EFFECT OF STRUCTURING COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE APPROACH ON STUDENTS' UNDERSTANDING OF THE CONCEPTS OF MIXTURES AND THEIR MOTIVATION

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ABSTRACT

EFFECT OF STRUCTURING COOPERATIVE LEARNING BASED ON CONCEPTUAL CHANGE APPROACH ON STUDENTS' UNDERSTANDING OF THE CONCEPTS OF MIXTURES AND THEIR MOTIVATION

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The purpose of this study is to investigate the effect of structuring cooperative learning based on conceptual change approach on grade nine students' understanding the concepts of mixtures and their motivation, compared to traditional instruction. Mixtures Concept Test (MCT), self-efficacy for learning and performance, task value, control of learning beliefs, and test anxiety sub-scales of Motivated Strategies for Learning Questionnaire (MSLQ), and mastery approach goals, mastery avoidance goals, performance approach goals, and performance avoidance goals dimensions of Achievement Goal Questionnaire (AGQ) were assigned to the sampled students before treatments are commenced as pretests and after treatments are completed as posttests. There were statistically significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures and their motivation. Results drawn upon interviews verified results of percentages of students' correct responses on the post-MCT that students in the structured cooperative learning group had fewer alternative conceptions about the concepts of mixtures as compared to students in the unstructured cooperative learning group and control group. Specifically, results of the present study revealed that students exposed to Cooperative Learning based on Conceptual Change (CLCC) had better understanding and lower alternative conceptions about the concepts of mixtures, perceived contents related to chemistry more valuable, felt greater control over their own learning, and adopted mastery approach goals more than students instructed by Cooperative Learning based on Conceptual Change without Well-Structuring the Basics of Cooperative Learning (CLCC(-)) and Traditional Instruction (TI).

Keywords: Constructivism, Conceptual Change Approach, Cooperative Learning, Mixtures, Motivation

ÖZ

KAVRAMSAL DEĞİŞİM YAKLAŞIMINA DAYALI İŞBİRLİKLİ ÖĞRENMEYİ YAPILANDIRMANIN ÖĞRENCİLERİN KARIŞIM KAVRAMLARINI ANLAMALARI VE MOTİVASYONU ÜZERİNE ETKİSİ

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Bu çalışmanın amacı, geleneksel anlatım yöntemi ile kıyaslandığında, kavramsal değişim yaklaşımına dayalı işbirlikli öğrenmeyi yapılandırmanın dokuzuncu sınıf öğrencilerinin karışım kavramlarını anlamaları ve motivasyonu üzerine etkisini incelemektir. Karışımlar Kavram Testi (KKT), Öğrenmede Güdüsel Stratejiler Anketi'nin (ÖGSA) öğrenme ve performans öz-yeterlik inançları, kimya değer inançları, öğrenme inançları denetimi ve sınav kaygısı alt-ölçekleri, ve Başarı Hedefi Anketi'nin (BHA) öğrenme-yaklaşım hedefleri, öğrenme-kaçınma hedefleri, performans-yaklaşım hedefleri ve performans-kaçınma hedefleri boyutları örneklemde bulunan öğrencilere çalışma başlamadan önce öntest olarak ve çalışma tamamlandıktan sonra sontest olarak dağıtılmıştır. Öğrencilerin sontest puanları, karışım kavramlarını anlamaları ve motivasyonu bakımından, kavramsal değişime dayalı işbirlikli öğrenme uygulamaları ile öğretim yapılan gruplar ve geleneksel anlatım yöntemi ile öğretim yapılan gruplar arasında anlamlı ortalama farkları olduğunu göstermiştir. Öğrencilerin sontest olarak dağıtılan KKT'ni doğru cevaplama yüzdesinden elde edilen sonuçlar, mülakatlardan elde edilen sonuçları doğrulamaktadır. Şöyleki, yapılandırılmamış işbirlikli öğrenme grubu ve kontrol grubundaki öğrencilerle kıyaslandığında, yapılandırılmış işbirlikli öğrenme grubunda yer alan öğrenciler karışım kavramları ile ilgili daha az kavram yanılgısına sahiptir. Bu çalışmadan elde edilen bulgular, İşbirlikli Öğrenme Temellerinin İyi Yapılandırılmadığı Kavramsal Değişime dayalı İşbirlikli Öğrenme (KDİÖ(-)) ve Geleneksel Anlatım (GA) ile öğretim gören öğrencilere kıyasla, Kavramsal Değişime dayalı İşbirlikli Öğrenme (KDİÖ) ile öğretim gören öğrencilerin karışım kavramlarını daha iyi anladıklarını ve daha az kavram yanılgısına sahip olduklarını, kimya ile ilgili içeriklerin daha değerli olduğuna inandıklarını, kendi öğrenmesi üzerinde daha fazla denetimleri olduğuna inandıklarını ve daha çok öğrenme-yaklaşım hedeflerine yöneldiklerini ortaya koymuştur.

Anahtar Kelimeler: Yapılandırmacılık, Kavramsal Değişim Yaklaşımı, İşbirlikli Öğrenme, Karışımlar, Motivasyon

To my dear family

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LIST OF ABBREVIATIONS

SCLG:	Structured Cooperative Learning Group
UCLG:	Unstructured Cooperative Learning Group
CG:	Control Group
CLCC:	Cooperative Learning based on Conceptual Change
CLCC(-):	Cooperative Learning based on Conceptual Change without Well-Structuring the Basics of Cooperative Learning
TI:	Traditional Instruction
STAD:	Student Teams-Achievement Divisions
MCT:	Mixtures Concept Test
WHGQ:	What Happened in the Group Questionnaire
MSLQ:	Motivated Strategies for Learning Questionnaire
SELP:	Self-Efficacy for Learning and Performance
TV:	Task Value
CLB:	Control of Learning Beliefs
TA:	Test Anxiety
AGQ:	Achievement Goal Questionnaire
MAP:	Mastery Approach Goals
MAV:	Mastery Avoidance Goals
PAP:	Performance Approach Goals
PAV:	Performance Avoidance Goals
MANOVA:	Multivariate Analysis of Variance
IV:	Independent Variable
DV:	Dependent Variable
SD:	Standard Deviation
N:	Number of Students
p:	Significance Level
F:	F Statistic
df:	Degrees of Freedom

CHAPTER 1

INTRODUCTION

The expanding role of science and technology on today's rapidly changing world brings it compulsory to make all citizens scientifically literate (Rutherford, 2001) who have "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" (OECD, 2003, p. 133). With these circumstances in mind, the essential function of science education is to enable students to live with appropriate levels of understanding and confidence within the world of science and technology as human endeavors (OECD, 2003). Instead of supplying science education exclusively to the students who will be the scientists of tomorrow, all students should have a chance to experience science concepts and scientific processes as being citizens of the society. Following these developments, both international and national reform documents reported the essential goal of science education as to educate scientifically literate students (American Association for the Advancement of Science, 1989; Ministry of National Education, 2004).

Scientific literacy is not an unidimensional construct that covers only learning of scientific concepts (Osborne, 2007) but also includes beliefs about the nature of knowledge and learning, in other words epistemology of science (Schommer, 1990). Students who have sophisticated or constructivist understanding of epistemology of science view the nature of knowledge as a set of complex constructs and tentative, believe the importance of reasoning and creativity for the growth of scientific knowledge, realize the role of social communications for the development of science, view scientific concepts as constantly changing, and feel the active role of themselves during scientific knowledge construction (Schommer, 1990). Developing students' beliefs about the epistemology of science is a common goal of science education, accepted in all over the world (American Association for the Advancement of Science, 1989; Lederman, 1992; Ministry of Education, 2004; Osborne, 2007).

The requirements of the world of science and technology and the resulting concerns, scientific literacy and epistemology of science, force national education systems to change comprehensively in such a way to internalize constructivist approaches to learning not only on philosophical enterprises and educational policies but also on each of the elements of the educational program which are objectives; learning units or themes; instructional methods, strategies, activities, materials; assessment and evaluation circumstances. Besides educational issues related with the program, institutions within the educational settings such as teacher education departments of universities and schools and education-related people like policy makers, administrators, teachers, students, and families experience shift in the view of learning and teaching.

Constructivism, the dominant learning approach in recent decades, is a broad term that roots in philosophical stances of epistemology of science which results in various usage of the term by different authors. For providing a common understanding of constructivism therefore, it becomes important to define in what aspects a researcher employs constructivism like stating constructivism as a pedagogic movement concerning with how students construct new knowledge in their minds during learning (Bektaş & Taber, 2009). Piaget (1950) viewed constructivism as a process under the view of cognitive development in which students construct their own meaning of concepts by means of assimilation and accommodation. According to the definition of constructivist view of learning, it is especially important to analyze two features of it which are, the active nature of learning process, and the existing knowledge of learners (Driver & Oldham, 1986). Opposite to empiricist view that emphasizes exclusively the importance of the quantity of knowledge gained as a product of learning, theories of learning based on constructivist ideas declare that learning is a process in which students acquire knowledge actively and it is this process that learning takes place, or in other words not only quantity but also quality of knowledge acquired is crucial for learning (Alexopoulou & Driver, 1996). Correspondingly, students within constructivist environment do not memorize scientific truths arbitrarily rather employ conceptual learning by involving in various activities, working collaboratively, negotiating with peers and the teacher, attending lessons actively, and relating new ideas with previous knowledge. Actually, one of the most important principle of constructivist view of learning is that students' existing ideas form the basis for interpreting new knowledge. In other words, constructivist thought emphasizes meaningful learning of scientific concepts that can be acquired through forming links between new information and what learners already have (Posner, Strike, Hewson, & Gertzog, 1982). Ausubel (1968) stated that "the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (p.vi). To sum up, students within constructivist oriented view are at the center of learning through active exploration of new knowledge by the guidance of the teacher who facilitates learning process by teaching in such a manner to make information meaningful and relevant to students (Slavin, 2009).

As a result of taking students' previous ideas into consideration and giving them chance to build up meaning of the scientific concepts in their own minds, constructivist approach deals automatically with issues in the case of absence or incomplete prerequisite knowledge, alternatively presence of alternative conceptions. The concepts which are not consistent with science communities' points of view are mentioned as "misconceptions" (Nakhleh, 1992; Wandersee, Mintzes, & Novak, 1994; Schmidt, 1997), "preconceptions" (Ausubel, 1968), "children's science" (Gilbert, Osborne, & Fensham, 1982; Osborne & Wittrock, 1983), or "alternative conceptions" (Driver & Easley, 1978; Dykstra, Boyle, & Monarch, 1992; Taber, 2001), which have similar meanings in nature whereas each of which reflects researchers' approach to education. Using the term misconceptions reflects traditional view of learning, the term alternative conceptions, on the contrary, indicates an internalization of constructivist view of learning (Taber, 2000; 2001). Although alternative conceptions are not get along well with scientists' explanations, students often believe correctness of their own conceptions which cause alternative conceptions to settle down and resistant to change through traditional instruction (Driver & Easley, 1978; Gilbert, Osborne, & Fensham, 1982; Tsai, 1999).

Hence most of the students view chemistry lessons rather challenging, various research studies have been conducted to examine what causes chemistry to be perceived as such a difficult lesson (Bodner, 1991). Making necessary connections among macroscopic, sub-microscopic, and symbolic representations of chemistry concepts, the abstract and conceptual nature of the chemistry discipline and its corresponding call for higher order thinking skills, and inconsistency between terminologies of chemistry classes and daily lives, are the mostly pronounced difficulty areas of chemistry lessons (Sirhan, 2007). Learners' conceptions regarding the concept of mixtures, one of the most basic and abstract chemistry concept, have been searched deeply by various researchers within international (Cosgrove & Osborne, 1981; Holding, 1987; Fensham & Fensham, 1987; Prieto, Blanco, & Rodriguez, 1989; Stavy, 1990; Johnson & Scott, 1991; Abraham, Grzybowski, Renner, & Marek, 1992; Abraham, Williamson, & Westbrook, 1994; Ebenezer & Erickson, 1996; Blanco & Prieto, 1997; Sanger, 2000; Valanides, 2000a; 2000b; Stains & Talanquer, 2007) and national contexts (Çalık, 2003; Pınarbaşı & Canpolat, 2003; Çalık & Ayas, 2005a; 2005b; 2005c; Uzuntiryaki & Geban, 2005; Pınarbaşı, Canpolat, Bayrakçeken, & Geban, 2006; Çalık, Ayas, Coll, Ünal, & Coştu, 2007; Coştu, Ayas, Niaz, Ünal, & Çalık, 2007; Pınarbaşı, Sözbilir, & Canpolat, 2009; Tüysüz, 2009; Kalın & Arıkıl, 2010).

As a result of realizing that students bring ideas into science classes, it becomes imperative to elicit learners' alternative conceptions before science instruction to inform teaching or even after the science instruction due to persistent nature of alternative conceptions by the ways of traditional means (Wandersee, Mintzes, & Novak, 1994; Taber, 2001). However, identifying alternative conceptions is not a sufficient solution to remedy their formation (Mulford & Robinson, 2002), which results in widespread research in science education literature for twenty years or more that suggest alternative learning methods based on constructivist views of learning in order to prevent formation of alternative conceptions and to remove inhibiting effects of them on student achievement (Stavy, 1988; Hand & Treagust, 1991). Conceptual change has long been emphasized as one of the constructivist approaches in science to overcome alternative conceptions (Hewson & Hewson, 1983; Hand & Treagust, 1991; Treagust, Harrison, & Venville, 1998; Tsai, 2000) through making learners experience conflicts with noninstance examples of the concept under examination as a means of promoting their cognitive structures (Posner et al., 1982). Conceptual change model has deep roots on the Piaget's theory of cognitive development which has influential implications on the theory and practice of education. According to Piaget, children adapt schemes, which are patterns in the mind that direct behavior, through the processes of assimilation and accommodation. The former takes place when a new knowledge could be handled by already existing scheme, the latter, on the other hand, occurs if new knowledge could not be explained by existing scheme of how the world works which results in adaptation of current scheme or development of completely new scheme in cognitive structures. In other words, students effort to return equilibration from the state of disequilibrium that is the condition for learning to take place (Dykstra, 1992; Slavin, 2009). Posner and his colleagues (1982) expanded Piaget's notions of assimilation and accommodation and focused especially on the accommodation phase which occurs when the intelligible, plausible, and fruitful knowledge contradicts with the existing knowledge structure. Theories being reviewed can be applied into science classes by organizing learning environment in a manner to provide learners interact with each other, discuss different opinions, and manage cognitive conflicts constructively for conceptual change to take place (Dykstra, 1992).

Like Piaget, who proposed peer interaction as a valuable condition for conceptual change to happen, Vygotsky (1978) deeply emphasized the role of cultural contexts on learning in the sociocultural theory. According to Vygotsky, students learn knowledge through assistance of others and after that rigorous scaffolding students are encouraged to do the professionalized work individually to let knowledge to be internalized which shows learners' ability to know without the aid of others. Student learning is mediated by adults or more capable peers than by individual efforts, however there is a condition to make it true-the learning tasks should fall within the zone of proximal development which is the "level of development immediately above a person's present level" (Slavin, 2009, p. 43). In other words, a student can learn only concepts that fall within zone of proximal development but cannot acquire more complex one if that knowledge is beyond the capability of the learner even studying with their peers. Based on the cognitive developmental perspective of Vygotsky, current constructivist view of learning suggests extensive use of cooperative learning as a pedagogical practice to promote higher student outcomes (Cohen, 1994; Slavin, 1996; 2009; Johnson & Johnson, 2002).

Deutsch (1949) differentiated three kinds of goal structures, strategies that indicate the nature of interaction among students and the teacher to reach the desired outcome in the subject under attention, as cooperative, competitive, and individualistic (as cited in Johnson, Maruyama, Johnson, Nelson, & Skon, 1981). These goal structures separate from each other with regard to some aspects such as the learning goal, the quantity and quality of interaction, and the way of assessing student learning. Cooperative goal structure, for example, suggests applications of cooperative learning which can be defined as "the instructional use of small groups so that students work together to maximize their own and each other's learning" (Johnson & Johnson, 1999, p. 5). Slavin (2009), furthermore, described cooperative learning as "an instructional method in which students work together in small-mixed ability groups to help each other learn" (p. 243). Cooperative learning has been searched extensively that results in numerous studies related to the effects of this innovative approach on students' cognitive (Johnson & Johnson, 1999; Fall & Webb, 2000) and non-cognitive outcomes (Johnson & Johnson, 1989; Slavin, 1991; 1996) across various disciplines from primary school through to high school, and college levels (Johnson, Johnson, & Stanne, 2000; Slavin, 1996). Despite definite benefits, however, it is well known that just placing students together and expecting them to work cooperatively may not guarantee they did so (Johnson & Johnson, 1999; 2009). In other words, whether a group is to be a truly cooperative learning group depends on how firmly it is structured; that is, the basic elements of cooperative learning are well established or not. Johnson and Johnson (1999) distinguished pseudo and traditional learning groups from cooperative learning groups on the basis of goal structures. More specifically, although pseudo and traditional learning groups make use of small group practices, neither pseudo-learning groups nor traditional learning groups promote cooperation among members, but intragroup competition and individualistic work with talking, respectively. Similarly, Gillies (2004) differentiates cooperative groups by manipulating the components of cooperation and described the group as structured cooperative group if basics are well-structured, and unstructured cooperative group if components of cooperative learning are not structured well, but on ad hoc basis.

Johnson and Johnson (1999) described basic components of effective cooperative learning as positive interdependence, individual and group accountability, face-to-face promotive interaction, social skills, and group processing. Positive interdependence, the most essential element of cooperative learning, is the perception that each member's contribution is valuable for attaining a shared goal, or in other words, a person cannot complete the assigned task without contribution of others. When positive interdependence among group members is well-structured, intellectual disagreements may emerge which result in better mastery and retention of tasks if it is managed constructively. Individual and group accountability is another element of a healthy cooperative learning that makes individuals to learn the assigned material and to ensure that all members of the group are ready to get the highest point from the quiz following team practice. Face-to-face promotive interaction is the most powerful element of cooperative learning in terms of psychological adjustment (Johnson & Johnson, 1989). Establishing promotive interaction enables members to discuss on the assigned task, share resources and information, give feedback to each other, encourage and praise each other's efforts to learn, behave in trustworthy ways, and develop personal rapport which in turn increases students' motivation to work together (Sharan & Shaulov, 1990; Johnson & Johnson, 1999). Besides academic work, students are required to learn teamwork skills in order to be successful in cooperative learning. Students must know how to communicate effectively, manage conflict constructively, listen to each other, give and receive help, share leadership, respect each other, share resources, and make democratic decisions (Johnson & Johnson, 2009) within structured cooperative learning groups. In fact, social skills are pre-requisite behaviors for all other elements of cooperative learning. Group processing is the last element of an effective cooperative learning which requires students to plan, monitor, and evaluate efforts in order to facilitate future performance of the group (Johnson & Johnson, 1994). In other words, group processing involves students' perceptions of what happened within the group (Johnson, Johnson, Stanne, & Garibaldi, 1990; Gillies, 2004). To sum up, any group that lacks these basic elements cannot be labeled as cooperative learning group but can be a traditional learning group which is characterized by Johnson and Johnson (1999) as a group in which students work individually with little or no commitment to each other's learning and with neglected social skills and group processing. According to Gillies (2004), unstructured cooperative learning groups have the same framework with what Johnson and Johnson (1999) labeled as traditional learning groups, and structured cooperative learning groups have the same discourse with that of truly committed cooperative learning groups.

Several cooperative learning methods have been developed and evaluated in recent decades (Slavin, 2009), some of them are suitable for specific disciplines and grade levels, like Team-Assisted Instruction (Slavin, Madden, & Leavey, 1984) and Cooperative Integrated Reading and Composition (Stevens, Madden, Slavin, & Farnish, 1987), and some of them are applicable to broader subjects and grade levels, such as Student Teams-Achievement Divisions (Slavin, 1995), Teams-Games-Tournament (DeVries & Edwards, 1974), Jigsaw (Aronson, Blaney, Stephen, Sikes, & Snapp, 1978), Learning Together (Johnson & Johnson, 1999), and Group Investigation (Sharan & Sharan, 1992). Student Teams-Achievement Divisions (STAD), for instance, can be employed through following regular cycle of five major components namely class presentation, team study, individual quizzes, individual improvement scores, and team recognition (Slavin, 1991; 2009). Being offered as one of the greatest success of educational history (Slavin, 1996), the cooperative learning strategy has been reported to have positive effects on various variables such as student achievement, motivation to learn, and socialization among peers (Slavin, Madden, & Leavey, 1984; Johnson & Johnson, 1989; Slavin, 1990; 1996; Calderon, Hertz-Lazarowitz, & Slavin, 1998; Johnson & Johnson, 1999; Fall & Webb, 2000; Johnson, Johnson, & Stanne, 2000), when it is committed effectively (Slavin, 1996; Johnson & Johnson, 1999).

Cooperative learning is an exceptional strategy which encourages conceptual change by providing learning environments where students have a chance to make their internal speech public within small groups that frequently results in facing with divergent viewpoints and experiencing intellectual disagreement, the crucial occasion for students to search for more information (Webb, 1997; Johnson & Johnson, 1999). The stimulating impact of intellectual disagreement becomes evident when positive interdependence is firmly structured and students are taught on how to resolve conflicts constructively. When managed constructively, intellectual disagreement among members results in frequent use of higher-order thinking skills, higher mastery and retention (Johnson & Johnson, 1999), and greater commitment to the task assigned to group (Behfar, Mannix, Peterson, & Trochim, 2010), which is not the case when students working alone in competitive and individualistic learning environments (Johnson & Johnson, 1999). Besides task-related interactions, interpersonal interactions take place within groups as a result of realizing the meaning of being together as a group that increases enthusiasm for and motivation to group which in turn help students change their alternative conceptions with scientifically accepted ones (Pintrich, Marx, & Boyle, 1993). Based on the given theoretical perspective, the purpose of this study is to investigate the effect of structuring cooperative learning accompanied with conceptual change approach on grade nine students' understanding the concepts of mixtures and their motivation.

1.1. The Main Problem and Sub-Problems

1.1.1. The Main Problem

What is the effect of structuring cooperative learning based on conceptual change approach (CLCC and CLCC(-)) on grade nine students' understanding the concepts of mixtures and their motivation, as compared to traditional instruction?

1.1.2. The Sub-Problems

1. Is there a statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures?

2. Is there a statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' motivation (Self-Efficacy for Learning and Performance, Task Value, Control of Learning Beliefs, Test Anxiety, Mastery Approach Goals, Mastery Avoidance Goals, Performance Approach Goals, Performance Avoidance Goals)?

3. What are grade nine students' conceptions about the concepts of mixtures?

1.2. The Hypotheses

The first and second research problems were tested with the subsequent hypotheses, stated in null form:

1. There is no statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures.

2. There is no statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' motivation (Self-Efficacy for Learning and Performance, Task Value, Control of Learning Beliefs, Test Anxiety, Mastery Approach Goals, Mastery Avoidance Goals, Performance Approach Goals, Performance Avoidance Goals).

1.3. Definition of Important Terms

The following definitions are provided for the purposes of this study.

Constructivism: The basic premise of constructivist theory of knowledge is that knowledge is constructed in the mind of the learner (Bodner, 1986, p. 873).

Alternative Conceptions: Divergent student beliefs regarding how the world works (Dykstra, Boyle, & Monarch, 1992) which are potential barriers to oncoming learning (Hewson & Hewson, 1983) and resistant to change through traditional instruction (Driver & Easley, 1978).

Conceptual Change: A popular approach in explaining how learners change their alternative conceptions with that of scientifically correct ones through introducing disagreement with the intelligible, plausible, and fruitful information (Posner et al., 1982).

Conceptual Understanding: The performance of students regarding the concepts of mixtures assessed quantitatively by the Mixtures Concept Test, and qualitatively by the semi-structured interviews, both of which were developed by the researcher.

