önüne alındığına göre bir tepkimenin hızı için de benzer kavramlar birlikte düşünülmelidir. Başka bir alan veya bilim dalı ile bağlantı kurularak kavramsal değişim koşullarından *verimlilik (fruitfulness)* sağlanmış olur. Ayrıca, öğretmen tartışmaları güçlendirmek ve *çelişki* yaratmak için "tepkime boyunca girenlerin derişimi sabitken hızı nasıl tanımlarsınız?" sorusunu sorabilir. Grup tartışması sonucunda kavram yanılgısı içeren açıklamalar tarışılarak doğru cevaba ulaşlılacak ve konuyla ilgili kavram yanılgısı oluşumu önlenmiş olacaktır.

Çalışma Sayfası 2

$NO_2(g)$ ısıtıldığında aşağıdaki tepkimeye göre bozunmaktadır.

$2NO_2(g) \rightarrow 2\,NO(g) + O_2(g)$

Ahmet, $NO_2(g)$ 'yi ısıtarak yaptığı deneylerde $NO_2(g)$ derişiminin zamanla değişimini aşağıdaki gibi not etmiştir:

Zaman	**$[NO_2]$**
0 dk	$1{,}50 \times 10^{-2}$
10 dk	$1{,}29 \times 10^{-2}$
20 dk	$1{,}10 \times 10^{-2}$
30 dk	$0{,}95 \times 10^{-2}$

Bu verilere göre aşağıdaki soruları cevaplayınız:

1. Her bir zaman aralığı için $NO_2(g)$' nin ortalama bozunma hızını hesaplayınız.

2. Bulduğunuz sonuçlara göre $NO_2(g)$' nin ortalama bozunma hızının zamanla değişimi hakkında ne söyleyebilirsiniz?

Çalışma Sayfası 2'deki bu soru ile öğrencilerden, Çalışma Sayfası 1'de yaptıkları hız tanımına göre uygulamalı olarak problem üzerinde, verilen tepkimenin hızının zamanla değişimini tartışmaları beklenmektedir. Bu sayfadaki her iki sorunun çözümü ile ilgili olarak, grup üyelerinden farklı fikirler öne sürülmesiyle, öğrencilerin çelişkiler yaşaması sonucu kavramsal değişim koşullarından *memnuniyetsizlik* (*dissatisfaction*) sağlanmış olacaktır. Öğrenciler bu memnuniyetsizliği ortadan kaldırmak için ortak bir çözüme ulaşmaya çalışacaklardır. Gruplar soruyu tartışırken öğretmen yine sınıfta dolaşacak ve öğrencilere yol gösterecektir. Bu noktada öğretmen, bilim insanlarının da bir tepkimenin hızını hesaplamak için böyle bir yöntem kullandığını vurgulayarak, öğrencilerin okulda öğretilen kimya ile kimyagerlerin laboratuarları arasında bağlantı kurmalarına yardımcı olur. Böylece kavramsal değişim koşullarından *verimlilik (fruitfulness)* sağlanmış olur. Öğretmen sorunun ilk kısmı için öğrencilere hızı nasıl tanımladıklarını hatırlatarak hesaplamalarda yol gösterir. Öğrencilerden TH= $\Delta M / \Delta t$ 'ye göre her bir zaman aralığındaki derişim değişimini hesaplayarak ortalama hızı bulmaları beklenmektedir. Her aralık için bulunan ortalama hız değeri zamanla bir öncekinden daha düşük olacaktır. Sorunun ikinci kısmı için öğretmen, hızdaki değişmenin düzgün mü değişken mi olduğunu sorar. Öğrenciler bu soruyu tartışarak hızın zamanla değişken olarak azaldığını uygulamalı olarak görmüş olurlar.

Tüm grup üyeleri tartışmalarını bitirip cevaplarını çalışma sayfalarına yazdıktan sonra öğretmen her gruptan bir kişiyi rastgele seçerek çözümlerini sınıfa açıklamasını ister. Seçilen sözcü açıklama yaparken yanlış cevap verdiğinde veya öğretmen gerekli gördüğünde müdahale ederek öğrenciyi doğru cevaba yönlendirecek sorular sorabilir ya da açıklamalar yapabilir. Bu kısımda sınıftaki diğer öğrenciler de tartışmaya katılabilirler. Öğretmen mutlaka her gruba doğru ya da yanlış olsun, cevapları ile ilgili geribildirim vermelidir. Tüm gruplar cevaplarını açıkladıktan sonra öğretmen soruların tam doğru cevabını özetler, varsa öğrencilerin sorularını cevaplandırır. Böylece kavramsal değişim koşullarından *anlaşılabilirlik (intelligibility)* ve *inandırıcılık (plausibility)* sağlanmış olacaktır. Öğretmen etkinlikler sonunda gruplardan, cevaplarının yazılı olduğu çalışma yapraklarını toplar ve onları değerlendirir. Bir sonraki derste cevaplarına göre her gruba geribildirim verecektir.

Ders sonunda tüm sınıfa Quiz 1 dağıtılır. Bu testin soruları grupça değil bireysel olarak cevaplandırılacaktır. Quiz sonuçları önemlidir çünkü tüm quizlerden en yüksek puanı alan grup üyeleri ödüllendirilecektir. Quizler daha sonra öğretmen tarafından değerlendirilerek ertesi hafta grup üyelerine, bireysel ve grup olarak performanslarını değerlendirmeleri için geri dağıtılır.

APPENDIX N

SAMPLE PHOTOGRAPHS FROM CONTROL GROUP

Figure N.1 A lesson from control group classroom in Anatolian high school.

Figure N.2 A lesson from control group classroom in Anatolian high school.

Figure N.3 A lesson from control group classroom in ordinary state high school.

Figure N.4 A lesson from control group classroom in ordinary state high school.

APPENDIX O

SAMPLE PHOTOGRAPHS FROM EXPERIMENTAL GROUP

Figure O.1 A lesson from experimental group classroom in Anatolian high school.

Figure O.2 A lesson from experimental group classroom in Anatolian high school.

Figure O.3 A lesson from experimental group classroom in ordinary state high school.

Figure O.4 A lesson from experimental group classroom in ordinary state high school.

VITA

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