Traditional Instruction: An instruction favoring environments based on rote learning where the teacher explains scientific knowledge through lecturing and asking factual questions mostly to successful students without taking possible alternative conceptions into account when individual students silently listen and take notes.

Cooperative Learning: An exceptional instructional strategy that enables students to work together in small groups where members bound each other through common group goal, joint reward, challenging task, mutual identity, complementary role and resource (Johnson and Johnson, 1999).

Structured Cooperative Learning Group: A learning group having the same framework with that of a truly committed cooperative learning group whose members are aware of the importance of working together to achieve group's goal, are accountable as an individual and as a group, promote each other's learning by giving help and encouragement, receive training in interpersonal and small group skills necessary to complete tasks as a group, and reflect on what happened in the group while members work together (Johnson & Johnson, 1999).

Unstructured Cooperative Learning Group: A learning group having the same discourse with that of a traditional learning group whose members appear as if cooperating with each other but working alone with talking, are accountable solely as an individual, committed to their own learning but not to each other's learning, are not taught teamwork skills, and do not assess members' contribution to group (Johnson & Johnson, 1999).

Student Teams-Achievement Divisions: A method grounded on the motivational perspectives of cooperative learning which attributes achievement outcomes to group goals or group rewards based on individual learning of every group members (Slavin, 1996).

Motivation: Students' beliefs about how valuable chemistry is, their efficacy to be successful in chemistry, control over their own learning in chemistry and their anxiety in chemistry tests, measured by the sub-scales of the Motivated Strategies for Learning Questionnaire (task value, self-efficacy for learning and performance, control of learning beliefs, test anxiety), which was developed by Pintrich, Smith, García and McKeachie (1991), and students' purposes of being engaged in chemistry tasks assessed by the sub-scales of the Achievement Goal Questionnaire (mastery approach goals, mastery avoidance goals, performance approach goals, performance avoidance goals), which was established by Elliot and McGregor (2001).

1.4. Significance of the Study

Various research studies have been conducted on learners' alternative ideas on scientific concepts in sevaral topics of the chemistry discipline (Cosgrove & Osborne, 1981; Haidar & Abraham, 1991; Tan & Treagust, 1999; Niaz, 2002). Mixtures, one of the most basic and abstract topic of chemistry, covers heterogeneous and homogeneous mixtures as physical composition and atoms and/or molecules as chemical composition. Therefore, the concepts of mixtures provides basis for more advanced chemistry concepts that handle both sub-microscopic and macroscopic representations to explain chemical phenomena like the structure of matter and its properties, and solution chemistry (Fensham & Fensham, 1987; Ebenezer & Erickson, 1996). Besides its fundamental position in chemistry programs, the position of it in real life situations makes valuable contributions to the importance of mixtures since the main goal of science education is to educate scientifically literate students (American Association for the Advancement of Science, 1989; Ministry of Education, 2004) who are able to transfer knowledge from classroom settings to real life circumstances. Furthermore, researchers prefer dealing only with students' ideas on some important aspects of homogeneous mixtures, called solutions as well, such as the nature of solutions (Prieto, Blanco, & Rodriguez, 1989; Fensham & Fensham, 1987), types of solutions (e.g. saturated, unsaturated, supersaturated, diluted, concentrated solutions) (Pınarbaşı & Canpolat, 2003; Çalık, 2003; 2005), dissolution process (Abraham et al., 1992; Abraham et al., 1994; Ebenezer & Erickson, 1996; Çalık, 2003; Uzuntiryaki & Geban, 2005), and factors affecting solubility (e.g. temperature, pressure, stirring, surface area) (Blanco & Prieto, 1997; Çalık, 2003; 2005; Valanides, 2000a), but skipping various related concepts out like heterogeneous mixtures and separation of mixtures. There are a few studies related with separation of mixtures that are conducted in international (Valanides, 2000a; 2000b) and national (Tüysüz, 2009) basis, however, it is one of the two sub-topics of mixtures in grade nine chemistry program. To sum up, the essential place of mixtures in the chemistry program and in real life situations, and the necessity to cover the concepts of mixtures as a whole make it crucial to study on the concepts of mixtures which is the first reason of conducting this study.

Related literature not only emphasizes the importance of identifying alternative conceptions but also implies the necessity of employing alternative instructional methods and strategies to traditional instruction for eliminating specified alternative conceptions and diminishing their inhibitive effects on future learning (Osborne, 1983; Stavy, 1988; Hand & Treagust, 1991). Cooperative learning is proved to be as a beneficial teaching strategy that affects students' science achievement, motivation to learning, and social relations among peers positively when compared to traditional instruction (Cohen, 1994; Shachar & Sharan, 1994; Slavin, 1996; Fall & Webb, 2000; Johnson & Johnson, 2002; Gillies, 2003; 2004). However, the related literature points out that it is necessary to investigate the conditions under what cooperative learning has positive effects on such diverse student outcomes (Slavin, 1996; Johnson, Johnson, & Stanne, 2000; Gillies, 2004). To inspect the necessary conditions, it is important to differentiate cooperative learning groups from other types of learning groups through structuring cooperative work, explicitly (Johnson & Johnson, 1999; Gillies, 2003; 2004). Johnson and Johnson (1999) stated that performance of learning groups depends on the way cooperation is structured, that is whether or not the basics of cooperation are well established. Gillies (2004) differentiates cooperative groups by manipulating the components of cooperation and described the group as structured cooperative learning group if basics are well-structured, and unstructured cooperative learning group if components of cooperative learning are not structured well, but on ad hoc basis. Johnson & Johnson (1999), on the other hand, defined learning groups as pseudo-learning group, traditional learning group, and cooperative learning group with regard to goal structures. In particular, the structure of pseudo and traditional learning groups do not encourage cooperation with group members, but competition among members and individualistic work with talking, respectively. Besides examining potential effects of structuring learning groups (i.e. unstructured and structured cooperative learning groups), combining cooperative learning with conceptual change approach is hoped to make this study more valuable. Actually, both conceptual change approach and cooperative learning strategy proved their effectiveness in their own rights, whereas the strength of applying cooperative learning on the basis of conceptual change conditions is assumed to be overwhelming since "the greater the positive interdependence within a learning group, the greater the likelihood of intellectual disagreement and conflict among group members" (Johnson & Johnson, 1999, p. 87). As members share divergent thoughts on a subject matter within groups, they frequently experience cognitive conflicts that cause every members to search for more information to achieve the specific goal as a group. The necessity of structuring cooperative efforts in order for to have a healthy cooperative learning group and the potential of using combination of cooperative learning and conceptual change approach are hoped to enrich this study which forms the second reason of performing this study.

There are many research studies related with the effect of cooperative learning on science achievement and motivation of students including a range of grade levels from primary to high and to college levels. The rationale of selecting the subjects of this study from grade nine students is threefold; first of all, students select subject specialists at grade ten in Turkish context and all of the students do not prefer dealing with scientific concepts in their future lives. As a result, ninth grade is crucial for supplying adequate scientific information to survive without science education for the following times, that is grade nine is the constitutive level for the main goal of science education which is to educate scientifically literate students. Second reason of working with grade nine students is the positive effects of cooperative learning on diminishing problems related with the period of adolescents. Adolescents cope with the problems of this developmental stage by the means of peer collaboration since most of them feel that peers are closer to them as compared to teachers, or even family members. Research studies reported that cooperation among peers results in better social communication, higher achievement, and enhanced self-esteem (Rutherford, Mathur, & Quinn, 1998). The last reason of preferring grade nine students is related to the content of mixtures in ninth grade chemistry program. The chemistry program is spiral in nature in Turkish context, that is students encounter similar contents at different grade levels according to gradual complexity levels. Students are exposed to the concepts of mixtures at grade four in relatively easy form, at grade seven in more complex form, and at grade nine in the most comprehensive form. As a result, grade nine is the appropriate level that serves the purpose of covering the concepts of mixtures as a whole. To sum up, being at the core of the main goal of science education, including students who might experience several problems regarding the period of adolescents, and involving the most comprehensive content related to the concepts of mixtures make grade nine significant level to be studied which constitutes the third reason of conducting this study.

As noted in the second reason of conducting this study, cooperative learning is a beneficial instructional strategy not only for achievement gains but also for motivational outcomes (Slavin, 1996; Dörnyei, 1997; Johnson & Johnson, 1999; Taştan, 2009). Researchers described how cooperative learning motivates students on the basis of reward or goal structures. While Slavin (1996) stated that students are motivated to learn as a result of rewarding groups based on the individual learning of every group members, Johnson and Johnson (1999) assumed that it is not rewards, but "working together and joint aspirations to achieve a significant goal" (p. 188), that motivates students to help each other's mastering the task and praise joint efforts. Dörnyei (1997), further described how students are motivated by cooperative learning interventions by applying group cohesiveness, which is proposed to be promoted by positive interdependence and the small group style. When descriptions of above researchers are analyzed thoroughly, it is possible to attribute motivation gains to the basics of cooperative learning, as in the case of achievement gains. Whereas there are numerous studies reporting that cooperative learning has positive effects on students' motivation, there are inadequate amounts of research study investigating particularly the effect of structuring cooperative learning on specific motivational constructs. Among scarce research studies, Johnson and Johnson (1994) suggested that students' motivation for learning and working as a group and their sense of self-efficacy for learning and performance are to be enhanced by assessing students' behaviors while they were working in groups and giving simultaneous feedback to make them know how they have processed. Therefore, it is crucial to conduct an experimental study examining conditions under which students' adaptive (e.g. self-efficacy, task value, control of learning beliefs, mastery approach goals) and maladaptive motivational beliefs (test anxiety, performance avoidance goals) are promoted. In addition to the necessity of structuring cooperative efforts, it is important to analyze the effect of motivational beliefs on the conceptual change process since goals, values, self-efficacy, and control beliefs were proposed as the mediators of conceptual change by Pintrich et al. (1993). They claimed that students approach scientific concepts through adopting mastery goals and developing higher levels of self-efficacy when tasks are optimally challenging, open-ended and related closely with real life circumstances; instructional strategies depend heavily on vigorous interaction between students and the teacher; learning contexts favor students' responsibility on their own learning; and evaluation procedures promote cooperative goal structure instead of competitive and individualistic goal structures. Correspondingly, this study combines cooperative learning with conceptual change approach to investigate its effect on student' self-efficacy for learning and performance, task value, control of learning beliefs, test anxiety, and achievement goals. The necessity of structuring cooperative efforts to develop students' adaptive motivational beliefs and the mediating effects of certain motivational beliefs on students' understanding the scientific concepts are hoped to enlighten the related literature, which is the last reason conducting this study.

CHAPTER 2

REVIEW OF RELEVANT LITERATURE

Behavioral theory of learning, which had great influence on education during the century of early 20, deals primarily with observable and measurable behaviors without taking internal mental structures present within the mind of learners into account. Behaviorists describe learning as an observable process through which learners give responses to stimuli by the means of experiences they acquire within the environment that is responsible for development and learning (Wodsworth, 1996). Viewing environment as the unique distinctive of learning can be interpreted as treating students as passive receptors of absolute reality of the world and teachers, on the contrary, as the authority responsible for learning by well-organized direct instruction. In other words, behaviorist view of learning assumes that "knowledge can be transferred intact from the mind of the teacher to the mind of the learner" (Bodner, 1986, p. 873). The roles assigned to learners and teachers encourage rote learning in which the knowledge to be learned is arbitrarily emposed into learners' knowledge structure (Ausubel, Novak, & Hanesian, as cited in Bodner, 1986) and the learners who learn by rote are unsuccessful to remember that knowledge which mostly results in situated learning, that is, being unable to transfer knowledge into different contexts like other lessons or real life conditions (Novak, 2002). In brief, behaviorists' points of view on how learning occurs, nature of knowledge, roles of students and teachers during learning and, the way students approach to learning reflect traditional aspects of learning, and education in a broader sense. The main goal of traditional science education is to make students to acquire every bits of scientific knowledge implanted through teachers who are the experts of knowledge under discussion. To sum up, behavioral view of learning views quantity of knowledge gained as a product of learning which emphasizes the importance of the content based programs on learning. However, educating students exclusively to cover all of the contents within the science programs without considering their cognitive structures does not satisfy the needs of today's world of science and technology which results in a "paradigmatic shift from behavioristic to cognitivistic views of learning" (Carter-Cohn, 1993, p. 5).

Cognitive theory of learning mainly concerned with the effects of stimuli on internal mental structures of learners through which response to that stimuli is generated. Cognitive perspective views learning as a reflection of mental processes that makes learners mentally and physically active during knowledge acquisition (Wodsworth, 1996). Active construction of knowledge in the mind of the learner enables students to take responsibility for their own learning by the active guidance of teachers and even peers. Moving students to the center of learning instead of teachers and educational programs can be interpreted as learners have prior knowledge on which new knowledge is constructed. Making necessary connections between what the learner already knows and the knowledge to be learned promotes meaningful learning (Novak, 2002) that makes knowledge to gain functionality not only in the classroom but also in the real life conditions. However, the extent of prior knowledge may be limited or not in conformity with scientifically accepted views and such a situation may prevent knowledge construction or results in deviated meanings of that knowledge (Chandran, Treagust, & Tobin, 1987; Novak, 2002) which are called alternative conceptions (Dykstra, Boyle, & Monarch, 1992; Taber, 2001) and resistant to change through traditional instruction (Driver & Easley, 1978; Wandersee, Mintzes, & Novak, 1994). Briefly, cognitive view of learning does not primarily deal with what is taught and how much is gained but focuses mainly on how knowledge is constructed by the learner and the quality of knowledge gained as a product of learning that is in accordance with the essential goal of contemporary science education which is to educate scientifically literate students (American Association for the Advancement of Science, 1989; Ministry of National Education, 2004). Since cognitive theory of learning has given rise to constructivist view of learning (Carter-Cohn, 1993), one can extend the notion as; the aim of science education can be achieved through putting constructivist ideas into practice.

Constructivist approach encourages science educators to assist learners by the means of various instructional approaches and strategies which are appropriate to students' developmental stages, interests, needs, and the extent of their prior knowledge. Conceptual change, which is an instructional approach to dispel alternative conceptions and facilitate meaningful learning, is consistent with the constructivist theory of learning (Posner et al., 1982). Research studies point that strategies that promotes conceptual change are effective in eliminating scientifically incorrect conceptions (Niaz, 2002). Among strategies used in conceptual change, cooperative learning is an efficient way of making students experience cognitive conflict through negotiating with peers and the teacher which in turn helps learners to change their existing scheme with the scientifically correct concept and results in higher understanding and thinking skills (Cohen, 1994; Hogan, Nastasi, & Pressley, 1999) if learning groups are well-structured as to be truly cooperative learning groups (Johnson & Johnson, 1999; 2009). Based on this ground, the purpose of this study is to investigate the effect of structuring cooperative learning based on conceptual change approach on grade nine students' understanding the concepts of mixtures and their motivation.

The review of literature is organized in a manner to comprehend concepts related to the underlying theoretical perspective, deductively. Literature review commences with constructivism as a learning theory under the cognitive view of learning and, proceeds with alternative conceptions in the chemistry as one of the disciplines of science and in the mixtures as one of the most abstract concepts of chemistry, continues with conceptual change approach and cooperative learning as the instructional strategies based on constructivist approach and, ends with concerns related to motivation.

2.1. Constructivist Theory of Learning

It is universally accepted that possessing full list of knowledge present within the science programs is almost impossible to achieve. Fortunately, this is not the condition to be a scientifically literate person. Contemporary science education aims to educate students who have the capacity to apply their knowledge in school and other related contexts to live with appropriate levels of understanding and confidence in present and future lives (OECD, 2003) rather than students who arbitrarily place all sorts of knowledge into the knowledge structure without comprehending the meaning of that knowledge. In order to be able to transfer a scientific knowledge in contexts of relevance, students have to understand meaning and connect necessary links with related concepts. In other words, students have to internalize scientific knowledge to be able to apply that knowledge into related contexts. Actually, constructivism can be a cure for enabling students to transfer knowledge since it is based on the assumption that "knowledge is constructed in the mind of the learner" (Bodner, 1986, p. 873). This single statement has a power to summarize constructivist theory of learning by emphasizing several important features of it which are knowledge construction takes place within the mind of the learner and learners are active participants of learning process. In addition to knowledge construction process and the roles of learners on their own learning, constructivist theory of learning focuses on the nature of knowledge and the roles of teachers as well. All of the specified features of constructivist theory of learning are reported in the following paragraphs.

According to the epistemological perspective of constructivism, it is a theory of knowledge that focuses on the nature of knowledge and knowledge acquisition (Duit, 1996; Novak, 2002). Traditional theories of knowledge are based on the realist philosophy of science and constructivist theories of knowledge, on the other side, internalized the ideas of relativist philosophy of science. Realists and relativists disagree on "the extent to which the world is knowable" (Bodner, Klobuchar, & Geelan, 2001, p. 6). Realists believe that humans have truths in their minds when they come into the world and the function of science education is to reveal existing mental structures related to the external world through replicating directed experiments. Relativist point of view, on the other hand, embraces existence of real world and reality but queries whether that reality is observable truly or not (Bodner, Klobuchar, & Geelan, 2001). In other words, constructivist theory views reality as unknown and knowledge as tentative and emphasizes that the important point is not whether true knowledge is accessible or not but knowledge works or not (Bodner, 1986). Learners make inferences on the basis of their prior knowledge, beliefs, and values that result in various explanations for the same concept. More specifically, social interactions and cultural milieu influence learners' construction of meaning in their minds. Of course, some scientific knowledge are factual and require solely remembering whereas, the others which can be labeled as "useful knowledge" are relative and necessitate meaning making (Bodner, Klobuchar, & Geelan, 2001).

Up to here, information related to the nature of knowledge was manifested. Then, it is the time to discuss the knowledge construction aspect of constructivism. Students in constructivist learning environment acquire knowledge through making connections between the knowledge to be learned and the existing knowledge structure. In other words, learning is viewed as a process in which mentally active learners construct their own meaning by arousing existing structures, that is, in a meaningful way. Two conditions are necessary for meaningful learning to occur namely "the quantity and quality of relevant knowledge possessed by the learner" and "the degree of her/his effort to integrate new knowledge with existing relevant knowledge" (Novak, 2002, p. 552). Moreover, Ausubel (1968) claimed that "the most important single factor influencing learning is what the learner already knows" (p.vi). It is obvious that faulty or unintended prior knowledge of learners has great influence on their future learning because in that case, the recent knowledge cannot be constructed on the existing one and correspondingly, the existing knowledge cannot be reconstructed. In order to be able to understand profoundly how learners construct knowledge in their minds-personally or socially-discussing on Piaget's and Vygotsky's views of cognitive development seems to be appropriate for the scope of the dissertation.

Piaget (1950) claimed that all children experience the same mental sequences as they grow up but the pace of development is not the same which is a variable influenced mostly by environment rather than heredity. In other words, individuals' cognitive structures become more sophisticated naturally as they develop but the pace of development may be different for individuals who are at the same age, which means that there are individual differences among children. In the theory of intellectual development, Piaget (1950) believed that students construct knowledge through adjusting existing schemes by assimilation or accommodation, that is, through the process of adaptation. Assimilation occurs when the meaning of new knowledge can be constructed by means of the existing scheme. Accommodation, however, takes place if the new knowledge cannot be explained in terms of the present scheme which creates disequilibrium in the mind of learners. Under such an imbalance between new and old knowledge, learners effort to turn back to equilibrium which is the process described by Piaget as equilibration. Actually, learners carry out accommodation to be able to get rid of situations that cause conflict in their cognitive structures and it is this process that is responsible for learning. Learners change their existing scheme through developing a completely new scheme or repairing the existing one which is the view of learning from the conceptual change perspective. Based on the ideas of Piaget (1950), the following inferences can be made; learners construct meaning by themselves through processing cognitive structures, situations that originate conflict in students' mind can be handled as valuable chances for directing students to search for valid explanations of the scientific phenomena, and environments where students negotiate with peers and the teacher help students construct a meaningful explanation for the knowledge to be learned.

In contrast to Piaget, Vygotsky (1978) suggested that development requires self-regulation of the meaning instead of self-construction. In other words, children can be thought as developed after internalizing knowledge acquired from others within the cultural settings where they grow up and become able to apply that knowledge without the aid of others, become self-regulated in brief. Vygotsky (1978) believed that learning has sociocultural nature which means that children may grasp the meaning of a knowledge more by negotiating or collaborating with more capable peers or adults than by doing alone which is the belief corresponds to the famous notion of zone of proximal development. Zone of proximal development is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). In other words, zone of proximal development indicates the extent of capacity of a learner that has its maximum value by providing socially mediated environments and minimum value by working individually. Socially mediated environments can be explained with regard to Vygotsky's other key opinion which is scaffolding. A person provides scaffolding to another person by giving a great deal of support at the beginning of learning and lowering the amount of support in a manner to let that person apply what is learned individually (Vygotsky, 1978). Then, socially mediated environment can be defined as learning environments where learners are supported vigorously at the beginning of the learning process by more capable peers or adults, then a gradual decrease in the amount of assistance takes place, and finally learners do the professionalized work individually. Obviously, Vygotsky's ideas encourage the use of cooperative learning strategy in which students learn together within their zone of proximal development, and apply learned knowledge alone (Slavin, 2009). The sociocultural theory of Vygotsky (1978) can be interpreted as follows; individuals differ in their zone of proximal development because every individual has different quantity and quality of prior knowledge which is a personal characteristic; zone of proximal development is an indicator of learners' learning capacity which changes between the highest value that can be achieved through cooperative learning arrangements, peer tutoring and reciprocal teaching, and the lowest value that can be revealed by working alone and direct teaching; and the knowledge which requires capacity above a learner's zone of proximal development cannot be learned even studying with their peers.

The roles or responsibilities of learners within the constructivist theory of learning can be deduced through departing from the notion of Bodner (1986) which stated that "knowledge is constructed in the mind of the learner" (p. 873). Since students are responsible for construction of meaning, they are the active participants of their own learning. Active involvement does not mean studying a lot in a manner to learn all sorts of knowledge by memorization but trying to form meaningful associations between new knowledge and what has already been known, testing whether new knowledge can be explained by present knowledge structure, modifying or completely changing present cognitive structure to be satisfied and, restructuring the meaning upon new scheme (Huba & Freed, 2000). Meanwhile, it is obvious that learners' present cognitive structures behave as the starting point for meaningful learning to occur, that is, the situation necessitates taking students to the center of learning. Since students have different ranges of prior knowledge at the start of the learning process, it is almost impossible to expect them learn in the same way and in the same amount which makes constructivism an indispensable approach to learning and teaching as it suggests to use instructional strategies which permit students' active contribution during the process of learning (Huba & Freed, 2000).

Emphasizing active involvement of students within their learning process by referring to their existing cognitive structures, interests and, needs, constructivist theory does not ascribe the meaning of teacher as not an important participant. Constructivist view proposes an innovation by describing the role of teachers as "from someone who teaches to someone who facilitates learning" and the way of teaching as "from teaching by imposition to teaching by negotiation" (Bodner, Klobuchar, & Geelan, 2001, p. 6). In order to be able to facilitate learning, teachers have to behave with regard to "where the students are rather than where the teacher would like them to be, or where the curriculum suggests they should be" (Taber, 2001, p. 46) which is the statement that indicates internalization of student centrality when planning teaching activities and deciding on the instructional strategies to be applied. Research findings suggested that meaningful learning results in better understanding of the scientific knowledge (Cavallo, 1996) and the corresponding research studies investigated what causes meaningful learning to happen. Novak (2002) reported two conditions for meaningful learning to occur by taking learner characteristics into account which are the degree of learners' effort to learn meaningfully and the extent of prior knowledge learners have. The former can be promoted by encouraging learners to adopt constructivist views about the nature of knowledge and knowing (Lederman, 1992; Tsai, 1996) and by inciting teachers to arrange learning environments in a manner to give students opportunities to reconstruct their existing cognitive structures, reflect their opinions, participate in self and peer assessment activities, learn to respect other's ideas, contribute to democratic decision making activities, negotiate with the teacher related to the activities they embedded in, all of which can be achieved by collaborative working (Trigwell & Prosser, 1991; Valanides & Angeli, 2005). The second condition suggested by Novak (2002) for meaningful learning to take place is the extent of learners' prior knowledge which promotes students' subsequent learning if it is scientifically correct in nature whereas inhibits learning when it is in the form of alternative conception with which scientifically accepted conception is not congruent (Hewson & Hewson, 1983; Chandran, Treagust, & Tobin, 1987; Uzuntiryaki & Geban, 2005). Since learners' prior knowledge has influential effect on their successive learning, identification and remediation of them when it is scientifically incorrect are crucial for enabling higher understanding of scientific concepts. There are various instructional strategies that facilitate understanding of scientific knowledge by using conceptual change approach (Niaz, 2002) which requires reconceptualization of existing ideas. On this ground, this study aims to investigate the effect of structuring cooperative learning based on conceptual change approach on grade nine students' understanding the concepts of mixtures and their motivation. It seems logical to discuss the nature of alternative conceptions and introduce what ideas students bring to chemistry classes considering mixtures before getting through conceptual change approach as a cure for removing alternative conceptions.

2.2. Alternative Conceptions

Opposite to the idea of handling science as "only a collection of laws, a catalog of unrelated facts", constructivist theory views science as "a creation of the human mind, with its freely invented ideas and concepts" (Kuhn, as cited in Bodner, 1986, p. 877). In other words, useful knowledge can be acquired through constructing meaning among interrelated ideas which are formed in terms of human's perceptions or interpretations of how the world works. It is well established that individuals generate conceptions before entering classroom on the basis of their everyday experiences and these preconceptions vary both in quantity and quality. Preconceptions promote future learning if they are scientifically correct and adequate in amount, whereas they have inhibiting effects on future learning when they are far from explanations of scientific communities (Hewson & Hewson, 1983; Chandran, Treagust, & Tobin, 1987). Realizing potential effects of prior conceptions on the way students interpret the world, an extensive body of research has been conducted concerning science education (Driver & Easley, 1978; Wandersee, Mintzes, & Novak, 1994; Taber, 2000), which reported that students may have different beliefs about how the world works than those of scientists. The concepts which are not consistent with science communities' points of view are mentioned with various names such as "misconceptions" (Nakhleh, 1992; Wandersee, Mintzes, & Novak, 1994; Schmidt, 1997), "preconceptions" (Ausubel, 1968), "children's science" (Gilbert, Osborne, & Fensham, 1982; Osborne & Wittrock, 1983), or "alternative conceptions" (Driver & Easley, 1978; Dykstra, Boyle, & Monarch, 1992; Taber, 2001) which have similar meanings in nature whereas each of which reflects researcher's approach to education. Using the term misconceptions reflects traditional view of learning, the term alternative conceptions, on the contrary, indicates an internalization of constructivist view of learning (Taber, 2000; 2001). For the purpose of this dissertation, the term "alternative conceptions" will be used in the following parts.

Scientifically incorrect conceptions are constructed by learners as scientifically correct ones which results in having such powerful beliefs about the correctness of those alternative conceptions that prevent future knowledge construction (Novak, 2002). Incorrect conceptions hold strictly by students should be eliminated to be able to understand scientific concepts meaningfully. Correspondingly, considerable body of research has focused on some common features and possible sources of alternative conceptions in science education to remove their inhibiting effects on learning since it is a general rule that people should investigate the sources or reasons of any problem to be able to solve whatever the problem is. Wandersee, Mintzes and Novak (1994), for instance, claimed that "the alternative conceptions that learners bring to formal science instruction cut across age, ability, gender, and cultural boundaries" (p. 185). Researchers proposed that students have more alternative conceptions as they grow up as a result of cumulation of prior knowledge they possess (Duit, 1996), which is one of the most influential source of alternative conceptions (Haidar & Abraham, 1991; Abraham et al., 1994). In fact, not only students but also pre-service teachers, teachers, and even university professors (Goodwin, 1995; Valanides, 2000a; 2000b; Çalık, Ayas, & Coll, 2007) hold conceptions far from the ideas accepted by science communities which cause formation of alternative conceptions by students in turn. Under such circumstances, teachers cannot identify and eliminate alternative conceptions students have, and even transmit their own alternative conceptions to students during instruction, that is, instructors may be another source of alternative conceptions (Ebenezer & Erickson, 1996; Valanides, 2000a; Taber, 2001). Another well known feature of alternative conceptions was reported as they are resistant to change through traditional science instruction (Driver & Easley, 1978). Taber (2001) stated that students may have alternative conceptions not only at the beginning of a topic but also after the instruction is completed which can be interpreted as it is not an easy task to remove alternative conceptions students have unless the new knowledge is fruitful, plausible, and intelligible. Furthermore, students believe in their own conceptions' accuracy if they do not face with the adverse examples that create conflict in students' cognitive structure (Posner et al., 1982). In other words, students should experience disequilibrium and then try to attain equilibrium again which is the condition that is in harmony with the purposes of instructional strategies facilitating conceptual change. Students realize that their preconceptions are not adequate when explaining a scientific concept, and only after then they may change their schemes. Otherwise, they believe that the knowledge they gained by interacting with the environment is accurate to construct valid meanings of the new knowledge which can be counted as another source of alternative conceptions (Prieto, Blanco, & Rodriguez, 1989). Actually, students should have both everyday and scientific knowledge structures because alternative conceptions are context dependent (Ebenezer & Gaskell, 1995). To sum up, alternative conceptions may be originated from students' personal experiences (e.g. prior knowledge, everyday language), interaction with the environment (e.g. peers, family, siblings, media), the nature of the discipline to be learned (e.g. the abstract nature of chemistry), and instructors (e.g. instructional strategies and tools, terminology) (Wandersee, Mintzes, & Novak, 1994).

Research studies in science education deal as well as with how to elicit learners' alternative conceptions which can virtually be studied after mastering the concerns of features and sources of alternative conceptions. Alternative conceptions can be identified within three different seasons of the learning process according to the purpose of assessment namely, before instruction to diagnose readiness of students and plan instruction accordingly, during instruction to be aware of whether the method and strategies put into practice are effective, and after instruction to evaluate resistance of alternative conceptions. No matter when they are assessed, identifying alternative conceptions is crucial for realizing the way how students and even teachers think about the topic under investigation (Taber, 2001). Learners' alternative conceptions can be diagnosed by the use of various instruments such as interviews, concept maps, various forms of paper and pencil tests (e.g. multiple-choice tests, two-tier tests, essay type examinations), word association tests, drawings (e.g. Ebenezer & Erickson, 1996; Valanides, 2000a; 2000b; Uzuntiryaki & Geban, 2005; Pınarbaşı, Canpolat, Bayrakçeken and Geban, 2006; Coştu, Ayas, Niaz, Ünal, & Çalık, 2007), or combination of these means which give more valid and reliable results (Schmidt, 1997). Obviously, there are many ways to identify learners' alternative conceptions among which teachers should choose the most appropriate tool according to time and professionalism occasions, and to the nature of discipline. Conducting interviews, for example, require considerable time relative to paper and pencil tests and preparing multiple-choice tests, on the other hand, demand more expertise than word association tests.

Since chemistry is perceived as one of the most challenging science lesson by most of the students, various researchers view it crucial to investigate what makes chemistry such a difficult lesson (Bodner, 1991; Ebenezer, 1992; De Jong & Taber, 2007). Sirhan (2007) reviewed research studies that have addressed the reasons causing chemistry lessons to be perceived as hard to learn, and gathered areas of difficulty under five main categories: curriculum content, overload of students' working memory space, language and communication, concept formation, and motivation. The underlying causes that form these main fields of concern can be summarized as follows:

- The meaningful interaction among macroscopic, sub-microscopic and symbolic representations of chemistry concepts.
- The abstract and conceptual nature of chemistry concepts, that necessitates students to possess higher order thinking skills.
- The inconvenience between the sequence of chemistry concepts and needs, interests, and abilities of students.
- The overload of chemistry programs that result in holding students accountable from every pieces of knowledge including rather trivial chemistry concepts.
- The inconsistencies between terminologies used in chemistry classes and daily lives.
- The spiral nature of chemistry programs bring about learning future chemistry concepts impossible when the basic concepts have not been mastered by students well enough.
- The sense of learned helplessness.

2.2.1. Research on Alternative Conceptions in Mixtures

The review of literature detected that students have alternative conceptions on various chemistry concepts involving the particulate nature of matter (Novick & Nussbaum, 1978; Haidar & Abraham, 1991; Griffiths & Preston, 1992; Harrison & Treagust, 2003), chemical equilibrium (Hackling & Garnett, 1985; Hameed, Hackling, & Garnett, 1993), gases (Stavy, 1988; Benson, Wittrock, & Baur, 1993; Niaz, 2002), chemical bonding (Tan & Treagust, 1999; Coll & Treagust, 2003; Uzuntiryaki, 2003), acids and bases (Hand & Treagust, 1991; Demircioğlu, Ayas, & Demircioğlu, 2005), and mixtures (Cosgrove & Osborne, 1981; Holding, 1987; Fensham & Fensham, 1987; Prieto, Blanco, & Rodriguez, 1989; Stavy, 1990; Johnson & Scott, 1991; Abraham et al., 1992; Abraham et al., 1994; Ebenezer & Erickson, 1996; Blanco & Prieto, 1997; Sanger, 2000; Valanides, 2000a; 2000b; Mulford & Robinson, 2002; Çalık, 2003; Pınarbaşı & Canpolat, 2003; Kabapınar, Leach, & Scott, 2004; Çalık & Ayas, 2005a; 2005b; 2005c; Uzuntiryaki & Geban, 2005; Pınarbaşı, Canpolat, Bayrakçeken, & Geban, 2006; Stains & Talanquer, 2007; Çalık, Ayas, Coll, Ünal, & Coştu, 2007; Coştu, Ayas, Niaz, Ünal, & Çalık, 2007; Pınarbaşı, Sözbilir, & Canpolat, 2009; Tüysüz, 2009; Kalın & Arıkıl, 2010).

Mixtures, one of the most abstract and basic concept of chemistry, requires certain skills that enable to think on sub-microscopic level which is not an easy task since students should comprehend concepts on the particulate dimension (e.g. atoms, molecules), and to think on macroscopic level which demands making necessary connections between daily life and chemistry classes. It is obvious that individuals, who comprehend the concepts of mixtures well, feel themselves comfortable in their everyday lives because they are able to understand what is happening around them rather easily. Additionally, it is remarkable that the related literature prefers dealing exclusively with the solution aspect of mixtures but omits other significant parts such as heterogeneous mixtures and separation of mixtures. Accordingly, it is hoped to take literature that focuses on alternative conceptions in chemistry forward by investigating what conceptions learners bring to chemistry classes within the concept of mixtures as a whole. The following paragraphs report on various research studies investigating students' conceptions about the concepts of mixtures and presenting corresponding alternative conceptions students hold related to mixtures.

Abraham, Grzybowski, Renner and Marek (1992) examined eighth grade students' understandings and misunderstandings regarding the dissolution process. Apart from conceptual understanding, researchers were interested in analyzing correlations between students' reasoning ability and chemistry scores taken from a conceptual test involving open-ended questions. Results of the study were viewed as inconclusive by researchers since the vast majority of students had several misconceptions due to the intellectual level they are in, that is, most of the students were concrete operational, whereas dissolution concepts demand formal operational students. As a result of this conclusion, Abraham, Williamson and Westbrook (1994) renewed the study with high school and introductory college chemistry students, who were thought as formal operational student. Abraham and his colleagues (1994) identified several misconceptions considering how sugar dissolves in water, such as "sugar undergoes a phase change, melts or evaporates", "sugar changes chemically into a new substance", "sugar breaks down into ions or elements", "sugar particles floated or sank to the bottom of the beaker instead of evenly mixing", and "water absorbed the sugar similar to the action of a sponge" (p. 160). Solute disappears when dissolution takes place was the additional misconception detected by Abraham et al. (1992). These misconceptions indicate that most of the students consider dissolution process as melting that solute turns into liquid or evaporates, and instead of thinking interaction between the particles of solute and solvent, they try to explain dissolution process by introducing some physical properties of solute (e.g. density). Noted misconceptions are suited well with the misconceptions established by Abraham et al., (1992) and Prieto et al., (1989).

Like Abraham et al., (1992), Prieto, Blanco and Rodriguez (1989) investigated the ideas of elementary students about the nature of mixtures and the process of dissolution. The study compared the thoughts of 319 Spanish students attending different grade levels of elementary schools by assigning a conceptual test consisting of open-ended items and drawings. Researchers concluded that students have various misunderstandings regarding solutions and how dissolution occurs, which were especially evident for those who were sixth and seventh graders. Everyday experiences were found as the strongest source of misconceptions, for instance, solute vanishes during dissolution, dissolution is same with melting, and a new substance emerges after dissolution. In addition, researchers observed that students generally tend to view that solvent has a rather passive role as compared to solute has.

Similar to Prieto et al., (1989), Blanco and Prieto (1997) conducted a cross-age study to examine secondary school students' thoughts about the impacts of stirring and temperature on dissolution of salt in water. Students were asked for drawings and explanations to the behaviors of salt-water solution under three different conditions: just leaving the solution for a while, stirring the solution and then leaving it to stand, and adding salt to hot water and then leaving the solution alone. Researchers witnessed misconceptions of students regarding the impacts of these two external factors on the salt-water system. For example, most of the students believe that the amount of dissolved salt increases as a result of the stirring process and salt dissolves if water is hot, otherwise it precipitates. The second misconception appeared in the study is in accord with the study of Cosgrove and Osborne (1981).

In their phenomenography on students' conceptions of solubility, Ebenezer and Erickson (1996) conducted clinical interviews with 13 eleventh grade students regarding three chemical systems: sugar/water (system A), water/alcohol/paint thinner (system B), and salt/water (system C). As a result of interviews, the researchers identified six categories of description, which were physical transformation from solid to liquid, chemical transformation of solute, density of solute, amount of space available in solution, properties of solute, and size of solute particles. After determining these categories, the researchers calculated frequencies of responses with regard to the systems and categories. In other words, the researchers developed a table indicating frequency distribution of conceptions across the systems A, B, and C. For example, the first two categories of description (i.e. physical transformation from solid to liquid and chemical transformation of solute) were encountered mostly in systems A and C, which can be interpreted as students tend to confuse dissolution and melting when the solute is solid (sugar or salt), whereas they do not experience some trouble if the solute is liquid and it forms a heterogeneous mixture (like system B). Other alternative conceptions that were situated under categories of description were consistent with the findings of other researchers (Cosgrove & Osborne, 1981; Fensham & Fensham, 1987; Prieto et al., 1989; Abraham et al., 1992; Abraham et al., 1994), such as:

- "The solute (sugar or salt) melts and become liquid when it is added to water" (p. 187)
- "Liquid-solution state and a true liquid state have the same meaning" (p. 187)
- "A new substance forms when sugar is added to water, that is, sugary water" (p. 190)
- "Sugar occupies air spaces in water" (p. 190)
- "Water is a solution that hydrogen is the solvent and oxygen is the solute since there is greater quantity of hydrogen within the structure of water" (p. 191)
- "Solubility depends on the density of solute" (p. 191)
- "Substances do not dissolve because they do not find sufficient space in the dissolving medium" (p. 192)
- "The size of the solute particles must be small enough for dissolution to take place" (p. 193)
- "For a substance to dissolve in another substance, the solute must possess certain properties" (p. 194)

Valanides (2000a) dealt with conceptions of primary student teachers (PST) regarding dissolution of a solid (sugar or salt) and a liquid (alcohol) in water, and the behaviors of respective solutions by the effects of filtering or heating. Like Ebenezer and Erickson (1996), one-to-one clinical interviews were conducted with 20 female PST of different backgrounds in science, which revealed diverse alternative frameworks PST have related to the solution concepts. The researcher concluded that vast majority of the PST have only perceptual understanding of the particulate nature of matter and the distinction between physical and chemical changes, and they experience troubles with attributing macroscopic changes (e.g. volume, density) to microscopic events (e.g. arrangement and movement of molecules). When PST were asked what happens after some amount of solid (salt or sugar) is added to water, for instance, some students believed that solid sink to the bottom and remain there since the solid is heavier than water. The thought of solids to be denser than water cause many of the PST to claim that salt dissolved in water is not a homogeneous mixture since it involves different density phases that the bottom is the most dense part and the top is the least dense layer. Moreover, those students explained disappearance of solid after stirring the solution as an effect of stirring and they further believed that when one does not stir it, solid reappears again that proposes the idea of viewing dissolution process as instant and reversible, which is consistent with the findings of Blanco and Prieto (1997). Unlike most of the other studies, Valanides (2000a) investigated PST's thoughts related to what would happen when salt-water or sugar-water solutions were filtered, which contributes to the related literature since there were a few studies interested in separation of mixtures. Interestingly, some students viewed filtering as a general method of separating all kinds of solids from liquids. In other words, some of the students expressed that "if the solution is filtered, sugar (or salt) will remain on the filter paper" (p. 253). Some other students claimed that filtering can be used to separate sugar from the solution if the size of the grains are smaller and invisible enough that can be achieved through stirring the solution. Accordingly, "the bigger ones would remain on the filter paper and the filterable liquid would be less sweat (or salty)" (p. 253). Regarding the situation where a liquid (alcohol) is mixed with water, many PST proposed that the solution would involve layers that can be seen easily, that is, they insisted that the mixture of alcohol-water is a heterogeneous mixture. Additionally, the researcher established that students stated different reasons to explain the phenomenon of reduction in volume when alcohol is mixed with water, such as the reason why volume of the solution is due to "a chemical change", "water and alcohol vapours escaped", and "some drops of the liquid remain in the other cylinder" (p. 256). This comprehensive study brought out many more alternative frameworks that are in compliance with several researchers (Prieto et al., 1989; Abraham et al., 1992; Abraham et al., 1994; Ebenezer & Erickson, 1996), such as:

- "Salt or sugar would melt when added to water" (p. 252)
- "The solvent is a rather passive component" (p. 253)
- "Solid turns to liquid after dissolution" (p. 253)
- "An entirely different substance is formed (i.e. salty water or sugary water) during the process of dissolution" (p. 253)
- "The volume of the solution would increase as much as the volume of the added solute" (p. 254)
- "Molecules of solids do not move" (p. 254)
- "Alcohol would lose its flammability after mixing with water" (p. 256)
- "Sugar or salt evaporates when their solution with water is heated" (p. 258)
- "Air is not a mixture" (p. 258)

In another study, Valanides (2000b) examined the conceptions of PST of different backgrounds in science through conducting one-to-one interviews, similar to the study of Valanides (2000a). Unlike the previous study, however, Valanides (2000b) focused on the process and effects of distillation on various water solutions (e.g. tap water, salt solution, tea, coke), which is actually a generic concept (i.e. distillation) cutting across chemistry, physics, and biology. This study is particularly valuable due to its supplementation to the literature of sepapration of mixtures, an omitted aspect of mixtures concepts by most of the researchers. The findings of the study indicated that students tend to explain the properties of molecules by thinking the properties of substances (i.e. the macroscopic representation), that conclusion was found later by Mulford and Robinson (2002). The researcher presented various alternative frameworks PST have by asserting students' inadequate explanations about the concepts closely related to distillation, like the particulate nature of matter, evaporation, boiling point, and condensation. For example, students who cannot distinguish between evaporation and boiling, predict correctly the content of vapor when water vaporizes, and describe how the process of dissolving takes place, were viewed as foreigners of the idea of distillation. When students were asked to compare the properties of distillate with the properties of tap water at the same temperature, many PST believed that "the distillate has exactly the same density as tap water" or "the distillate has smaller density, because the distance of the molecules would be bigger after distillation" (p. 359). To sum up, PST tend to express the color, taste, and density of distillate with overgeneralizing the properties of the liquid used for distillation.

Uzuntiryaki and Geban (2005) compared the effects of conceptual change texts accompanied with concept mapping instruction and traditional instruction on eighth grade students' understanding of solution concepts. Solution Concept Test, a 20-item multiple choice test, has been developed by researchers through placing common misconceptions regarding solution concepts as the distractors, which were reported by various research studies and stated by science teachers. As a result of 4-week intervention, students who have been instructed by conceptual change texts accompanied with concept mapping instruction (experimental group) learned the scientific explanations of solution concepts better than control group students who have been taught through traditional instruction. For instance, when students were asked what happens when a small amount of salt is added to water, most of the control group students answered as "salt occupies air species in water", "salt is absorbed by water", and "a new chemical species is formed" (p. 331). Other common misconceptions stated by researchers were consistent with the findings of other researchers (Prieto et al., 1989; Abraham et al., 1992; Abraham et al., 1994; Ebenezer & Erickson, 1996; Valanides, 2000a), such as:

- "Solid salt is converted into liquid salt when added to water" (p. 326)
- "Salt evaporates when mixed with water" (p. 326)
- "A new substance forms as a result of dissolution" (p. 326)
- "The solution stays the same when it is cooled" (p. 332)
- "The water emits salt when the solution is cooled" (p. 332)
- "A homogeneous mixture is obtained after cooling" (p. 332)
- "Sugar breaks into ions when added to water" (p. 332)
- "Sugar molecules do not retain their identity when mixed with water" (p. 332)
- "Sugar solution conducts electricity" (p. 332)
- "Air is not a solution" (p. 332)
- "A salt-water solution boils at a constant temperature" (p. 332)
- "The weight of the sugar-water solution was either greater or less than the total weight of sugar and water" (p. 332)
- "The volume of the sugar-water solution was greater than or same with the total volume of sugar and water" (p. 332)

Like Uzuntiryaki and Geban (2005), Pınarbaşı, Canpolat, Bayrakçeken and Geban (2006) investigated whether the conceptual change instruction based on texts results in better acquisition of concepts related to the nature of dissolution and properties of solutions, as compared to traditional instruction. Unlike Uzuntiryaki and Geban (2005), the sample of the study involved 87 undergraduate students attending an introductory chemistry course. Although results indicated positive and significant effects of text-based conceptual change instruction on students' comprehension of solution concepts, researchers noted that there were alternative conceptions even after instruction that were valid especially for students who have been instructed traditionally. The most widespread alternative conceptions were as follows:

- "A solution containing undissolved solute is a supersaturated solution" (p. 315)
- "The volume of solution equals the sum of the volume of solute and solvent" (p. 328)
- "Solute particles have no motion" (p. 328)
- "Dissolved particles in a solution lose weight or have no weight" (p. 328)

The alternative conceptions, which were made straightforward by Pınarbaşı et al., (2006), were in harmony with the findings of Mulford and Robinson (2002), Uzuntiryaki and Geban (2005), and Pınarbaşı and Canpolat (2003). Pınarbaşı and Canpolat (2003), for instance, examined undergraduate students' ideas about the microscopic representation of unsaturated, saturated, and supersaturated solutions. Researchers concluded that participating students believe that undissolved solute is a component of solution and supersaturated solutions contain undissolved solute at the bottom of the beaker.

In a cross-age study, Çalık (2005) focused on seventh-tenth grades students' ideas on solution concept that were not searched before profoundly. In particular, the researcher covered electrical conductivity, freezing and boiling points, the effect of surface area, and types of solutions in terms of their concentration levels. A four-item test involving open-ended questions, designed in a manner to assess throughly all of the mentioned aspects of solution concepts, was administered to 441 students. Among different grade levels, students attending grade nine were found to have less alternative conceptions than students in other grade levels did, excluding the third item of the test. Related to electricity conductivity of sugar-water solution, many students thought that "all solutions conduct electricity", "sugar dissolved in water conducts electricity", "conductivity does not depend on the types of solution", or "electricity conductivity depends on negatively charged ions" (p. 678). When students were asked for comparing freezing and boiling points of salt-water solution and water, some students answered that there were no difference between freezing and boiling points of salt dissolved in water and water, or both freezing and boiling points of salt dissolved in water are higher than those of water. Additionally, students were questioned on the effect of surface area on the rate of solution and results indicated that most of the students were able to give the correct answer as the rate of solution increases when the surface area of solute increases. However, great many students were inable to explain the reason of relationship between surface area of solute and the rate of solution. The following misconceptions were presented about the reason of the effect of surface area: “the speed of the dissolution process depends on stirring which apparently results in an increase in the surface area of solute”, and “mass of the crushed salt is less than the uncrushed salt” (p. 683). Besides to the incorrect explanations for increasing rate of solution, some students believed that “the amount of the dissolved substance depends on the surface area of solute” (p. 683). Finally, when students were asked to label solutions that contain same amount of milk but different amounts of sugar inside, it was observed that many students have troubles regarding saturated and concentrated solutions, unsaturated and diluted solutions, and they named types of solutions by using different terminologies, like “light solution”, or “semi-saturated solution” (p. 685).

Çalık, Ayas, Coll, Ünal and Coştu (2007), furthermore, examined whether constructivist-based teaching activities result in better understanding of the effects of pressure and temperature on the dissolution of gases in liquids. Researchers collected both quantitative and qualitative data through triangulation, that is, they assigned two items of a solution concept test, conducted semi-structured interviews with different ability-level students (i.e. high, medium, and low achieving students on the posttest), and distributed the self-assessment forms to be filled up by all of the participating students attending grade nine. The conceptual questions used in the study were two-tier in nature which enable researchers to evaluate if or not students know the reason of behaviors of gases when pressure increases or decreases, and while temperature does so. According to the results of the study, students learn the patterns of gases dissolved in liquids better and retain meaningful conceptions in their long-term memories when the instruction designed on the basis of constructivist-based activities. Data drawn upon face-to-face interviews, furthermore, revealed students’ reasonings on the effects of pressure and temperature on the dissolution of gases in liquids that differ considerably from scientists’ point of views. For example, some students described the reason of increase in solubility of gases when pressure increases as the gap among gas particles decreases or as gas particles take the form of beaker. Other alternative conceptions detected by researchers were as follows: temperature does not affect the dissolution of a gas into a liquid since the ratio is stable for all gases, there is a linear relationship between temperature and the solubility of a gas into a liquid, the solubility of gases decreases as pressure of gas-liquid solution increases since gas particles become liquid under pressure or since different gas particles emerge under pressure, and solubility of gas particles in liquids is stable because gas particles cannot be squeezed.

Moreover, Coştu, Ünal and Ayas (2007) designed a hands-on activity to analyze its effects on seventh grade students’ understanding of the two categories of matter: mixtures and compounds. Researchers have generated Mixture and Compound Test (MCT) to specify misconceptions, in which six open-ended questions were situated. Of six items, two of them were related to mixtures and their properties, two of them were associated with compounds and their properties, and the remaining two of them were interested in the distinction between mixtures and compounds on both the macroscopic and sub-microscopic basis. Researchers found that some of the misconceptions hold by students at the pretest were overcome as a result of intervention, which were: “the components of a mixture cannot be physically separated”, “the components of a mixture combine in exact proportion”, and “the properties of components in a mixture are not retained” (p. 41). The last misconception was consistent with the findings of Uzuntiryaki and Geban (2005) and Valanides (2000a). Although they could not change completely, there were additional misconceptions that had lower percentages on the posttest as compared to the pretest percentages, such as “all mixtures are heterogeneous, mixtures are pure substances, all mixtures are homogeneous substances, mixtures are combination of two or more substances that are not pure, and mixtures are always combination of two different elements” (p. 41).

Apart from studies noted previously, Tüysüz (2009) developed a two-tier test specifically on the concept of separation of mixtures and tested this instrument to be able to understand whether or not it is effective in identifying misconceptions grade nine students have on that concept. The rationale of selecting separation of mixtures as the unit to be investigated was stated as it is a challenging and real life related concept. The items of the test involved multiple choice and explanation parts, both of which included one correct answer and four alternatives that reflect common misconceptions students have on separation of mixtures. Only two sample items of the test were made apparent: question 3 was assessing if students know the difference between crystallization and distillation, and question 10 was testing whether students comprehend the particulate nature of matter and know the fact that physical methods are used to separate mixtures into their components. It was concluded that participating students were more successful when they were assigned traditional multiple choice test as compared to two-tier test. This conclusion was interpreted as students are not accustomed to be assessed with tests that question the reason of selected response, but it is a desired way of establishing misconceptions. The researcher identified that majority of students believed that crystallization is a method used to get solid and liquid separately from homogeneous mixtures, liquid-liquid solutions (e.g. alcohol in water) can be separated through distillation, and filtering is a general method of separating solids from liquid solutions. The last misconception is consistent with the findings of Valanides (2000a).

2.3. Conceptual Change Approach

Identifying the quality and quantity of preconceptions students hold and trying to understand whether or not those conceptions are scientifically correct at the beginning of instruction are crucial precautions for controlling the following stages of learning process, however, not satisfactory for remediation of alternative conceptions (Mulford & Robinson, 2002). Furthermore, it is well established that traditional science instruction cannot be an influential mean to wipe alternative conceptions out (Driver & Easley, 1978; Wandersee, Mintzes, & Novak, 1994), which does not actually take learners, and correspondingly their alternative conceptions into account. Accordingly, alternative instructional approaches that are consistent with the constructivist theory of learning were developed to dispel alternative conceptions and facilitate meaningful learning (Posner et al., 1982; Hewson & Hewson, 1983; Driver & Oldham, 1986). Conceptual change is one of the most effective teaching approach which enables to apply views of constructivism into science instruction (Hewson & Thorley, 1989). Since conceptual change requires internalization of constructivist theory of learning, it can be said that constructivism and conceptual change are at the same line. As an example, constructivist theory views learning as a process of meaning construction by humans (Duit, 1996), in that case, conceptual change also states that learning is a process of personal knowledge construction (Cobern, 1996). Conceptual change defines knowledge construction as a process of forming connections between what a learner already knows and what the learner to be learned which is the condition that promotes meaningful learning (Novak, 2002) at the same time. More specifically, meaningful learning can be considered as conceptual change which aims to change alternative conceptions with scientifically correct ones.

Then, “how to alter alternative conceptions with that of correct conceptions?”, “how conceptual change occurs?”, or more particularly, “what changes in conceptual change?”. To be able to address these types of questions, Posner et al. (1982) developed an instructional approach and defined conceptual change on the basis of Piaget’s (1950) idea of assimilation, accommodation, and equilibration. Assimilation occurs when a learner is able to explain new knowledge by using the existing knowledge structures, whereas accommodation happens if the current concepts are not adequate or conflict with the new knowledge that results in disequilibrium in the mind of learners. Learners try to get rid of from the state of disequilibrium which is the process described by Piaget as equilibration and it is this process that is responsible for learning. Posner and his colleagues (1982) focused vigorously on accommodation as a way to remove alternative conceptions by suggesting four conditions to be accomplished;

1) There must be dissatisfaction with existing conception. Accommodation requires radical changes of current conception which cannot be achieved until students are faced with anomalous information that contradicts with their current cognitive scheme.
2) A new conception must be intelligible. New information becomes intelligible when students are able to comprehend the meaning of it, paraphrase it with their own words, give relevant and irrelevant examples, and put it on by divergent means like graphic, drawings, or analogies (Hewson & Thorley, 1989).

3) A new conception must be plausible. It is impossible for new information to be plausible unless it is intelligible. Besides to intelligibility as a prerequisite of plausibility, new information should be coherent with other conceptions of students present in their minds.
4) A new conception must be fruitful. Intelligible and plausible information should have the potential to be transferred in different contexts, subject matters, or topics. Students should believe that new information is fertile enough to be used in different occasions.

In brief, Posner et al. (1982) claimed that students replace alternative conceptions with scientifically correct ones if they dissatisfy with that of existing knowledge and if the new knowledge is superior than the existing one in terms of the extent of intelligibility, plausibility, and fruitfulness. However, many researchers criticize the idea of replacement of alternative conception and reported that it is not usually the case that students give up former conceptions completely rather they change the status of those conceptions (Ebenezer & Gaskell, 1995) which can be defined as the extent of conceptions' intelligibility, plausibility, and fruitfulness (Hewson & Thorley, 1989). According to Ebenezer and Gaskell (1995), students raise or lower the status of conceptions with regard to the context they are in. More specifically, prior knowledge and new knowledge coexist in the conceptual ecology of students and they raise the status of their prior knowledge within their daily lives and lower the status of their prior knowledge within the classroom. In other words, students have multiple explanations about a scientific concept and they decide on which explanation to make active according to the context they involve in. Pintrich et al. (1993), furthermore, criticized the conceptual change model developed by Posner and his colleagues (1982) through labeling their approach as "cognition-only model". Pintrich et al. (1993) viewed Posner and his colleagues' suggestions as cold, or rational, model of conceptual change that tends to describe whole learning process by emphasizing solely the importance of students' prior knowledge, but omitting the influences of the nature and functions of motivation and classroom contextual factors on learning, which are actually the important mediators and moderators of learning. They draw upon this conclusion by discussing the indisputable but deficient role of prior knowledge in students' learning by indicating the point where researchers are exhausted to explain why students do not make use of related knowledge although they have adequate prior knowledge. Regarding students who do not change their conceptual frameworks even if they have adequate knowledge base, Pintrich et al. (1993) suggested that it may be a result of the mediating effects of motivational beliefs (e.g. goal orientation, self-efficacy, value and control beliefs) on the process of conceptual change. A student may have related prior knowledge but does not learn much at the end of the learning, for instance, may be explained as the student does not value the learning process, or student has another goal orientation like being belonged to a popular group in the classroom. In addition to the impacts of motivational beliefs on the process of conceptual change, classroom contextual factors are viewed as the facilitator between cognition and motivation. Pintrich and his colleagues (1993) stated that classroom contextual factors should favor students' motivational beliefs, which in turn affect their cognitive strategies promoting conceptual change. Within a classroom in which there is an in-depth interaction between teachers and students, for example, students are to be motivated to adopt mastery goal orientation that facilitates the process of conceptual change. In fact, cooperative learning is an effective way of making students interact with each other and the teacher through which not only cognition (Johnson & Johnson, 1999; Fall & Webb, 2000) but also affect develop (Johnson & Johnson, 1989; Slavin, 1991; 1996). In particular, cooperative learning is a valuable instructional strategy that encouraging conceptual change through accommodating not only cognitive but also affective, and contextual factors. Based on this ground, the following part gives detailed information related to cooperative learning.

2.4. Cooperative Learning

The ultimate goal of contemporary science education is to educate students who have "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" (OECD, 2003, p. 133). Being able to educate scientifically literate students however, requires a dramatic change in current learning environment which is dominated mostly with competitive or indivudialistic learning (Johnson & Johnson, 2008). Instead of competing or doing alone, cooperating with others to achieve mutual goals becomes one of the most essential skills in modern life (Jolliffe, 2007; Murdoch & Wilson, 2008), which in turn makes cooperative learning to be one of the most wonderful innovations of both psychology and education in recent times (Slavin, 1996; Johnson & Johnson, 2008).

Cooperative learning has been grounded on various theoretical perspectives such that any discussion of cooperative learning starts generally with behavioral learning theory, cognitive-developmental theory, or social interdependence theory (Johnson & Johnson, 1999). Behavioral learning theory involves motivational perspectives on cooperative learning through focusing primarily on interpersonal reward structures. In other words, groups are rewarded on the basis of group performance which extrinsically motivates group members to do their best by giving and receiving help, and encouraging each other's efforts since they realize the only way to get a reward is to achieve the joint goal as a group (Slavin, 1996). Cognitive-developmental theory, on the other hand, deals mainly with sociocultural effects on individuals' cognitive processes. More specifically, individuals enter learning settings with some sorts of preknowledge that indicates their actual developmental level which can be enhanced to potential developmental level through scaffolding by the teacher or students with higher subject-matter knowledge (Vygotsky, 1978). When students learn instructional tasks cooperatively, they more readily realize each other's alternative conceptions than their teachers and practice inconsistent knowledge up to internalize the correct explanations which in turn promotes individual performance and correspondingly group performance (Webb, Nemer, & Zuniga, 2002). The social interdependence theory, furthermore, "assumes that cooperative efforts are based on intrinsic motivation generated by interpersonal factors in working together and joint aspirations to achieve a significant goal" (Johnson & Johnson, 1999, p. 188), which contrasts with the ideas of behavioral learning theory as it focuses on extrinsically motivated student efforts to achieve group rewards. Moreover, although social interdependence theory deals with the issues among individuals, cognitive-developmental perspective emphasizes the importance of considering a unique individual instead of a group of people. Eventhough they seem to claim opposing ideas, perspectives of cooperative learning do not confront with but complement each other through emphasizing on various aspects of cooperation (Slavin, 1996), and form the theoretical base of cooperative learning. No matter which, all of the theoretical perspectives served the improvement of cooperative learning and corresponding research they have produced (Johnson & Johnson, 1999). Then, it is the time to discuss on different ways of interaction among students and between students and the teacher to accomplish the goal, that is, "goal structures" (Johnson & Johnson, 1999), and what cooperative learning is and is not.

Within the theory of social interdependence, Johnson and Johnson (1989) described three ways of interaction as competitive, individualistic, and cooperative. Competitive learning can be summarized as the following statement "the more you gain, the less for me; the more I gain, the less for you" (Johnson & Johnson, 1999, p. 7). More specifically, individiuals try to be the best through searching useful ways for themselves whereas detrimental ways for others, perceive the way of success as the failure of others, and interdepend each other negatively. Students within an individualistic learning environment, on the other hand, try to achieve a certain criteria determined as the success level independently from others, and do not interact with each other, which can be summarized as "whether my classmates achieve or not does not affect me" (Johnson & Johnson, 1999, p. 8). Cooperative learning, on the contrary, requires individuals to try to enhance both their own and each other's success, perceive the way of success as the success of each individual, and interdepend each other positively. In brief, students in a cooperative learning environment know that "we all sink or swim together" or "all for one and one for all". Cooperative learning can be defined as "an instructional approach in which students work in small mixed-ability groups" (Slavin, 2009, p. 243), or as "the instructional use of small groups so that students work together to maximize their own and each other's learning" (Johnson and Johnson, 1999, p. 5).

However, having students work together and telling them to cooperate with each other does not assure they did so (Slavin, 1990; Johnson & Johnson, 1999; Jolliffe, 2007). Cooperative learning is not "pupils sitting at one table talking about their individual work, sharing materials for individual work, groups where only one or two pupils do all the work" (Murdoch & Wilson, 2008, p. 3), that may be called as "individualistic learning with talking" (Johnson & Johnson, 1994). A cooperative learning group should be structured through putting basic elements into practice to be able to distinguish it from other learning groups like pseudo-learning group and traditional learning group. Johnson and

Johnson (1999) noted that “how well any small group performs depends on how it is structured” (p. 71). Before reporting on the basic elements of cooperative learning therefore, it seems beneficial to discuss about learning groups that are not truly cooperative in nature. Students within a pseudo-learning group are aware of they are the members of that group whereas they do not want to cooperate with each other. The structure of pseudo-learning group promotes competition in such a way that students “block or interfere with each other’s learning, communicate and coordinate poorly, mislead and confuse each other, loaf, and seek a free ride” which results mostly in lower success than individualistic learning (Johnson & Johnson, 1999, p. 71) (see Figure 2.1). Members of a traditional learning group, on the other hand, perceive being together as a compulsory practice that they have to obey which causes little benefit from doing so. The frame of traditional learning group facilitates individualistic learning with talking in such a manner that each individiual is accountable only for ownself, assessed and rewarded individually instead of group as a whole. Performance of individuals working within a traditional learning group is equally well as individuals working alone, as shown in the figure of learning group performance curve developed by Johnson and Johnson (1999, p. 71). Moreover, there is not any effort for developing students’ social skills necessary to work together and the group does not reflect on how well they have progressed. The discourse of traditional learning group is same with what Gillies (2004) labeled as unstructured cooperative learning group.

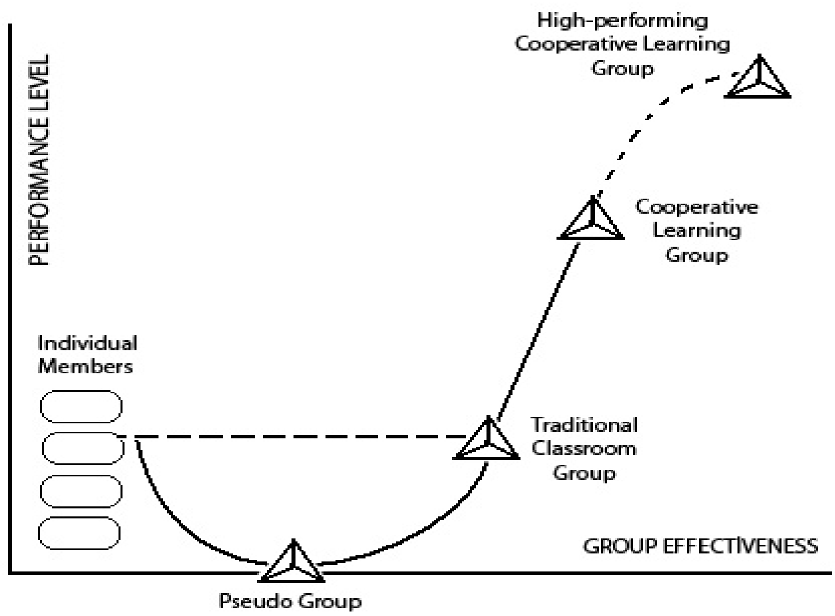


Figure 2.1 The learning group performance curve

Johnson and Johnson (1997) suggested ten potential obstacles inhibiting effectiveness of learning groups and preventing them to be a cooperative learning group as follows (as cited in Johnson & Johnson, 1999):

- “Lack of group maturity”. Groups with inexperienced students may suffer adequate maturity to work together effectively.
- “Uncritically giving one’s dominant response”. Group members benefit from cooperative efforts when they reach a common response among various ideas and disagreements instead of approving the response of students who have certain characteristics influencing other group members (e.g. achievement, leadership properties, physical appearance).

- "Social loafing-hiding in the crowd". Students may feel lower responsibility when they work on an additive task within a group than they feel while doing alone, that is, being in a group may result in overestimated effort and underestimated responsibility.
- "Free riding-getting something for nothing". Students contibute little or not at all when groups but not individuals are assessed on the group task.
- "Motivation losses due to perceived inequity-not being a sucker". If group members realize some of the members are not committed to group task but getting same grades, they diminish their efforts to complete the group task in order not to be a sucker.
- "Groupthink". Interdepending each other in such a way that viewing any disagreement or conflict as a threat to group cohesiveness which results in seeking permanent consensus on whatever the concern is.
- "Lack of sufficient heterogeneity". Students who have similar abilities, perspectives, and background experiences do not discuss on necessary tasks adequately which causes little benefit from cooperative learning.
- "Lack of teamwork skills". Students need to be taught interpersonal and small group skills to make them work effectively. Students may not perform well as a group as a result of lacking certain teamwork skills, even they are high-ability in terms of academic achievement.
- "Inappropriate group size". As the size of the group increases, the performance level of each member decreases since there are more people to do the same work.

2.4.1. Basic Elements of Cooperative Learning

Johnson and Johnson (1999) distinguished not only between pseudo and traditional learning groups but also between two forms of cooperative learning with regard to the level of commitment groupmates have to each other and the group's success, namely "high-performance cooperative learning group" and "cooperative learning group" (see Figure 2.1). Unfortunately, however, not only high-performance cooperative learning groups but also cooperative learning groups are rare in practice since most of the teachers oversimplify the basics of structuring cooperation and consider unstructured cooperative learning groups as equal with structured cooperative learning groups. More specifically, it is not easy to apply a qualified cooparative work unless the basic elements are structured effectively which are positive interdependence, individual and group accountability, face-to-face promotive interaction, interpersonal and small group skills, and group processing (Johnson & Johnson, 1999).

I. Positive interdependence

Positive interdependence is the most essential element of cooperative learning such that there is no cooperation unless it is well-structured (Johnson & Johnson, 1999) because positive interdependence results in promotive interaction that in turn creates a learning environment where group members encourage each other's efforts to reach the group's goal. Johnson and Johnson (1999) offer teachers or researchers three steps to structure positive interdependence: "first step is to inform students explicitly on how to handle the assigned task within their groups, second step is to structure positive goal interdependence, and third step is to supplement positive goal interdependence with other types of positive interdependence" (p. 75-76). It is obvious from the suggested steps that positive goal interdependence is the heart, whereas not the unique type of positive interdependence. To be able to understand how to structure positive interdependence, therefore, it is necessary to discuss on the types of positive interdependence in detail.

Positive interdependence can be structured through certain ways which can be gathered under three categories, namely outcome, means, and boundary interdependence which are reported below, respectively. Outcome interdependence concerns with the end of the cooperative efforts as its name implies and includes goal, reward and fantasy interdependence. Positive goal interdependence is the meaning of being in a group which ensures that group's goal cannot be achieved through individualistic efforts but through joint efforts of each individual in the group. In other words, members have to coordinate their efforts and create a group synergy to be able to reach a common goal since any dropping outs may cause groups to fail. Therefore, students have two responsibilities within a cooperative group: to master on the assigned task and to make sure that all members of the group learn that material. Johnson and Johnson (2008) stated that the nature of groups' goals can be "real or imaginary, such as surviving in a desert island" (p. 19). If the assigned task requires members to imagine an unrealistic action or event, positive fantasy interdependence is to be structured which promotes students' higher-level reasoning and situational interest (Pintrich et al., 1993). Positive reward interdependence is to be structured when each member gets the same reward for successful joint efforts to complete the assigned task, what Veenman, Kenter and Post (2000) call "cooperative incentive structure" (p. 282). Slavin and Cooper (1999) distinguish three types of reward structures: individual rewards based on individual learning, group rewards based on a single group product, and group rewards based on individual learning. Focusing on solely individual performance and awarding individuals according their own learning is the predominant reward structure within traditional learning groups (Johnson & Johnson, 1999; Slavin & Cooper, 1999). Receiving a single group grade with regard to the joint efforts of members (e.g. submitting a project, presentation of the completed task) can be used to structure positive reward interdependence, whereas this structure requires intensive attention that it may diminish group effectiveness through taking certain undesired behaviors in, such as social loafing, free riding, or motivation losses. Behfar et al. (2010) report that when group members "do not complete their assignments on time, free ride, or do not perform duties as expected or agreed" (p. 128), contribution conflict becomes indespensible that affects group satisfaction negatively. Providing groups academic (e.g. bonus point) or non-academic (e.g. extra free time, stickers, food, gift) rewards in terms of individual performance, on the other hand, is the most sincere way of structuring positive reward interdependence because members in that case try to do their best to exceed certain criterion as they feel personal accountability to help the group reaches certain criterion. Student Teams-Achievement Divisions, one of the widely used methods of cooperative learning (Slavin, 1995), for instance, emphasizes the importance of group rewards which can be received according to each member's improvement scores on individual quizzes. Reward structure used in the Student Teams-Achievement Divisions promotes both positive interdependence and individual accountability, two of the most crucial basics of cooperative learning.

Means interdependence accommodates role, resource, and task interdependence, all of which specify necessities to be overcome by members to achieve common goals of taskwork and teamwork. Role interdependence helps members realize each member's contribution is as crucial as their owns for accomplishing the group goal and regulating intragroup interaction as a result of the assigned complementary roles to each member. A member who is assigned the role of checker, for example, makes sure that each member within the group has mastered on the assigned material, that is, try to observe whether or not each member is accountable. The role of encourager, on the other hand, acknowledge the member involved in group discussions and praise the member's contribution. The crucial concern upon structuring role interdependence is to rotate roles within a group in such a way that each individual experiences all roles. More specifically, the same member should not always be kept as a reporter which may result in lessened contribution of other members to the mutual goal of the group. Structuring resource interdependence is especially important for groups where students are not accustomed to work within a group because it entails members to share materials or information required for the group to succeed. Actually, resource has a dual meaning that it may imply any materials or information necessary for groups to complete their work. Resource interdependence can be established in two ways as a result of the composite meaning of resource: groups can be assigned limited number of task (e.g. two copies of task can be distributed to four-member groups), or students can be given only a portion of task to make them synthesize what they have in hand. Jigsaw method of cooperative learning (Aronson et al., 1978), as an example, employs resource interdependence through assigning solely a section of task to one member and have that member teach what is learned to other members of the group, otherwise, the group may not succeed joint goal. If the task is divided into pieces as in the resource interdependence but requires each student to complete her own portion to allow other students to do their own part, the task interdependence is to be structured. In other words, there is a division of labor that necessitates each division to be done in a sequenced way which promotes students' responsibility since each member's success has an impact on other members' performance. In fact, resource and task interdepence overlap with each other on several common themes, such as both of them serve to means interdependence, require division of labor, and create positive relationships among members that result in enhanced group cohesion.

Environmental, identity, and outside enemy interdependence are located under the boundary interdependence which gives opportunity to describe “who is interdependent with whom” (Johnson & Johnson, 2008, p. 19). All types of boundary interdependence underline the need for being grouped together through incorporating various factors. In particular, students are bound together in terms of proximity through sitting together as a group for environmental interdependence to be structured, students are bound together with regard to being an entity through deciding on a group name, motto, or symbol associated with the group for identity interdependence to be established, and students are bound together on the basis of driving forces against other groups in the classroom through organizing intergroup competitions to structure outside enemy interdependence. Teams-Games-Tournament, one of the several methods of cooperative learning (DeVries & Edwards, 1974), is an impressive example introducing well-structured way of outside enemy interdependence. Within the Teams-Games-Tournament, heterogeneous team members prepare each other to be successful in a tournament in which students of similar abilities compete with the other teams. During intergroup competition, students of the same group support each other by realizing the importance of being a group that is the unique way of reaching mutual goals. Table 2.1 summarizes various forms of positive interdependence, which was adapted from Johnson and Johnson (1999, p. 77) and Johnson and Johnson (2008, p. 20).

Johnson and Johnson (2008) editted results of various research studies confronting the influence of different types of positive interdependence on achievement or productivity which are postulated as follows (p. 21-22):

1. Positive goal interdependence promotes higher achievement and greater productivity than does resource interdependence.
2. Positive goal and reward interdependence tend to be additive; while positive goal interdependence is sufficient to higher achievement and productivity than do individualistic efforts, the combination of goal and reward interdependence tends to increase achievement more than goal interdependence alone or individualistic efforts.
3. Resource interdependence by itself may decrease achievement and productivity compared with individualistic efforts. However, the combination of positive goal and resource interdependence tends to increase achievement more than goal interdependence alone or individualistic efforts.
4. Both working to achieve a reward and working to avoid the loss of a reward produced higher achievement than did individualistic efforts.
5. Positive interdependence does more than simply motivate individuals to try harder, it facilitates the development of new insights and discoveries through promotive interaction. Members of groups use higher level reasoning more frequently than do individuals working individualistically or competitively.
6. The more complex the procedures involved in interdependence, the longer it will take group members to reach their full levels of productivity. The more complex the teamwork procedures, the more members have to attend to teamwork and the less time they have to attend to taskwork. Once the teamwork procedures are mastered, however, members concentrate on taskwork and outperform individuals working alone.
7. When students define themselves in terms of their group membership, they are more willing to take less from common resources and to contribute more toward the public good.

Table 2.1 Descriptions and outcomes of various types of positive interdependence

Types of Positive Interdependence	Description	Outcome
1. Outcome Interdependence		
Positive Goal Interdependence	Students perceive that they can achieve their learning goals if and only if all the members of their group also attain their goals	Achievement
Positive Reward/Celebration Interdependence	A joint reward is given for successful group work and members' efforts to achieve	Long-term retention
Positive Fantasy Interdependence	A task is given that requires members to imagine that they are in a life or death situation and must collaborate in order to survive	Higher-level reasoning
2. Means Interdependence		
Positive Role Interdependence	Each member is assigned complementary and interconnected roles that specify responsibilities to be performed to complete a joint task	On-task behavior
Positive Resource Interdependence	Each member has only a portion of the information, resources, or materials necessary for the task to be completed and the member's resources have to be combined in order for the group to achieve its goal	Positive relationships
Positive Task Interdependence	A division of labor is created so that the actions of one group member have to be completed if the next team member is to complete his or her responsibility	Cohesion
3. Boundary Interdependence		
Positive Environmental Interdependence	Group members are bound together by the physical environment in someway	Heterogeneity
Positive Identity Interdependence	The group establishes a mutual identity through a name, flag, motto, or song	Academic support
Positive Outside Enemy Interdependence	Groups are placed in competition with each other. Group members then feel interdependent as they strive to beat the other groups and win the competition	Personal support

II. Individual and Group Accountability

The underlying purpose of cooperative learning is to enhance individual learning and productivity which can be realized by structuring individual accountability. When individuals are assessed on their own right and the results are turned back to the individual and the group, then there exists individual accountability. If assessments done with regard to the overall performance of the group and results are given back to the group, however, group accountability exists. Both individuals and groups should do their fair share of the work, otherwise, there is not any effective cooperative learning. Actually, positive interdependence and accountability are not independent from each other such that "the greater the positive interdependence structured within a cooperative learning group, the more students will feel personally responsible for contributing their efforts to accomplish the group's goals" (Johnson & Johnson, 1999, p. 81). Further evidences can be submitted concerning the relationship between positive interdependence and individual accountability, such as role interdependence may result in increased personal responsibility if one member of the group checks whether each individual learned the material, resource interdependence may contribute to individual accountability when members of the group are required to present what they know to other group members. When individual accountability is not well-structured, students may exhibit certain undesired behaviors that threat the effectiveness of cooperative learning. For example, some of the students may contribute less to the group's goal in order not to be a sucker or as a result of being assessed according to group's performance which cause motivation losses, contribution conflicts, or lessened group cohesiveness. The following ways can be used for structuring individual accountability (Johnson & Johnson, 1999, p. 81);

1. Keeping the size of the group small.
2. Giving an individual test to each student.
3. Giving random oral examination.
4. Observing each group and recording the frequency with which each member contributes to the group's work.
5. Assigning one student in each group to the role of checker.
6. Having students teach what they learned to someone else.

III. Face-to-Face Promotive Interaction

Positive interdependence has direct impacts on promotive interaction which happens as individuals "encourage and facilitate each other's effort to complete tasks, achieve, or produce in order to reach the group's goal" (Johnson & Johnson, 2008, p. 12-13). As environmental interdependence ensures, it is necessary for group members to sit together and establish eye contact with each other in order for to promote interaction (Murdoch & Wilson, 2008). When promotive interaction is to be structured, students readily try to learn the task and provide help to other members to make sure that every members learn the task, develop personal rapport that in turn increases their motivation to work together (Sharan & Shaulov, 1990), share materials and information, give feedback to each other, encourage and praise each other's effort to learn, challenge each other's responses, and behave in trustworthy ways (Johnson & Johnson, 1999). Research studies indicate that mixed-ability and gender balanced groups of three to four members is the ideal group composition for enabling high-quality group interaction which in turn promotes learning, psychology, and social relations (Webb, 1984; Gillies, 2003).

IV. Interpersonal and Small Group Skills

Students cannot cooperate effectively unless they have learned the assigned task (taskwork) and crucial interpersonal and small group skills (teamwork). Coping with taskwork as well as teamwork makes cooperative learning more challenging than competitive and individualistic efforts. Johnson and Johnson (1999) states that "we are not born instinctively knowing how to interact effectively with others...Students must be taught the social skills required for high-quality collaboration and be motivated to use them if cooperative groups are to be productive" (p. 82-83). Research studies indicate that students, who were trained in interpersonal and small-group skills, engage in more task-related discourse, use more complex cognitive language strategies, provide elaborated help and assistance to each other, and assure high quality promotive interactions (Ashman & Gillies, 1997; Johnson & Johnson, 1999; Gillies, 2004), if positive interdependence is also to be well-structured (Johnson & Johnson, 1994). Efficient communication, conflict management, listening to each other, giving and receiving help, sharing leadership, trust-building, respecting each other, sharing resources, taking turn, and democratic decision making are some of the social skills required in a healthy cooperative learning (Johnson & Johnson, 1989; 2009).

V. Group Processing

Group processing reveals how well any group put taskwork and teamwork into place. In other words, students constructively discuss on how well they have worked together while completing the assigned task and the way group members coordinate their efforts (Bertucci, Johnson, Johnson, & Conte, 2012). Group processing is a kind of formative assessment during which students plan, monitor, and evaluate the group's and individual's performances and suggest new ways to dispose efforts that did not work. In brief, small group processing involves students' perceptions of what happened within the cooperative learning group (Johnson et al., 1990; Gillies, 2004). To be able to reflect on their own learning processes, students have to have interpersonal skills (especially, conflict management), metacognitive, critical, and reflective thinking skills. In other words, group processing enhance students' ability in coordinating both taskwork and teamwork which in turn help them be successful as a group (Bertucci, Johnson, Johnson, & Conte, 2012). Group processing can also be in the form of whole-group processing in which teachers reflect on groups' performances by observing groups and filling a formal checklist for each group. It is important for teachers to share the results of the observations at the end of each lecture hour as a feedback with individuals, groups, or whole class (Johnson & Johnson, 1999), among which the most effective way is to provide individual feedback (Archer-Kath, Johnson, & Johnson, 1994). Moreover, compared to no group processing at all and group processing provided by teachers alone, the combination of teacher and student processing has a greater effect on students' problem solving ability (Johnson, Johnson, Stanne, & Garibaldi, 1990). In their study, Yager, Johnson, Johnson and Snider (1986, as cited in Johnson & Johnson, 2008) examined the effect of group processing on three measures of achievement namely, daily achievement, post-instructional achievement, and retention by assigning students to groups with group processing, groups without any group processing, and individualistic condition. The results of the study revealed that students in both of the two cooperative groups outperform students who worked alone. Of cooperative groups, furthermore, students within group processing condition performed better on three of the achievement measures as compared to students in without group processing condition.

Table 2.2 Comparison of unstructured and structured cooperative learning groups

Unstructured Cooperative Learning Groups	Structured Cooperative Learning Groups
Low interdependence. Members take responsibility only for self. Focus is on individual performance only.	High positive interdependence. Members are responsible for own and each other's learning. Focus is on joint performance.
Individual accountability only.	Both group and individual accountability. Members hold self and others accountable for high-quality work.
Assignments are discussed with little commitment to each other other's learning.	Members promote each other's success. They do real work together and help and support each other's efforts to learn.
Teamwork skills are ignored. Leader is appointed to direct members' participation.	Teamwork skills are emphasized. Members are taught and expected to use social skills. All members share leadership responsibilities.

Table 2.2 (continued)

Unstructured Cooperative Learning Groups	Structured Cooperative Learning Groups
No group processing of the quality of its work. Individual accomplishments are rewarded.	Group processes quality of work and how effectively members are working together. Continuous improvement is emphasized.

To sum up, every small groups may not be a cooperative learning group, but a traditional learning group. The distinction between unstructured and structured cooperative learning groups were made apparent in the Table 2.2 (Johnson & Johnson, 1999, p. 73). Although it is a well known fact that basic elements of cooperative learning have to be put into practice to make groups truly cooperative, that may challenge teachers since it demands unfamiliar practices which is the concern of the following part.

2.4.2. The Role of Teachers in Cooperative Learning

Cooperative learning groups can be divided into three according to the period groups continue to work, namely formal cooperative learning groups, informal cooperative learning groups, and cooperative base groups (Johnson & Johnson, 1999). Formal cooperative learning groups are the most structured one where students work together from one lecture period to several weeks to finish the assigned work. Informal cooperative learning groups, on the other hand, are formed temporarily (on ad hoc basis) that proceed from a few minutes to one lecture period for several purposes, such as to take students attention to the subject matter under examination, inform students on the content of the lesson, and raise students' motivation to the lesson. Apart from formal and informal cooperative learning groups, cooperative base groups sustained at least a year, in which students are fixed and heterogeneous in nature, in order to help, assist, and encourage each other to achieve academic tasks. Of several forms, "formal cooperative learning groups are the heart of cooperative learning" (p. 15), thereby it is within the scope of this dissertation.

Teachers are the essential components of a healthy cooperative learning since they have multiple roles not only during application of cooperative learning but also before that practice commences and after implementation ceases. Murdoch and Wilson (2008) listed the following role of teachers by emphasizing that teachers determine those roles with regard to students' age, nature of the assigned materials, the extent of prior knowledge students have, and the culture in which students are embedded in;

I. Explicit instruction: Teachers instruct students on how to cooperate effectively, how to manage disagreements, and why working well as a group is important in a manner to ensure that students perceive cooperative efforts as worth to try. Brainstorming on why to work well as a group, inviting a guest speaker who has the ability to impress students with her own stories, and preparing posters to show how and why to cooperate are some of the suggestions that can be put into practice when teachers wish to instruct explicitly.

II. Modelling: Taking the social environment into account may be an impressive way of learning which requires individuals to monitor what is happening around them and to imitate observed behaviors, correspondingly. Therefore, teachers should be accurate models for students by interacting cooperatively with students, families, and other teachers. It should not be forgotten that "cooperative learning in the classroom requires cooperative learning in the staffroom" (Jolliffe, 2007, p. 5).

III. Feedback: To be able to know what is working well, even what is not working well, students need some sorts of feedback from the teacher and other members of the group. Providing elaborated and constructive feedback let students be motivated, be accountable, and think in a reflective and metacognitive manner. Teachers observe whole class by filling the checklist related to taskwork and teamwork as well as small groups to be able to control whether each individuals master the assigned task and cooperate effectively. It is important for teachers to share what has been observed during cooperative learning practice with students.

IV. Intervention: Students should realize that they have to cooperate well by managing conflicts constructively, learning the assigned task, helping other group members to learn the material under examination, tolerating and listening to each other as long as possible. However, if students face with sustained disagreements, permanent off-task and disruptive behaviors, or misinterpretation of the task, teachers should intervene to encourage students to work cooperatively again. Within the case of undesirable behaviors, teachers may exhibit various intervention strategies, such as behaving like an additional member of the group who experiences the same problem with the group, making students to remember the behaviors predetermined at the beginning of the lecture (the role of explicit instruction), or encouraging students to try to resolve the problematic situation under the control of the teacher.

V. Strategic task selection: Teachers should prepare or select academic tasks according to the objectives of cooperative learning practices. When objectives include poor abilities like memorization, or have a single correct answer that one person can reach the solution easily, then it is not logical to assign tasks which are conceptual in nature. On the other hand, if objectives require higher order intellectual abilities, or have multiple ways to attain solution, the task assigned to students has to be a challenging one (Cohen, 1994)- what Slavin (2009) calls "ill-structured problems" (p. 247).

Johnson and Johnson (1999) stated that "any assignment in any subject area may be structured cooperatively" if teachers are committed to apply basic elements of cooperative learning in a disciplined way. As implementation of formal cooperative learning requires to be well disciplined, teachers should follow certain steps all of which are the review of the role of teachers, meanwhile. More specifically, teachers should act as follows;

I. Make preinstructional decisions: Before cooperative learning practice starts, teachers "formulate objectives, decide on the size of groups, choose a method for assigning students to groups, decide which roles to assign group members, arrange the room, and arrange the materials students need to complete the assignment", respectively (p. 17-18). To be able to reach the desired outcome, the first step is to know what the desired outcome is. More specifically, teachers have to decide explicitly on the aim of the cooperative practice in terms of both taskwork and teamwork. After formulating objectives to be acquired by students, teachers consider about group formation with regard to the size, the composition (heterogeneous or homogeneous), and the way to form groups. There is not an exact formula for these concerns which are determined on the basis of the number of students in the classroom, amount of resources present, nature of the task assigned, the period of the instruction, or the objectives of the practice. However, it can readily be said that the smaller the size of the group, the better the success of the students within cooperative groups as a result of percentage of responsibility per each student. In other words, students share responsibility to achieve group goal and as the number of students increases, each student's responsibility decreases at the same rate. In a group of two-people, for instance, each individual has 50 % responsibility but in groups of four-people, each individual has 25 % responsibility to complete group task. As size of the group increases, the possibility of social loafing and free-riding effects raise which makes difficult to assess individual performance. Besides to the size of groups, the research studies constantly point out that teacher-selected groups prevent the feeling of being rejected and provides, on the contrary, a deep sense of belonging to a group (Strijbos, Martens, & Jochems, 2004). Moreover, when teachers deliberately assign students to groups in a manner to form heterogeneous groups in terms of gender, ability, or talent, students learn more, the retention time of the learned knowledge increases, and the amount of off-task behaviors decreases (Johnson &

Johnson, 1999). The next stage of planning is to give complementary roles to students which enhances positive interdependence and individual accountability (especially, the role of checker) since roles imply the expectations of the teacher and other group members from the person whom that role was assigned. Mudrack and Farrell (1995) reported that "the opinions that others form about one's contribution to the group effort will likely be influenced, in part, by which roles the focal group members play" (p. 559). As the final decision before instruction, teachers decide on the arrangement of rows as to encourage promotive interaction, and the assignment of materials to satisfy various forms of positive interdependence like, distributing one material per a group to provide resource interdependence, assigning materials as a jigsaw puzzle to promote information interdependence.

II. Explain the task and cooperative structure: Up to now, the planning of cooperative learning practice has been completed but there is much to do to have a truly committed cooperative learning. First of all, students should explicitly be informed on what the assigned task is about, the way of completing that assignment, and the level of excellence to be accepted as successful. The criteria for success can be determined according to the objectives of the practice like "students who are able to acquire three of the five objectives determined at the beginning of the planning step", content of the lesson like "students who mastered on seventy percent of the content under discussion", correct answers given at the test as an individual, as a group, or as a class like "students/ groups/ class score(s) above seven correct answers out of ten items", or students' improvement scores compared to last performances like "students who exceed the score of last week". No matter what the criteria of success is, the important point is that the assessment is to be criterion-referenced in nature since the underlying purpose of cooperative efforts and criterion-referenced assessments are congruent with each other, which is to make each individual to learn better. In other words, students do not compete with each other to be the best in the group as the situation in norm-referenced assessments but to cooperate with each other within the group to exceed certain set of standards as in the criterion-referenced assessments. Actually, the desired condition for an effective cooperation is to provide intragroup cooperation and intergroup competition, like Teams-Games-Tournament which is developed by DeVries and Edwards (1974) and Student Teams-Achievement Divisions which is established by Slavin (1979), those of which create certain amounts of arousal to struggle on the task assigned as a group that facilitates group accountability in turn. In addition to the information about the task and the criteria for success, teachers should structure three elements of cooperative learning firmly which are positive interdependence, individual and group accountability, and interpersonal and small group skills in a way noted previously. Finally, it is the time to implement cooperative learning practice through putting various methods into practice, such as Team-Assisted Instruction, Teams-Games-Tournament, Group Investigation, and Student Teams-Achievement Divisions, all of which was explained in detail in the following part of the dissertation.

III. Monitor and intervene: The job of the teacher does not finish once students work in the cooperative groups, it is the time to check how students worked on the task and worked as a team, continuously. To be able to guarantee students work well with each other, teachers should observe all groups systematically during a lesson and have some students observe their groupmates within a cooperative learning practice which is an effective way of understanding what is going around because it is reasonable for students with close ages to communicate better with each other than the teacher. Teachers should monitor groups by means of formal observation forms since "the more concrete the data, the more useful it is to the teacher and to students" (Johnson & Johnson, 1999, p. 43). Observations conducted by teachers and trained students are powerful tools for teachers to diagnose what students understand and do not understand, and whether or not students have been accustomed to working together. Therefore, it can be stated that the results derived from observations direct teachers to intervene to help groups eliminate alternative conceptions and unskillful behaviors which require frequent use of positive reinforcement and questions that promote students' metacognitive skills, such as what is the reason of doing it?, why do you think so?, and how can you reach that solution?

IV. Evaluate and process: Once students complete the cooperative learning practice under monitoring and intervening of the teacher, how students performed in terms of taskwork and teamwork should be assessed not only to determine the amount of success but also to the quality of learning. The teacher put predetermined criteria of success, which was criterion-based in nature, into practice through the involvement of students since they are still at the center of their own learning. Teachers, who have internalized the constructivist thoughts, have wide variety of opportunities when evaluating students, such as project-based assessment, portfolio assessment, performance-based assessment, and individual and peer assessments. The quality of student learning, furthermore, can also be processed both by students and the teacher. Teachers let students process their group in which group members try to understand what happened in the group, what should have been and should not have been in the group, in a constructive manner to be improved in future practices. Teachers, on the other hand, direct questions to whole class to realize whether or not each individual, each group, or the class has experienced maximum benefit from the cooperative practice. Moreover, teachers provide simultaneous feedback and become sure that students reflect on the feedback given by the teacher. As the final step, teachers encourage groups to celebrate their excellence.

2.4.3. Cooperative Learning Methods

Several cooperative learning methods, which indicate the way to implement a cooperative lesson, have been developed and evaluated for several decades those of which belong to one of the two fundamental categories, namely "group study methods" and "collaborative learning methods" (Slavin, 2009). The former provide an arena where students work together up to all group members learn the assigned task which is comparatively well-structured (e.g. Student Teams-Achievement Divisions). The latter, on the other hand, ensure a domain in which students work together on relatively less-structured tasks to create certain kinds of product like a report, a poster, a project, or an experiment set up (e.g. Group Investigation). In brief, the main differentiation point of group study methods and collaborative learning methods is the nature of the task assigned students to complete through working together. In their meta-analysis, Johnson, Johnson and Stanne (2000) situated cooperative learning methods into a continuum from direct (concrete or prescribed) to conceptual (flexible) and described direct method as the one which includes well-defined and relatively inflexible steps that enable teachers to master the method in a few minutes and implement readily. Conceptual methods, on the contrary, involve rather complex and flexible steps which can be used as a template throughout the cooperative lesson. More specifically, more direct methods can be learned in a few minutes and applied simultaneously but cannot be soon modified to varying conditions, that is, they are generally dependent on subject areas or grade levels. In contrast to direct methods, more conceptual models are not simple enough to learn and apply readily, whereas they can be customized rather easily to different conditions, that is, conceptual methods can be used frequently in various subject areas and grade levels. In brief, it is more easy to learn and apply more direct methods of cooperative learning but it is more easy to adapt more conceptual models in various conditions that gives flexibility to the person who applies it.

Another point to separate cooperative learning methods from each other is related to their applicability fields. More specifically, some of the cooperative learning methods are suitable for specific disciplines and grade levels, what Johnson, Johnson and Stanne (2000) call "nonrobust methods", like Team-Assisted Instruction (Slavin, Madden, & Leavy, 1984) and Cooperative Integrated Reading and Composition (Stevens, Madden, Slavin, & Farnish, 1987), and the others are applicable to broader subjects and grade levels, such as Student Teams-Achievement Divisions (Slavin, 1995), Teams-Games-Tournament (DeVries & Edwards, 1974), Jigsaw (Aronson et al., 1978), Learning Together (Johnson & Johnson, 1999), and Group Investigation (Sharan & Sharan, 1992). Of these diverse cooperative learning methods, however, research studies primarily focus on the group study methods those of which are applicable to any grade level and subject area (Slavin, 2009). Consequently, the following four methods of cooperative learning are incorporated within this dissertation; Student Teams-Achievement Divisions, Teams-Games-Tournament, Jigsaw, and Learning Together.

- **Student Teams-Achievement Divisions (STAD):**

STAD is one of the direct methods of cooperative learning, that is, it is not difficult to learn how to implement STAD within the classroom and it is applicable to any grade level and subject matter. STAD, however, is most suitable for giving information on "well-defined objectives with single right answers, such as science facts and concepts" (Slavin, 2009, p. 244) which does not actually mean it is not adaptable to different conditions. Through incorporating open-ended worksheets for students to work together in teams, STAD becomes adaptable to "ill-structured problems" which can be defined as problems with less-defined objectives.

STAD includes a schedule of class presentation, team study, individual quizzes, individual improvement scores, and team recognition, all of which are arranged in a manner to follow each other (Slavin, 1991; 2009). Within a lesson in which STAD is put into practice, the teacher starts to present the lesson through lecturing and discussion in order to form adequate knowledge base in the mind of learners. Teacher presentation in STAD is not the same with lecturing since the former solely focus on the specific part of a topic which is the topic of worksheet and quiz, at the same time. In brief, the purpose of teacher presentation is to prepare students to work well in teams by generating necessary prior knowledge which in turn help students be successful in the quiz and have high team scores at the end. After teacher presents the topic, students meet with their predetermined teams which are composed of four or five students who are heterogeneous in terms of gender, intellectual ability (past grades can be used on behalf of intellectual ability), and ethnicity (if students with different ethnicity present). To be able to generate heterogeneous groups, teachers have to deliberately select group members instead of random sampling, or student-selected groups which often result in homogeneous groups. Being the most important step of the STAD, team work on worksheets in a manner to learn the material precisely as well as to make sure that all other members master the assigned material perfectly. More specifically, the primary purpose of team work is to have students prepare each other to the quiz as each member will take 100 percent which can be achieved when groupmates interdepend each other positively, and try to do their best individually. The function of the teacher is not only to present the lesson and prepare worksheets but also to prepare quizzes concerning relevant content to be assigned to groups after they have completed their work on worksheets. Once learning together, students take the quiz alone to be able to realize whether every member of the group have mastered the knowledge acquired through teacher presentation and teamwork. Students apply what they learned in the quiz if they have actually learned, that is, not only one or two students but all students are accountable for achieving group goal. More specifically, assigning individual quizzes reduce social loafing and free rider effect that is the desired condition for having more accountable and better learned individuals.

Slavin (1996) suggested a remarkable scoring system for monitoring students' excellence after they have taken individual quiz, which is the individual improvement scoring. Initially, each student is given a base score which is "the minimum the teacher expects the student to make on a 30-item quiz" (Slavin, 1996, p. 26). The tests having different numbers of items than 30 should be adjusted in a manner to possess a 30-item test. For example, each item on a 10-item test is worth three points, or each item on a 25-item test is worth 1.2 points. The first three students are assigned an initial base score of 20 out of 30, the next three students are assigned an initial base score of 19 out of 30, and the same procedure is followed until each student is given a base score. The maximum improvement a student can gain is adjusted to 10 points and the minimum improvement a student can gain is set to zero points. In other words, the students who gained more than 10 points in the following quiz are established just 10 improvement score and the students who showed a lower performance than their base scores are assigned zero improvement score, not negative improvement scores. For instance, when a student, who has been assigned as a base score of 15, gets 28 points in the following quiz, the student's improvement score was not computed as 13, but 10 points which is the maximum improvement score a student can be assigned. Likewise, when a student, who has been assigned a base score of 15, gets 12 points in the quiz, the student's improvement score was not computed as -3, but zero points which is the minimum improvement score a student can be assigned. Assessing students' excellence on the basis of their own improvement aims to make students to compete solely with their own past performances which ensures a feeling of justice since any student (either high-performing or low-performing) has a chance to exceed their own past performances through studying hard and be announced as the person who contributed maximum to group goal. It is crucial for the teacher to compute team scores by summing up individual improvement scores and make those scores public by the means of a bulletin board right after the lesson at which students take quiz because it “makes the connection between doing well and receiving recognition clear to students, increasing their motivation to do their best” (Slavin, 2009, p. 245). When determining the winner team with the highest improvement score, furthermore, it is important to make necessary adjustments if groups do not have same number of students, that is, if a team with four members scores 20 and a team with five members scores 25, then the second team’s score has to be justified as 20 as behaving that group to have four members in fact.

- **Teams-Games-Tournaments (TGT):**

Likewise STAD, TGT can be used to teach any material to any grade level and any subject area, and it is not difficult to master on how to implement TGT in classroom. Moreover, TGT accommodates a regular schedule as STAD wheras instead of individual quizzes and individual improvement scores, TGT has academic games and tournaments. Actually, it is not surprising to have various similarities between STAD and TGT methods since Slavin established STAD (1979) by extending the notions of DeVries and Edwards (1974) who are the developers of TGT. Once the teacher presents the lesson, predetermined four-member teams get together to work on the assigned worksheet and prepare each member to do well in the tournament. Afterwards, students play academic games with three members of different groups who resemble each other in terms of their academic performance to have a fair competition. For instance, high-performing students are assigned to tournament table 1, average-performing students are assigned to table 2, low-performing students are assigned to table 3, and so on. The games function as a formative-assessment during which students’ success level is evidenced since they have prepared to test the amount of knowledge gained by students. Eventually, the individual scores gained through games are gathered together to determine the team scores and as in STAD, the teams that exceed certain standard point are announced in the bulletin board once a week.

- **Jigsaw:**

The original Jigsaw method, developed by Aronson et al. (1978), involves academic tasks for the purpose of forming knowledge base within the mind of learners instead of teacher presentation as in STAD and TGT. Size of the group is particularly important in the original Jigsaw because students within groups do not read the whole document but a portion of the assigned task in home groups, therefore the number of student within a group is a concern to be determined according to the number of sub-topics. After preliminary reading, students from other groups who have read the same section come together to discuss vigirously their own section in expert groups. Expert students are responsible to teach the knowledge in their portion to the rest of the group upon turning back to home groups. In brief, all of the members of the group have specialized on certain sections of the material and inform other members of the group on that part. Students have to listen to each other since learning from others is the unique way to learn the whole task and then, prepare a final report as a group. The original Jigsaw was modified by several researchers, in Jigsaw II, for instance, heterogeneous teams with four or five students are formed, as in STAD and TGT. Each member of the team reads all sections of an academic material but focuses mainly on one section. As in the original Jigsaw, students who have focused on the same section meet in expert groups and discuss the topic under examination in detail since they are the experts of that section and responsible for teaching it to other members of the group. Upon returning to their initial groups, each student in turn share their thoughts with groupmates in a manner to make sure that each member of the group has learned the whole material. Students take individual quizzes at the end of the cooperative practice at which they cannot help each other. Therefore, students realize that the only way of learning the assigned material is to listen to their groupmates, carefully. Unlike the original Jigsaw, teachers compute team scores on the basis of individual’s improvement scores and announce the group(s) exceed standard point in the bulletin board, as in STAD. The research studies point out that there are other versions of Jigsaw method generated through modifying the conditions related to the way knowledge base is formed at the beginning of the practice and the way students are assessed at the end of the practice.

- **Learning Together:**

Learning together, one of the most widespread methods of cooperative learning developed by Johnson and Johnson (1999), involves heterogeneous groups of students who have primarily two functions, namely to learn the assigned material and to help groupmates learn the task under examination. In other words, students interdepend each other positively and each individual is accountable for the mutual goal. Moreover, groupmates interact with each other in a manner to promote each other's learning through putting interpersonal and small group skills into practice. To be able to learn better and achieve group's goal, students regularly reflect on the effectiveness of group's performance. At the end of learning together, groups are rewarded on the basis of a single group product.

2.4.4. Research on Cooperative Learning

There is a substantial body of research on the effectiveness of cooperative learning across a range of subject areas (Ashman & Gillies, 1997; Johnson, Johnson, & Stanne, 2000) in preschool through graduate school levels (Johnson, Johnson, & Smith, 2007) on cognitive, affective, and social outcomes, among which the most extensively searched are achievement, conceptual understanding, motivation, higher-level reasoning, retention, attitudes, self-esteem, and social skills (Johnson & Johnson, 1979; Madden & Slavin, 1983; Webb, 1997; Johnson, Johnson, & Smith, 1998; Hancock, 2004; Bilgin & Geban, 2006; Acar & Tarhan, 2007). Tarhan and Acar-Sesen (2012), for instance, investigated whether instruction based on jigsaw method of cooperative learning is superior than traditional instruction in terms of undergraduate students' understanding of acid-base theories. In addition to conceptual understanding, students' ideas regarding cooperative learning practices were examined by conducting interviews with the experimental group students. The findings of the study indicated that students, who were exposed to instruction based on cooperative learning (i.e. experimental group students), learned acid-base concepts better and had fewer misconceptions on the corresponding chemistry concepts than students instructed through traditional means. Moreover, experimental group students perceived jigsaw implementations as more interesting and beneficial for interpersonal relationships among students and their achievement gains, as compared to traditional chemistry instruction. Similar to Tarhan and Acar-Sesen (2012), Taştan-Kırık and Boz (2012) analyzed the effectiveness of cooperative learning on students' understanding of chemical kinetics and their motivation. Unlike Tarhan and Acar-Sesen (2012), on the other hand, the sample of the study conducted by Taştan-Kırık and Boz (2012) were eleventh grade students, and STAD was selected for the application of cooperative learning in the classrooms. The researchers concluded that experimental group students, who were taught through STAD method, understood the related concepts better and possessed greater motivation to study chemistry than control group students instructed through traditionally designed chemistry instruction, when students' science process skill scores were assigned as covariate.

Currently, it is almost universally accepted among researchers, who have spent their research career for developing precessor ideas on cooperative learning, that cooperative learning is an effective instructional pedagogy on such diverse learning outcomes if it is applied properly, which makes it unique among all other instructional approaches (Johnson & Johnson, 1999). What is disagreed upon, on the other hand, is what mediates cooperative learning to bring about higher academic outcomes, and even more specifically, under which conditions cooperative learning results in higher achievement (Cohen, 1994; Slavin, 1996; Ashman & Gillies, 1997; Johnson & Johnson, 1999; Gillies, 2003; 2004). Johnson and Johnson (1999) state that "having a number of people work together does not make them a cooperative group...Groups do not become cooperative groups simply because that is what someone labels them" (p. 70-71). It is now a well-known fact that any small group becomes a cooperative group if and only if the group is structured in certain ways, that is, if the basic elements of cooperative learning are well-established in the group where students interdepend each other positively, be accountable to achieve the mutual goal, interact with each other in a manner to promote each other's learning, operate interpersonal and small group skills, and reflect on the process of learning to increase group members' commitment to reach the mutual goal of the group (Johnson & Johnson, 1989; 1999; 2008). Johnson and Johnson (1999) claim that students cooperate with each other when these elements were structured firmly, otherwise, the groups cannot be labeled as cooperative learning group but "pseudo-learning group", or "traditional learning group". Other researchers, furthermore, described groups as "unstructured cooperative learning group" (Gillies & Ashman, 1996; 1998; Gillies, 2004), "group work-only group" (Gillies, 2006), "loosely structured cooperative learning group" (Ahmad & Mahmood, 2010), or "informal cooperative group" (Gillies, 2008; Slavin, 2009), when basic elements of cooperative learning are not well-established. Chiriac and Granström (2012) viewed low-quality group work as the one in which "students work *in* a group instead of *as* a group...this is just individual work, which makes very little use of the group as a forum for mutual learning" (p. 360). In fact, the purpose of this dissertation is coherent with what related literature discusses on, that is, the effect of structuring cooperative learning based on conceptual change approach on students' understanding and motivation can be deduced through reviewing research studies investigating various group dynamics empirically (e.g. basic elements of cooperative learning, group composition, group size). The following part, as a result, presents a collection of research studies which have dealt primarily with various group dynamics in order for better understanding of conditions under what cooperative learning results in higher learning outcomes.

Webb, Nemer, Chizhik and Sugrue (1998) explored the impact of group ability composition on group processes and outcomes in group and individual of a science assessment. 662 eighth-grade students from five schools in Los Angeles were assigned to low, low-medium (below average), medium-high (above average), or high ability group compositions according to the scores measured by non-science (vocabulary, verbal and non-verbal reasoning tests) and science related pretests. More specifically, students in the lowest quartile were placed into the low-ability groups, students in the highest quartile assigned to high-ability groups, and the remaining students were situated in one of the two medium-ability groups on the basis of quartile they fell into. The participants were assigned either to heterogeneous or homogeneous three-member groups (random assignment in terms of gender and ethnicity) to work together on the science task after that, however all students were required to complete similar task individually. The results indicated in general that ability group composition affects both group and individual performances in a varying trend. More specifically, students in below-average condition produced more accurate and high-quality explanations as a group and as an individual when heterogeneous groups were formed including above-average students than homogeneous groups of below-average students. High-ability students, in contrast, indicated higher performances as a group and as an individual unless they were assigned to heterogeneous groups with lower-ability students. To conclude, heterogeneous grouping is desirable for below-average students but detrimental for high-ability students.

As an extension of the study conducted by Webb et al. (1998), Webb, Nemer and Zuniga (2002) investigated the effects of group ability composition on high-ability students' group processes and outcomes in a science assessment to be able to understand deeply whether or not high-ability students perform as well in heterogeneous grouping as in homogeneous grouping. The sample was selected purposively from two schools in Los Angeles in a manner to have high-ability students who were located in the highest quartile during the previous study (Webb et al., 1998). 83 high-ability students were assigned to four group compositions with regard to a composite score based on non-science (vocabulary, verbal and non-verbal reasoning tests) and science related pretests , namely low, low-medium, medium-high, or high ability groups. Students within the lowest quartile were situated in low-performing high-ability groups, students in the highest quartile were assigned to high-performing high-ability groups, and the middle 50 % of the students were placed into one of the two average conditions on the basis of their composite scores. The procedure of the study followed three phases in which all participants took three non-science pretests individually (Phase 1); students have been instructed on the unit of electricity and electric circuits for three weeks by their teachers and have been assigned two posttests (hands-on and paper-and-pencil) right after the instructional unit which were completed individually (Phase 2); one month later, students worked as groups of three on the same hands-on activity as the posttest (Phase 3a), and on the same paper-and-pencil test as an individual posttest (Phase 3b). The study did not focus only on performance differences among group ability compositions but analyzed also certain behavior variables as predictors of students' performance, such as co-construction of solutions, giving and receiving help, the quality of group functioning, the frequency of domineering, insulting, and off-task behaviors, and free-rider effect. The researchers stated that the results of the previous study (Webb et al., 1998) need a revision since the results of this study suggested that some compositions of heterogeneous grouping (e.g. groups of below-average and above-average performing high-ability students) promote performance of high-ability students equally well as homogeneous grouping. Of predictors of high-ability students' performance, the quality of group functioning was found as the most influential variable that accounted for much of the effect of group composition. The study concluded that differentiating high-ability students as low-performing or high-performing creates an opportunity to claim that high-ability students perform equally well in heterogeneous groups as in homogeneous groups when groups function effectively.

Gillies (2004) investigated the effects of structured and unstructured cooperative learning experiences on junior high school students' behaviors, interactions, learning, and perceptions of what happens during cooperative learning. Among 223 grade nine students, 99 of them were assigned to structured cooperative learning groups and the remaining 124 students were placed to unstructured cooperative learning groups through stratified random sampling. Both the structured and unstructured cooperative learning groups involved three to four students in a mixed gender and achievement group, that is, each group involved one high-achieving student, two medium-achieving students, and one low-achieving student. Among six schools from Australia, three of them had high commitment (i.e. participated in extensive professional development activities to be able to learn how to apply cooperative learning in their classes) but the other three schools had low commitment (i.e. teachers had not participated in any activity concerning cooperative learning practices) to implement cooperative learning in classes. The researcher, correspondingly, assigned high commitment schools to the structured groups which exhibit many key elements of cooperative learning, such as task interdependence and individual accountability, and the students were trained in social skills necessary to promote cooperative learning. Low commitment schools, on the other hand, were labeled as unstructured cooperative groups where students worked on "ad hoc" basis instead of practicing cooperative learning in a disciplined way, were deprived of many basics required to cooperate effectively, and did not receive any training on small group skills necessary to promote healthy cooperation. Moreover, teachers in the unstructured cooperative groups did not have a chance to be informed on how to apply cooperative practice regularly. The students were observed by the means of two observation forms on "behavior states" and "verbal interactions" when they work on activities on a unit of geometry (4-6 weeks) which were videotaped in the last two weeks of the study. Students were initially assigned "What Happened in the Group Questionnaire (WHGQ)" right after they were videotaped and then, the mathematics questionnaire was distributed to the students one to two weeks after videotaping. The results of students' behavior states revealed that students within unstructured groups displayed more noncooperative behaviors and more individual non-task behaviors than their peers in structured groups. Although, students in unstructured groups gave short answer responses to their groupmates when they worked on activities, students in structured groups provided elaborated help in a manner to facilitate each other's learning. Results regarding learning, furthermore, indicated that students in structured groups outperformed their counterparts in unstructured groups. Even more, students in structured groups perceived their groupmates as more willing to help each other and promote each other's learning as a group than students in unstructured groups. The study concluded that students learned better, involved more in elaborated help with each other, promoted more each other's learning, and formed a stronger group cohesion which results in higher willingness to work with others when they worked in structured cooperative groups as compared to students did in unstructured cooperative groups.

Gillies (2008), furthermore, investigated the effects of structured and unstructured cooperative learning experiences on junior high school students' behaviors, discourse, and learning as they worked on a science problem-solving activity. The researcher described experimental conditions as structured and unstructured regarding the presence of basic elements of cooperative learning. Students worked in unstructured groups, for instance, were not linked interdependently around the task and were not informed on any small group skills required for an effective cooperative learning. Of 164 grade nine students, 77 of them were assigned to structured cooperative learning groups and the remaining 87 students were placed to unstructured cooperative learning groups. Students were assigned either to structured or to unstructured cooperative learning groups through stratified random sampling in a manner to make each group involving one high-achieving student, two medium-achieving students, and one low-achieving student. Four kinds of measures were used to collect data on students' behavior states, verbal interactions, cognitive language strategies, and science understandings. The duration of the study was four to six weeks and after the second week, students were videotaped when they were working in their groups on science activities and one to two weeks following the group videotaping session, students took the science probe questionnaire as an indication of understanding. The results of the study indicated that students within structured cooperating groups behaved more cooperatively, on-task, and group focused, gave more elaborated help to each other, made more evaluative statements instead of repetitive comments (the dominant discourse observed in unstructured groups) which was the indicator of higher level thinking, and learned more than students did in unstructured cooperative groups. The researcher implied that cooperative efforts should be structured and applied according to the basic elements of cooperative learning, otherwise, cooperative efforts cannot be admitted as an innovation but a practice for teachers' convenience solely.

In another study, McGregor (2008) analyzed the influence of task structure on students' learning processes in the arena of case studies in secondary school science. The researcher hypothesized that the structure of the task has an impact on the nature of the social interactions in the group which in turn effect cognitive gains. Four schools were selected purposively among the UK schools in which 72 students were randomly assigned to one of the three experimental conditions. Single-sex triads of students worked together to solve the task concerning combustion of a candle which was differentially structured (or scaffolded) as; open (no structured in-task support), partially structured (some in-task support), and prescriptive (highly structured in-task support). Teachers did never intervene in any of the case rather scaffolding was controlled by the means of three instruction sheets, prepared in a manner to include only a description of the problem in the open task, description of the problem with critical suggestions to consider in the partially structured task, and description of the problem with step-by-step instructions in the prescriptive task. Differentially scaffolded tasks were solved by groups and responses were examined as a series of case studies to be able to realize whether or not the cooperative practice was effective. Besides to the standardized tasks for collecting data, non-participant observations were carried out while groups completed tasks by the aid of video camera with desktop microphone. The results of this qualitative study revealed in general that structure of group task has an effect on both the nature and extent of social interaction through which may influence the cognitive outcomes. The researcher concluded that prescriptive tasks prevent transactive discussions and spontaneous socratic evaluation of processes and outcomes during group work, whereas students involved in more frequent explanations of the evidences and results of the task under discussion as compared to students in other conditions since the instruction sheet directed students to solve the problem in a step-by-step manner. When working together on prescriptive tasks, students mostly approved ideas of high-status members instead of questioning each other's points of view and suggesting alternatives for the resolution of whatever the task covers. In other words, members were not encouraged or encultured into coming out against divergent opinions and they did not approach each other intellectually conscious but rather socially emotional. Students who have studied on partially scaffolded tasks, on the other hand, engaged in more creative, critical, and evaluative ways of thinking about the task, however even with some sorts of scaffolding, the type of talk among students was not mostly exploratory in nature. Completing partially scaffolded tasks took the longest time and that of prescriptive ones required the shortest time to complete. Students studied on open tasks, as compared to students did with prescriptive and partially scaffolded tasks, generated a wider range of talented ideas and collected not only quantitative but also qualitative evidences through which more questionable solutions were produced, whereas they did not involve in exploratory talk since they did not widen thinking behind their talented ideas.

Moreover, Buchs, Gilles, Dutrévis, and Butera (2011) conducted a study on second-year social psychology students to be able to conclude on the ongoing debate concerning whether or not the effectiveness of cooperative learning depends on positive reward interdependence. The research problem was grounded on the interaction between the two types of interdependence, namely resource and reward interdependence. In other words, the purpose of the study was to investigate the interaction between resource and reward interdependence which gave chance to interpret under which conditions reward interdependence has an influence on learning. For that purpose, two experimental conditions were manipulated in a manner to form dyads (i.e. two-member cooperative learning groups) working with their partners within either positive reward interdependence condition (in which dyads were assessed with regard to their common level of mastery on a multiple choice test) or reward independence condition (where dyads were assessed concerning their individual level of mastery on the same multiple choice test). Both of the reward conditions were also manipulated as students working with identical information (resource independence condition and viewed as a routine task) or complementary information (positive resource interdependence condition and considered as a true group task). In brief, 32 students were assigned to positive reward interdependence condition and among them, 20 students studied on identical information and 12 students worked on complementary information. Likewise, 30 students were assigned to reward independence condition and of them, 12 students studied on identical information and 18 students worked on complementary information. Other types of positive interdependence were held constant in both of the experimental conditions to control the effects of any extraneous variables, such as positive goal interdependence (students in both of the reward conditions were informed on the importance of learning as a group) and positive role interdependence (dyads in both of the reward conditions were assigned as summarizer or listener). The results of the study revealed that interaction between the reward interdependence and resource interdependence was significant which was interpreted as positive reward interdependence is necessary to be structured when students work on identical information, whereas both of the reward conditions result in same level of mastery if the nature of the task at hand is complementary. The researchers concluded that efficacy of positive reward interdependence depends on whether information provided through is routine or a group task which is in the same line with what Cohen (1994) concludes.

Unlike studies which examined the effects of structuring certain group dynamics on various learning outcomes in face-to-face learning environments, Nam and Zellner (2011) investigated the effects of positive interdependence and group processing on student achievement and attitude via e-learning system. 144 undergraduate students in three universities in South Korea participated in the study. All of the participating universities had an operating online course management system which was the necessary infrastructure for conducting the study. The experimental conditions were manipulated as “positive interdependence group”, “group processing group”, and “no structure group”, all of which included 48 students. Before study commenced, the instructors have been informed by the researchers on the principles of cooperative learning and teamwork skills in general. Two instructors, who were responsible to teach students within the positive interdependence and group processing conditions, have been trained on additional issues regarding the types of positive interdependence (goal, reward, role, and resource interdependence) and how to structure positive interdependence and group processing during implementation. Informed instructors, in turn, organized a workshop at the beginning of the course to share the information related to the general principles of cooperative learning with students. Detailed information concerning positive interdependence and group processing components of cooperative learning, on the other hand, submitted as a guideline exclusively to the students of interest. All of the three experimental groups were divided into small groups of four people to make them work together within three weeks, that is, each of the positive interdependence group, group processing group, and no structure group were made up of 12 small discussion groups for three-week period. All of the small groups submitted a group report regarding what they have studied on with their groups on the last day of the third week. The group reports were evaluated by the means of a rubric and the same scores were assigned to all members of that group which accounted for 60 % of the final course grade. The remaining 40 % of the course grade was determined on the basis of each student’s individual contribution to the group report and the discussion sessions. In other words, the final course grade was assigned according to both common and individual scores. In addition to achievement, attitudes of students were evaluated by using a five-point Likert-type scale at the end of the three-week period. The results of the study indicated that cooperative learning affects students’ achievement positively when the basic components were structured. Of two types of basics under examination, students in the group of positive interdependence outperformed students in the group of group processing. The researchers concluded that there were no significant difference among students involved in any of the three groups on their attitude scores.

In their exploratory study, Bertucci, Johnson, Johnson and Conte (2011) analyzed the effects of task and resource interdependence on achievement and social support (both academic and personal). The researchers manipulated three experimental conditions by holding positive goal interdependence constant within two of the cooperative learning conditions, that is, one of the condition included positive task and goal interdependence, the second condition involved positive resource and goal interdependence, and the last condition made up of students working individually. The participants were 66 seventh grade Italian students and had never before been involved in any cooperative learning practice. The study was conducted during the units of alcohol, tobacco, and drug abuse each of which require two instructional sessions and one achievement test, that is, there were six instructional units and three achievement tests assigned at the end of each unit. In addition to achievement, the Classroom Life Measure was assigned to all participants both as a pretest and posttest to investigate whether task interdependence, resource interdependence, or individual working has an effect on personal and academic support. The results indicated that students in both cooperative learning conditions (i.e. task interdependence and resource interdependence) outperformed the students who worked individually. Although there were no significant differences between the two cooperative conditions concerning achievement, there was a difference in terms of the rate of success. More specifically, task interdependence resulted in a quick start on achievement as compared to resource interdependence which requires more time to be influential on achievement since it scatters attention of students from taskwork to teamwork that in turn results in higher achievement. The results related to social support are twofold; first, students within task interdependence and resource interdependence groups perceived more positive academic support from their peers than did students working individually and there were no significant differences between the two conditions of cooperative learning and second, students within the resource interdependence group perceived more personal support from their peers as compared to task interdependence group and individually working students. Correspondingly, the researchers suggested teachers to structure either task interdependence or resource interdependence to develop academic support among students, whereas establish especially resource interdependence when they wish to promote personal support among group members.

More recently, Bertucci, Johnson, Johnson and Conte (2012) examined the effect of group processing on achievement and perception of personal and academic support in elementary inexperienced cooperative learning groups. Of 61 third-, fourth-, and fifth-grade Italian elementary school students, 30 of them randomly assigned to the cooperative learning with group processing condition and the remaining 31 students assigned to the cooperative learning without group processing condition. None of the participants (neither teachers nor students) had before been involved in any cooperative learning practice. Students within three-member groups work together in five instructional sessions concerning science, history and Italian (literature and grammar) subject areas during three weeks period. Before each instructional session, the researchers gave information about the importance of positive interdependence and individual accountability to all of the participated students when they work together. After each instructional session, furthermore, students in both of the experimental conditions (group processing and no group processing) took an achievement test to be completed individually. All of the procedures up to here were the same for both of the experimental coditions whereas there was a difference after students have completed individual tests that students in the group processing condition were assigned a processing questionnaire to complete but students in the no group processing condition have not received that questionnaire. Besides to achievement variable, the study investigated also the influence of independent conditions on perception of personal and academic support for which the Classroom Life Measure was distributed to all participants both as a pretest and posttest. The results of the study revealed that cooperative learning with group processing resulted in higher achievement solely after the first three tests compared to the performance of group without processing which was interpreted by the researchers as it may take time or require experience for group processing to positively affect achievement. The results of the study, moreover, indicated that group processing does not have an effect on teacher or student personal and academic support within three-week intervention period. As a result of ineffective results drawn upon group processing on teacher or student personal and academic support, the researchers suggested that it may be the promotive interaction component of cooperative learning that influence personal and academic support instead of group processing. The study suggested teachers to include group processing in cooperative learning practices to be able to reach higher achievement.

2.4.5. Cooperative Learning and Conceptual Change

Conceptual change, one of the approach that internalizes constructivist theory, has long been suggested in science as the most powerful way of meaningful learning through overcoming alternative conceptions (Hewson & Hewson, 1983; Hand & Treagust, 1991; Treagust, Harrison, & Venville, 1998; Tsai, 2000). Posner et al. (1982) described how students change their alternative conception with that of scientific conception as emphasizing the importance of students' prior knowledge and introducing four conditions necessary for recent information to possess. In particular, they stated that students change their alternative conceptions if and only if new information contradicts with what students hold in their minds which stimulates them search for the ways of understanding that information if it is intelligible, plausible, and fruitful. Therefore, it is obvious that the initial step for students to understand new information is to create learning environments where students have a chance to make their internal speech public which often cause facing with divergent thoughts, the most fundamental means of intellectual disagreement (Behfar et al., 2010). Vygotsky (1978) stated that individuals' potential cognitive development level increases when they have a chance to interact with peers and the teacher as such a case enables learners to raise the sound of what they have inside of their mind. Besides to the importance of bringing internal speech out, Vygotsky believed that students become self-regulated when they work together up to the level of professionalism which can be described as the qualification level of doing the same job without the aid of others. In brief, cooperative learning is an exceptional strategy which encourages conceptual change by providing learning environments where students put forward divergent viewpoints, question their own beliefs, help each other find new insights to be satisfied with contradicting information, and assist each other to learn the assigned material meaningfully (Johnson & Johnson, 1979; Webb, 1997), which is not the case when students working alone in competitive and individualistic learning environments (Johnson & Johnson, 1999). The power of making students experience disagreement is especially overwhelming when members realize that they have a common goal which can be achieved if and only if all members of the group are to be successful. Johnson and Johnson (1999) reported this situation as "the greater the positive interdependence within a learning group, the greater the likelihood of intellectual disagreement and conflict among group members" (p. 87). Well-structuring positive interdependence in cooperative efforts create a learning context in which members do not only try to learn the assigned task but also struggle to make sure that every members of the group master on task. Positive interdependence is the heart of cooperative learning such that there is no cooperation unless positive interdependence is firmly structured, whereas this does not mean that positive interdependence is the adequate condition for a qualified cooperative learning group. Actually, the importance of interpersonal and small group skills cannot be disregarded since students cannot be able to cooperate with other group members and complete taskwork unless they have taught teamwork skills (Johnson & Johnson, 1999). When members of a group experience intellectual disagreement concerning the task they work on, for instance, whether or not that conflict results in higher conceptual understanding became definite according to how the conflict is resolved, constructively or destructively. If members are able to manage conflict constructively, it facilitates ambiguity on coherence of opinions which serves as an arousing vehicle for more information that results in frequent use of higher-order thinking skills and greater mastery and retention of the material under examination.

Behfar et al. (2010), on the other hand, suggested that it is beneficial to distinguish among intragroup conflicts which are task, relationship, and process conflict (includes logistical and contribution conflict) since each type of conflict has effects on different outcomes. The researchers claimed that logistical conflict arises when there is a shortage among members regarding how to manage and use resources (e.g. division of labor, time and resource management) to achieve the assigned task and it is the logistical conflict which is detrimental to positive interdependence and performance on task. They further argued that task conflict, "an awareness of differences in viewpoints regarding the group's task" (p. 158), has positive effect on commitment to task, but not on performance of students on the task. They concluded that task conflict has no direct effect on students' performance but mediated by other variables, such as the nature of task under discussion: tasks involving challenging and unstructured items that give students flexibility to complete are viewed as potential means to task conflict, whereas routine and structured tasks are not considered as conflicting ones. In addition to the task-related conflicts (logistical and task conflict), Behfar et al. (2010) examined the effects of contribution and relationship conflict which are categorized as affective conflicts that reflect psychosocial aspects of teamwork. Both of the contribution and relationship conflicts are viewed as result of not managing task and group process well. Not contributing to the group's task (e.g. free riding), supression of disagreements by the dominant member of the group, or deficiency of respectful and effective communication cause feeling of dissatisfaction among group members and lessened enthusiasm for and commitment to the group. In brief, when basics of cooperative learning are not well-structured, certain types of conflicts arise which may threaten cognitive outcomes (i.e. the effect of logistical conflict) and affective outcomes (i.e. the effect of contribution and relationship conflict).

The relationship between motivation and cognition and the moderating role of classroom contextual factors between motivation and cognition were made explicit by Pintrich et al. (1993). They believed that students' prior knowledge affects how they change their alternative conceptions with that of scientifically correct explanations as Posner and his colleagues (1982) suggested, whereas they further believed that examining only the effects of cognitive factors on conceptual change limits understanding of the whole process of conceptual change. Motivational beliefs are reported as the important predictors of conceptual change whose impacts can be fostered when students interact with peers and the teacher. More specifically, cooperative learning settings enable students to interact with peers and the teacher that may results in higher motivation, which in turn facilitates the process of conceptual change. The effects of learning contexts designed on the basis of basics of cooperative learning on motivation were discussed deeply in the motivation part of this dissertation.

To conclude, conceptual change is to be promoted when basics of cooperative learning are structured firmly in a manner to inform students on teamwork skills necessary for the feeling of "all for one and one for all". Working together on tasks which are made up of possible alternative conceptions regarding the topic of interest act as potential sources of divergent thinking and intellectual disagreement through which students' performance on task and commitment to the group's task can be promoted. Students in structured cooperative learning groups interact on tasks which does not only result in greater mastery but also greater motivation, both of which have crucial impacts on the process of conceptual change. Conceptual change is viewed as one of the remarkable approach to meaningful learning of scientific concepts, cooperative learning is a desirable learning environment that results in multiple development (cognitive, affective, social) of students, and the combination of conceptual change and cooperative learning is hoped to serve as an overwhelming intervention on grade nine students' understanding the concepts of mixtures and their motivation.

2.5. Motivation

Conceptual change models focusing solely on the role of students' prior knowledge in their learning process stifle in explaining students who have necessary prerequisite knowledge, but do not excite that knowledge for learning tasks (Pintrich et al., 1993). Under such a circumstance, affective domain engages in expressing the reasons of not being involved in the learning tasks. Among affective constructs, the arena of motivation in education is especially so extensive, that is shaped by various theoretical frameworks since 1930s (Weiner, 1990). The common theme regarding what motivation is emerges from its name which implies a driving force making individuals to act (Eccles & Wigfield, 2002). Specifically, however, many definitions of motivation are introduced as a result of researchers' internalization of distinct theories of motivation which reflect either a pure perspective (e.g. behavioral, humanistic, sociocultural, and cognitive theories), or a dual-perspective (e.g. social cognitive theories). Pintrich and Schunk (2002) described motivation as the "process whereby goal-directed activity is instigated and sustained" (p. 5), that includes several assumptions of the social cognitive theories of motivation. In particular, motivational beliefs are not inherent traits as proposed by traditional views of motivation, but rather mediators of learning process which can be developed by the means of contextual factors (Pintrich et al., 1993; Duncan & McKeachie, 2005). Furthermore, motivational beliefs are assumed to direct students toward achievement goals, which are cognitive representations having direct associations with achievement behaviors through which the actual academic performance can be predicted (Pintrich et al., 1993; Pintrich, 2000). In other words, students' actual performance can be inferred from their achievement related behaviors (e.g. choice of task, persistence at task, engagement to deeper or surface level cognitive strategies, and use of metacognitive and self-regulatory strategies), which are initiated by promoting effects of motivational beliefs (Pintrich & De Groot, 1990; Elliot & McGregor, 2001; Pintrich & Schunk, 2002).

While motivation literature suffers from being unable to have a single view covering every dimensions of the phenomenon (Bong, 1996), the social cognitive theories of motivation seem to capture components of motivation more comprehensively that signalize theoretical understanding of motivational constructs. Researchers, who adapt theoretical framework with regard to social cognitive perspective on motivation, suggest three main motivational components (Pintrich & De Groot, 1990; Pintrich et al., 1991): expectancy, value, and affect. The expectancy component of motivation involves constructs related to students' beliefs about their efficacy to accomplish a task and perceptions of control over their learning. The value component, on the other hand, deals with why students contribute to the learning tasks that covers both achievement goals and beliefs regarding importance, interest, utility, and cost of academic tasks. The final component of motivation focuses on affect which contains not only worry but also emotion aspects of test anxiety. Particular constructs offered by Pintrich et al. (1991)-self-efficacy for learning and performance, task value, control of learning beliefs, and test anxiety-and the achievement goals extended by Elliot & McGregor (2001)-mastery approach goals, mastery avoidance goals, performance approach goals, and performance avoidance goals-are within the scope of this dissertation, all of which are reported in detail through explaining two grounded theories of achievement motivation: expectancy-value theory and achievement goal theory.

2.5.1. Expectancy-Value Theory

Contemporary expectancy-value theories are the extended versions of Atkinson's expectancy-value model (1964, as cited in Eccles & Wigfield, 2002). Expectancy-value theorists assumed that actual achievement or achievement related behaviors can be anticipated through examining two important aspects of motivation: expectancy and value, both of which include several motivational constructs inside. Within their expectancy-value model, Eccles et al., (1983) made distinction between expectancy and value beliefs in such a way that the former are relatively related to actual performance, whereas that of the latter are associated more with achievement related choices.

Expectancies for success can be defined as "individuals' beliefs about how well they will do on upcoming tasks, either in the immediate or longer-term future" (Eccles & Wigfield, 2002, p. 119). These future-oriented beliefs are viewed as efficacy expectations instead of outcome expectations, which are the expectations considered by Bandura (1977) as the key expectancy beliefs of goal orientation, task selection, and persistence. Self-efficacy and control beliefs for learning are two of the efficacy expectations, that cover students' perceptions about acting the behaviors required for generating the outcome (Pintrich et al., 1991; Eccles & Wigfield, 2002). Schunk (1985, as cited in Pintrich et al., 1993) described self-efficacy beliefs as representations of students' provisions regarding their academic abilities to succeed in a specific task. A student may possess higher levels of self-efficacy within a learning context, but the student may own lower levels of self-efficacy in another setting. In other words, self-efficacy beliefs are sensitive to situational factors (Pintrich et al., 1993). Having higher levels of self-efficacy beliefs for learning and performance is found to be positively associated with persistence, mastery goal orientation, cognitive engagement, and academic performance (Pintrich & De Groot, 1990; Hoy, 2004; Sungur, 2007). Control beliefs for learning, furthermore, can be described as beliefs about whether students retain control over their own learning, or students' perceptions of whether the outcome of performance is a result of their own efforts or dependent on external factors (e.g. the teacher) (Pintrich et al., 1993; Duncan & McKeachie, 2005). Locus of control theorists have separated control beliefs into two: internal control and external control. Connell (1985, as cited in Eccles & Wigfield, 2002) added unknown control category which is detrimental for motivation to learning since it refers to not knowing the reason of success and failure. When students believe in their competence, autonomy, and relatedness (Connell & Wellborn, 1991, as cited in Eccles & Wigfield, 2002), they feel a sense of internal control over their own learning which make them intentional learners, who are excited to learn academic tasks more conceptually (Bereiter, 1990). To sum up, students possessing higher levels of self-efficacy and internal control over their own learning are more ready to learn academic tasks, or reach specific goals.

Although students believe their cognitive abilities and they have a chance to control their own learning process, they may not learn more as a result of not having challenging purposes to accomplish the task, or not valuing it (Eccles & Wigfield, 2002). In other words, it is the combination of expectancy and value beliefs, that makes expectancy-value theory a powerful framework for expressing students' achievement motivation. Both goal orientation and task value beliefs contribute to provide explanations for reasons or purposes of being engaged in achievement tasks, whereas they are distinguished from each other in terms of the extent of stability over domain and time. In particular, task value beliefs refer to more affective and personal traits, but achievement goals are cognitive and relatively task and context-bound in nature (Pintrich et al., 1993). While value component of motivation is made up of goal and task value beliefs, solely the latter are explained here for the sake of simplicity and relevant scope of goal beliefs with the achievement goal theory.

Feather (1988, as cited in Eccles & Wigfield, 2002) described task value beliefs as "a set of stable, general beliefs about what is desirable" (p. 121), and introduced two sources of them: norms of society and core psychological needs of individuals. Eccles et al., (1983) widened the meaning of the term through outlining four components of task value: attainment value, intrinsic value, utility value, and cost value. Attainment value refers to students' interpretations of how much the task addresses their self-worth or self-scheme (Pintrich et al., 1993; Eccles & Wigfield, 2002), that is, perceiving performing well on the task as important (e.g. it is important for me to learn the concepts in chemistry course). Students perceive the task (or domain) intrinsically valuable when they like dealing with it, or have an interest in doing it (e.g. I am very interested in the content area of chemistry) (Eccles & Wigfield, 2002). Students view the task extrinsically valuable, on the contrary, when they behave under the control of sense of usefulness of that task in the immediate or long-term goals (e.g. I think I will be able to use what I learned in chemistry in other courses) (Eccles & Wigfield, 2002). Another decision making mechanism is related to cost issues in which students compare gainings (achievement related behaviors) and outgoings (amount of effort and time), through which possible outcome is interpreted and evaluated by students (e.g. it is worthwhile to learn the subject matter of chemistry). In brief, students perceive tasks as valuable when tasks are important, interesting, useful, or cost-effective for them, that results in higher cognitive engagement in turn (Pintrich & De Groot, 1990; Pintrich et al., 1991).

2.5.2. Achievement Goal Theory

Achievement goals are cognitive representations of intentions students possess to choose, effort, persist, and engage in an achievement context (Ames, 1992; Pintrich, 2000; Pintrich & Schunk, 2002). Accordingly, achievement goal theory deals with students' reasons of being involved in various avhievement behaviors through investigating their goal orientations. Achievement goal theorists introduced two goal orientations, initially, with alternative labels: task-involved and ego-involved goals (Nicholls, 1984), learning and performance goals (Dweck & Legett, 1988), task-focused and ability-focused goals (Maehr & Midgley, 1991), or mastery and performance goals (Ames, 1992). Although "task-involved", "learning", "task-focused", and "mastery" goals are used interchangeably, they have varied meanings on the theoretical basis (Pintrich, 2000). In contrast to more robust nature of learning goals, mastery goals are relatively flexible that may be oriented alternatively in distinct contexts (Ames, 1992). For instance, students may orient mastery goal when they have a chance to interact with peers and the teacher while learning a challenging task, whereas adopt performance goal if they compete with each other for deserving an external reward (Pintrich et al., 1993). Students who adopt mastery goals are oriented toward learning of the task and making an effort to develop level of competence, students who orient performance goals, on the other hand, try to surmount others and show superior competence to be the best (Ames, 1992; Pintrich, 2000). Research studies reported adaptive achievement behaviors as a result of mastery goal orientation, such as use of deep processing strategies necessary for conceptual change to happen, while less adaptive ones as a result of adopting performance goals, like use of superficial processing strategies (Ames, 1992; Pintrich et al., 1993).

As a result of inconsistent results considering the impact of performance goals on achievement behaviors, Elliot and Church (1997) introduced approach-avoidance dimensions of performance goals by claiming different outcomes emerge as a result of trying to accomplish a task and making efforts to begging from failure. Elliot and McGregor (2001), furthermore, developed the most recent achievement goal framework in which associations between mastery-performance goals and approach-avoidance goals were made explicit through figuring out definition and valence dimensions of competence, that was defined in terms of the standard used to assess performance. According to Elliot and McGregor (2001), students adopting mastery goals perceive their competence as intra-personal (own past performance) or absolute standards (the necessities of the task itself), as opposed to students orienting performance goals who define their competence as normative standards (the performance of others). Moreover, "competence is valenced in that it is either construed in terms of a positive, desirable possibility (i.e. success) or a negative, undesirable possibility (i.e. failure)" (p. 502). Positively valenced competence was anticipated to encourage emergence of approach dimension of both mastery and performance goals, negatively valenced competence, in contrast, promotes avoidance aspect of mastery and performance goals. Crossing two dimensions of competence (i.e. definition and valence) produces four achievement goals: mastery approach goals, mastery avoidance goals, performance approach goals, and performance avoidance goals (see Table 2.3). The properties each goal orientation possesses can be inferred from where they are situated in the achievement goal framework of Elliot and McGregor (2001). In particular, mastery approach goals focus on meaningful understanding of the task and self-improvement, mastery avoidance goals reflect a perfectionist manner that activate students to avoid any misunderstandings, performance approach goals focus on trying to be the best performer that requires spending part of energy to follow the performance of others, and performance avoidance goals represent trying not to be the owner of worst grade and avoiding looking fool (Pintrich & Schunk, 2002).

Table 2.3 Two dimensions of competence and four achievement goals

	Absolute/Intra-personal Standards	Normative Standards
Positive Valence	Mastery Approach Goal	Performance Approach Goal
Negative Valence	Mastery Avoidance Goal	Performance Avoidance Goal

Regarding intercorrelations among these achievement goals, Elliot and McGregor (2001) claimed that goals having common dimensions associate with each other. For example, mastery approach goals are hypothesized to be correlated with mastery avoidance goals and performance approach goals, since they share same standards of competence with mastery avoidance goals, and same valence of competence with performance approach goals. Sungur and Şenler (2009), on the other hand, concluded that all of the four achievement goals are significantly associated with each other. Research studies consistently indicate adaptive achievement behaviors as a result of adopting mastery approach goals, such as high levels of self-efficacy, deep processing strategies required for conceptual change to happen; and maladaptive patterns of behavior as a result of performance avoidance goals, like sense of worry and emotionality, surface processing strategies and disorganized study strategies (Pintrich et al., 1993; Kaplan & Midgley, 1997; Elliot & McGregor, 2001; Sungur, 2007). Sense of worry and emotionality are the two components of anxiety students cope with during tests. Emotionality component of test anxiety is closely related to students' physiological states, one of the major sources of self-efficacy suggested by Bandura (1977). According to Usher and Pajares (2008), negative emotional states (e.g. anxiety, fatigue, stress) destroy performance by diminishing self-efficacy in contrast to positive physiological states, which result generally in higher self-efficacy and more positive outcomes. Wolters, Yu and Pintrich (1996), furthermore, found that extrinsic goal orientation was positively associated with junior high school students' test anxiety. Interestingly, Sungur (2004) concluded that although non-significant, students who were instructed by problem based learning had higher level of test anxiety, as compared to students taught with traditionally designed biology instruction. In brief, classroom contextual factors favoring adoption of mastery goals are successful to provide necessary conditions for conceptual change to take place (Pintrich et al., 1993). It is assumed in this dissertation that cooperative learning environments encourage students to orient mastery approach goals through which alternative conceptions regarding the concepts of mixtures are overcome and motivation to learn is raised.

2.5.3. Motivation, Cooperative Learning and Conceptual Change

To date, considerable influences of motivational beliefs as well as cognitive factors on the process of conceptual change are almost universally accepted among education researchers. As a result of realizing remarkable effects of motivational beliefs on conceptual change, researchers designed various studies to investigate correlations between motivational constructs (e.g. achievement goals, self-efficacy, control beliefs, test anxiety, task value) and cognitive, metacognitive, and self-regulatory strategy use (e.g. elaboration, organization, planning, monitoring, regulating) (Pintrich & De Groot, 1990; Strike & Posner, 1992; Kaplan & Midgley, 1997; Zusho, Pintrich, & Coppola, 2003; Sungur & Şenler, 2009). These research studies found that students, who possess high levels of self-efficacy to understand scientific concepts; approach science through adopting mastery goals; have internal control over their own learning, perceive tasks as important, interesting, useful and cost-effective; and have lower levels of test anxiety, engage in deep processing strategies which in turn promote conditions required for conceptual change to occur. In brief, it is not adequate to explain the whole learning process by focusing solely on the cognitive factors, but inserting a link between cognition and motivation and suggesting moderating contexts in which students' motivational beliefs and conceptual change are promoted (Pintrich et al., 1993).

Although there are various research studies examining relationships between motivational beliefs and cognitive strategy use, the relevant literature does not accommodate plenty of studies offering appropriate learning contexts for promoting the linkage between motivational constructs and conceptual change process. However, it is especially important to introduce divergent learning environments in order to guide practitioners how they can achieve better conceptual learning and increased motivation in the science classrooms. Accordingly, the learning framework of this dissertation assumes that learning environments, where the basics of cooperative learning are well-structured, encourage conceptual change process and adaptive motivational beliefs. The cognitive aspect of conceptual change approach and its relations with cooperative learning were made explicit in the previous parts, then it is necessary to have a close look at the relationship between cooperative learning and motivational constructs, or discuss how motivational constructs are shaped by cooperative learning settings.

Pintrich et al. (1993) proposed that conceptual change process is influenced by the moderating effects of classroom contextual factors on motivational beliefs. In particular, certain motivational constructs (e.g. achievement goals, self-efficacy beliefs) are so sensitive to the nature of learning environments where the likelihood of conceptual change may be promoted or inhibited. They claimed that tasks which are optimally challenging, open-ended, and related closely with real life circumstances; instructional strategies depending heavily on vigorous interaction between students and the teacher; learning settings where students take responsibility of their own learning through being centered in the learning process; and evaluation procedures promoting cooperative goal structure instead of competitive and individualistic goal structures, facilitate approaching science through adopting mastery goals and developing higher levels of self-efficacy to comprehend scientific concepts. These claims can be interpreted as students may adopt different motivational beliefs in different times and contexts similar to lowering and raising the status of knowledge structures according to the context they are in (Pintrich, 2000). In other words, students may have multiple motivational beliefs and decide on which orientation to activate with regard to the information available to them in the environment. Pintrich (2000) exemplified that "a student may activate a performance goal orientation in a highly competitive classroom situation...In contrast, the same student may activate a mastery goal orientation when they are learning chemistry individually in a different, less competitive context" (p. 102). Moreover, instruction that is planned on the basis of conceptual change condition does not guarantee that students overcome alternative conceptions and learn scientific concepts meaningfully, when it does not fall into individuals' zone of proximal development. In such a case, additional factors should be inserted to widen students' zone of proximal development, such as arousing appropriate self-efficacy beliefs (Pintrich et al., 1993), and working together within small groups (Slavin, 2009). Taken together, it is obvious that cooperative learning environments, in which students work together in small groups through interacting readily with their peers and the teacher, control their own learning, promote each other's learning on challenging tasks, help each other resolve cognitive conflicts, is an exceptional instructional strategy that promotes activation of adaptive motivational constructs and conceptual change process.

Cooperative learning is viewed as one of the success stories of recent educational history since it results in higher cognitive, affective, and social outcomes, when the basics are well-structured (Slavin, 1996; Johnson & Johnson, 1999). Motivation is one of the affective variable that is found consistently by researchers to be increased as a result of cooperative learning practices, which is assumed to promote both cognitive and social student outcomes in turn (Pintrich et al., 1993; Dörnyei, 1997). Structuring basic elements of cooperative learning is crucial not only for achievement gains but also for motivational yields. As being at the center of cooperative efforts, positive interdependence is the key component to be established since it creates an affiliation that joint efforts are extrinsically (on the basis of motivational perspectives) or intrinsically (on the basis of social cohesion perspectives) valuable to attain group's goal. Slavin (1996) stated that rewarding groups based on the individual learning of every group members motivates students to represent peer norms fostering academic achievement, to help each other learn the material, and to supply reinforcements for encouraging efforts to accomplish group's goal, as opposed to the competitive and individualistic goal structures. Since STAD method of cooperative learning attributes achievement outcomes to group goals or group rewards based on individual learning of every group members of cooperative learning, it can readily be applied to increase students motivation to learn. In contrast to Slavin (1996), Johnson and Johnson (1999) assumed that it is not rewards, but "working together and joint aspirations to achieve a significant goal" (p. 188), that motivates students to help each other's mastering the task and praise joint efforts. Positive interdependence and the small group style promote emergence of group cohesiveness, or "the strength of relationship linking the members to one another and to the group itself" (Forsyth, 1990, p. 10), which is a powerful mediator of student motivation to learn (Dörnyei, 1997). Students within a highly cohesive groups frequently interact with each other on task-related concerns, care each other on the personal level, and form a warm group climate in which students feel less anxiety but a sense of autonomy to contribute to the group's goal (Dörnyei, 1997). As noted previously, positive interdependence increases the probability of cognitive conflict which directs students to search for more information to be satisfied with the new knowledge. In brief, intellectual disagreements are strong sources of conceptual change if and only if they are managed constructively. Otherwise, conflicts become powerful counterproductives damaging student motivation to learn by negatively affecting coordination among group members, commitment to the group's goal, and satisfaction with and enthusiasm for being together as a group (Behfar et al., 2010).

2.6. Summary of the Literature Review

The importance of students' prior knowledge in learning is almost universally accepted among educators who view meaningful learning as a process in which students' existing knowledge and their new experiences interact vigorously (Ausubel, 1968; Piaget, 1950; Posner et al., 1982). As a result of active interaction between what a student already knows and what the student expected to know, the student assimilates new information if prior knowledge is adequate to explain current phenomena, whereas new information is accommodated when existing cognitive structure does not acknowledge recent information. In assimilation, it can be readily said that students' prior knowledge facilitates future learning which is not a valid conclusion, however, in the case of accommodation that is a result of having alternative conceptions and it may impede oncoming learning if those conceptions are not overcome (Hewson & Hewson, 1983; Chandran, Treagust, & Tobin, 1987). Posner et al. (1982) emphasized the role of accommodation in students' coming learning through introducing properties new knowledge should has to make students change their alternative conceptions with that of scientific explanations. More specifically, students change their alternative conceptions if and only if new information contradicts with what students hold in their minds which stimulates them search for the ways of understanding that information if it is intelligible, plausible, and fruitful. In brief, meaningful learning of scientific concepts can be viewed as conceptual change which has long been suggested as one of the constructivist approaches in science to overcome alternative conceptions (Hewson & Hewson, 1983; Hand & Treagust, 1991; Treagust, Harrison, & Venville, 1998; Tsai, 2000).

Researchers do not focus only on theoretical underpinnings but also the ways of applying conceptual change approach into science classes, that is, strategies promoting conceptual change approach. Cooperative learning is one of the remarkable instructional strategy that encourages conceptual change by providing learning environments where students have a chance to hear others' opinions which may result in dissatisfaction, the most generic condition for conceptual change to happen (Webb, 1997). Students in cooperative learning groups put forward different viewpoints that cause members to question their own beliefs and find new insights to be satisfied with contradicting information (Johnson & Johnson, 1979), which is not the case when students working alone in competitive and individualistic learning environments (Johnson & Johnson, 1999). The possibility of intellectual disagreement increases when members promote each other's learning in order to complete the taskwork and manage task conflicts constructively. When managed constructively, task-related conflicts result in greater mastery, retention (Johnson & Johnson, 1999), and commitment to task (Behfar et al., 2010). All of the positive effects of cooperative learning, however, emerge exclusively when basics of cooperative learning are structured which are, positive interdependence, individual and group accountability, promotive interaction, interpersonal and small group skills, and group processing. Otherwise, learning groups are labeled as pseudo-learning group or traditional learning group, neither of which promote cooperation, but competition or individualistic learning with talking, respectively. Conceptual change is an intimately suggested approach for getting away alternative conceptions and learning scientific concepts meaningfully (Posner et al., 1982; Hewson & Hewson, 1983; Driver & Oldham, 1986) and cooperative learning is one of the greatest success of educational history (Slavin, 1996; Johnson & Johnson, 1999), the strength of cooperative learning based on conceptual change conditions is hypothesized to be an exceptional way of higher conceptual understanding and motivation.

CHAPTER 3

DESIGN OF THE STUDY

Previous chapters presented research problems and corresponding hypotheses tested against specified problems, gave definitions of important terms, made significance of the study explicit, and justified the essential background of the study through reviewing the related literature. This chapter introduces design of the study, population and sample, variables, instruments, instructional materials, procedure, treatments, analyses of data collected by the means of specified instruments, issues related to internal and external validity, and assumptions and limitations of the study, respectively.

3.1. Research Design of the Study

In this study, the nonequivalent control group pretest-posttest design was used to evaluate treatments without random assignment, the major weakness of the quasi-experimental study design (Gay & Airasian, 2000). The basic assumption of this design is that the sole reason of difference among groups is the independent variable if groups are similar at the pretest in terms of the variable, the effect of which is measured experimentally, although subjects were not assigned to groups by randomization. As a result of administrative constraints to random assignment of the subjects to the treatment groups, intact classes were assigned to the treatment groups randomly. The experimental research design of the study was shown in Table 3.1, and for what the abbreviations stand for were presented below Table 3.1.

The concept of mixtures was the unit of interest in the study which was covered as planned in the ninth grade chemistry education program by two 45-minute periods per a week in an Anatolian high school in Isparta in the spring semester of 2011-2012 over eight weeks. The same chemistry teacher instructed all of the treatments that have three levels: CLCC, CLCC(-), and TI (see Section 3.7). There were six intact classes and two of them were assigned randomly to SCLG, two of them assigned randomly to UCLG, and the other two classes were assigned randomly to CG. More specifically, 60 students involved in the SCLG who were instructed by CLCC, 60 students involved in the UCLG who were instructed by CLCC(-), and 60 students involved in the CG who were instructed by TI.

The MCT, MSLQ, and AGQ were administered to SCLG, UCLG, and CG as pretests in order to determine whether there were significant mean differences among the groups with respect to students' understanding the concepts of mixtures (pre-MCT), and their motivation (pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, pre-PAV). The MCT, MSLQ, and AGQ were administered to SCLG, UCLG, and CG as posttests to determine whether there were significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures (post-MCT), and their motivation (post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, post-PAV).

Table 3.1 Research design of the study

Groups	Pretest	Treatment	Posttest
SCLG	MCT MSLQ AGQ	CLCC	MCT MSLQ AGQ
UCLG	MCT MSLQ AGQ	CLCC(-)	MCT MSLQ AGQ

Table 3.1 (continued)

Groups	Pretest	Treatment	Posttest
CG	MCT	TI	MCT
	MSLQ		MSLQ
	AGQ		AGQ

SCLG:	Structured Cooperative Learning Group
UCLG:	Unstructured Cooperative Learning Group
CG:	Control Group
CLCC:	Cooperative Learning based on Conceptual Change
CLCC(-):	Cooperative Learning based on Conceptual Change without Well-Structuring the Basics of Cooperative Learning
TI:	Traditional Instruction
MCT:	Mixtures Concept Test
MSLQ:	Motivated Strategies for Learning Questionnaire
AGQ:	Achievement Goal Questionnaire

3.2. Population and Sample

The target population of the study is all grade nine students attending Anatolian high schools in Isparta. The accessible population, the realistic choice for generalizing the results of the study (Fraenkel & Wallen, 2003), is all grade nine students attending Anatolian high schools in the center of Isparta. More than twenty percent of the grade nine students enrolling an Anatolian high school in the center of Isparta constituted the sample of the study, who were selected through convenience sampling method. Since convenience sampling is one of the nonrandom sampling method, the researcher should include as much information as possible on sample characteristics to increase the representativeness of the sample studied (Fraenkel & Wallen, 2003). Among six schools in the accessible population (i.e. 780 students), one of the most crowded school consisting of six classes of grade nine students was chosen for the study. In particular, the sample of the present study involves 180 grade nine students (98 females and 78 males) instructed by the same chemistry teacher in an Anatolian high school in Isparta in the spring semester of 2011-2012 over eight weeks.

The sample was randomly assigned to one of the three experimental conditions according to the purpose of the study which is to investigate whether applications of cooperative learning result in greater understanding of the concept of mixtures and motivation to learn, and if yes, under what conditions cooperative learning practices cause that enhancement. More specifically, two of the six intact classes formed the first experimental group (i.e. SCLG) in which 58 students (33 females and 25 males) were instructed by CLCC, another two classes were assigned as the second experimental group (i.e. UCLG) where 60 students (35 females and 25 males) were taught by CLCC(-), and the other two classes were established as the control group (CG) where 58 students (30 females and 28 males) were instructed by the means of TI.

Demographic information was collected to infer representativeness of the sample by a questionnaire established by the researcher (see Appendix C). The ages of the participating students ranged from 14 to 16. The average last semester chemistry course grades of the students was 3.4, which can be interpreted as the participating students were at middle level in terms of their last semester chemistry course grades. Table 3.2 indicates frequencies and percentages of structured cooperative learning group (SCLG), unstructured cooperative learning group (UCLG), and control group (CG) students' last semester chemistry course grades. According to the table, the average chemistry course grades were 3.4, 3.2, and 3.4 out of 5.0 for SCLG, UCLG, and CG, respectively. The grade three was stated by 29 students in the SCLG (50 %), and 20 students in the UCLG (33 %) and CG (35 %).

Table 3.2 Frequency and percentage distribution of students’ last semester chemistry course grades with respect to groups

	SCLG		UCLG		CG	
Grade	Frequency	Percent	Frequency	Percent	Frequency	Percent
1	1	1.7	4	6.6	5	8.6
2	5	8.6	10	16.7	6	10.3
3	29	50.0	20	33.4	20	34.5
4	14	24.2	21	35.0	15	25.9
5	9	15.5	5	8.3	12	20.7

Table 3.3 presents demographic information regarding mother education level (MEL) and father education level (FEL) of students, as indicators of socio-economic status, in the SCLG, UCLG, and CG. As shown in the table, majority of the mothers possessed high school degrees in total (41 %). In particular, the number of mothers having high school degrees were 17 in the SCLG (29 %), 25 in the UCLG (42 %), and 32 in the CG (55 %). Most of the fathers, on the contrary, had university degrees in total (39 %). More specifically, the number of fathers having university degrees were 21 (36 %), 25 (42 %), and 23 (40 %) in the SCLG, UCLG, and CG, respectively. Overall, it can be concluded that students’ fathers were superior than their mothers in terms of their education level.

Table 3.3 Demographic information regarding socio-economic status of the students

	SCLG		UCLG		CG		Total	Total
Education Level	MEL	FEL	MEL	FEL	MEL	FEL	MEL	FEL
Primary School	15	8	18	9	12	3	47	20
Junior High School	11	7	6	3	5	5	22	15
High School	17	21	25	18	32	22	72	61
University	14	21	11	25	8	23	33	69
Post-Graduate	1	1	0	5	1	5	2	11

Although the chemistry teacher, who implemented the procedures in all of the three treatment groups, had 20 years experience in teaching, regulated-meetings were done in order for training the teacher on cooperative learning (CL) for three months before the implementation of the study (see section 3.6). Additionally, the teacher instructed students on the unit of chemical changes with CL to be accustomed to, which was the topic just before the concept of mixtures.

3.3. Variables of the Study

The study included ten variables in general, one of them was independent variable (IV) and nine of them were dependent variables (DV). Independent variable of the present study was type of instruction which has three levels: cooperative learning based on conceptual change (CLCC), cooperative learning based on conceptual change without well-structuring the basics of cooperative learning (CLCC(-)), and traditional instruction (TI). Dependent variables of the study were twofold: students’ understanding the concepts of mixtures and their motivation. Students’ understanding of the concepts of mixtures was assessed by the posttest scores of the Mixtures Concept Test (MCT) and interviews. Students’ motivation measured by the posttest scores of the Self-Efficacy for Learning and Performance (SELP), Task Value (TV), Control of Learning Beliefs (CLB), Test Anxiety (TA) sub-scales of the Motivated Strategies for Learning Questionnaire (MSLQ), and by the posttest scores of the Mastery Approach Goals (MAP), Mastery Avoidance Goals (MAV), Performance Approach Goals (PAP), Performance Avoidance Goals (PAV) dimensions of the Achievement Goal Questionnaire (AGQ). Table 3.4 identifies the nature of all of the specified variables of the study.

Table 3.4 Nature of the independent and dependent variables

Name	Variable Type	Value Type	Scale Type
Type of Instruction	IV	Categorical	Nominal
Students' Understanding	DV	Continuous	Interval
SELP	DV	Continuous	Interval
TV	DV	Continuous	Interval
CLB	DV	Continuous	Interval
TA	DV	Continuous	Interval
MAP	DV	Continuous	Interval
MAV	DV	Continuous	Interval
PAP	DV	Continuous	Interval
PAV	DV	Continuous	Interval

3.4. Data Collection Instruments

Quantitative data were collected by the means of Mixtures Concept Test (MCT), Motivated Strategies for Learning Questionnaire (MSLQ), and Achievement Goal Questionnaire (AGQ), which had been assigned before treatment is commenced as pretests and after treatment is finished as posttests in order to measure students' understanding the concepts of mixtures and their motivation, respectively. Qualitative data, on the other hand, were collected primarily through semi-structured interviews with purposively selected students from each treatment group to explore students' conceptions profoundly, at the end of the treatment.

3.4.1. Mixtures Concept Test (MCT)

Mixtures Concept Test (MCT) was developed by the researcher in order to measure grade nine students' understanding the concepts of mixtures. Content boundaries were described initially through determining the objectives of the unit of mixtures (see Appendix B) on the basis of ninth grade chemistry program (Ministry of National Education, 2007). Two headings were suggested in the program for teachers while they are teaching the mixtures: classification of mixtures and separation of mixtures. After deciding on the objectives of the MCT, the related literature was examined to identify common alternative conceptions students have regarding the concepts of mixtures. According to predetermined objectives and possible alternative conceptions, test items were constructed either by researcher made, or by incorporating some standard items into the test reported by research studies (Sanger, 2000; Mulford & Robinson, 2002; Pınarbaşı & Canpolat, 2003; Edwards & Soyibo, 2003; Çalık, 2006; Kıngır, 2011). The initial form of the MCT was explored by three educators from the chemistry education department in terms of content and face validity. More specifically, the 27-item MCT attached by the list of objectives was distributed to the experts for collecting content and face related evidences of validity, and necessary revisions were made according to the opinions of the experts. MCT was assigned to 124 students, who have already mastered the concepts of mixtures, to be able to realize whether the test is reliable. Besides to issues related to reliability, the duration of completing the test and the reactions of students toward items in terms of readability and clarity were to be checked by piloting the test. Students' answers were coded as 0 when it was scientifically incorrect and as 1 when it was scientifically correct, and they were entered in SPSS to estimate how consistently students respond to the items. Cronbach's alpha value was computed as .63 and the scores of the two of the items were negative in the "Corrected Item-Total Correlation" column of the SPSS output. Accordingly, the specified two items were excluded from the MCT and some of the items were clarified according to students' questions while piloting the test. After revisions, the 25-item MCT was piloted second time with 196 students possessing similar characteristics with the sample of the study, and the Cronbach's alpha value was computed as .71, an acceptable value for educational studies (George & Mallery, 2001; Fraenkel & Wallen, 2003).

The final form of the MCT was made up of 25 items (see Appendix D), among which 10 of them were two-tier in nature (i.e. items 1, 2, 7, 11, 16, 17, 19, 20, 21, 23). Both tiers of the two-tier items were in multiple-choice format where the first tier asked a question and the second tier questioned the possible reason of the answer given to the first tier. The answers given to the two-tier questions were accepted as correct when both tiers were correct (coded as 1). In the case of giving correct answer only to the first tier or the second tier, on the contrary, the answer was entered in SPSS as incorrect (coded as 0). The main difference between conventional multiple-choice tests and the MCT is incorporation of common alternative conceptions about the concepts of mixtures in the latter (see Table 3.5).

Table 3.5 Alternative conceptions probed by the MCT

Alternative Conception	Item Choice
1. All mixtures are heterogeneous in nature.	1(a)
2. Mixtures are pure substances.	1(b)
3. All mixtures are solutions or homogeneous substances.	1(d)
4. Homogeneous mixtures are pure substances.	2(b)
5. Mixtures are always combination of two or more substances that are not pure.	2(c)
6. Mixtures are always combination of two different elements.	2(d)
7. The properties of components in a mixture are not retained (e.g. flammability, reactivity, taste, odour).	3(a)
8. Solutions are always in liquid state.	3(b)
9. The components of a mixture cannot be physically separated since they lost their chemical properties.	3(c)
10. A new substance forms as a result of dissolution.	4(a), 5(c)
11. Dissolving is a process of combining two or more substances chemically.	4(c)
12. Dissolution requires a phase change, that is, solute melts or evaporates.	4(d), 20(d)
13. Solute disappears when dissolution takes place.	5(a), 10(c), 11(b)
14. Solute is absorbed by solvent during dissolution.	5(b)
15. Undissolved solute is a component of solution.	6(c), 7(1)
16. Supersaturated solutions contain undissolved solute.	6(d), 7(a), 18(a)
17. Supersaturated solutions are heterogeneous since there is precipitate at the bottom.	18(c)
18. Saturated and concentrated, and unsaturated and diluted solutions are equivalent.	6(a), 13(b), 13(d), 18(b)
19. Dissolution does not occur unless stirring process is taken place.	7(b)
20. Solid solute dissolves if the solvent is hot otherwise (cooled), solute settles down.	7(d), 23(c)
21. Boiling and freezing points of solutions are same with that of pure liquids.	9(d)
22. Boiling point of mixtures and pure liquids are not the same since solvent boils first and then solute boils.	9(b)

Table 3.5 (continued)

Alternative Conception	Item Choice
23. Both the boiling and freezing points of involatile solute (e.g. salt, sugar) dissolved in solvent are higher than those of solvent.	9(a)
24. Water is a solution that hydrogen is the solvent and oxygen is the solute since there is greater quantity of hydrogen within the structure of water.	10(a)
25. Solvent is a rather passive component of a solution or solute is the major component of a solution.	10(b)
26. Water is the solvent of all solutions or water plays the major role in the dissolution process.	20(b)
27. Physical properties of solute (e.g. density) determine whether or not dissolution occurs.	20(c)
28. Mass of a solution is greater or less than total masses of solute and solvent.	11(a)
29. Dissolved solute has no weight.	11(c)
30. The amount of dissolved substance depends on the surface area of solute.	17(a)
31. Dissolution takes place faster when solute is uncrushed since uncrushed solute exerts greater pressure.	16(a)
32. Dissolution takes place faster when solute is crushed since mass of the crushed solute is less than uncrushed form.	16(b)
33. The amount of dissolved substance is greater when solute is crushed since crushed solute does not dissolve but melts.	17(c)
34. If one does not stir the solution, some of the solute remains undissolved.	16(d)
35. The amount of dissolved substance increases as solution is stirred.	17(d)
36. The solubility of gases decreases as pressure of gas-liquid solution increases since gas particles become liquid under pressure.	21(a)
37. The solubility of gases decreases as pressure of gas-liquid solution increases since different gas particles emerge under pressure.	21(b)
38. Solubility of gas particles in liquids is stable because gas particles cannot be squeezed.	21(c)
39. Temperature does not affect dissolution of gases in liquids since the ratio is stable for all gases.	23(d)
40. The solution of salt and water stays the same when it is cooled.	23(b)
41. Changing amount of solvent affects the amount of dissolved substance.	8(a), 8(c), 8(d), 19(a), 19(c), 19(d)

Table 3.5 (continued)

Alternative Conception	Item Choice
42. Filtering is a general method of separating solids from liquid solutions.	12(a), 12(b), 12(c), 22(b)
43. Mixtures which are made up of substances having magnetic properties can be separated from each other by the means of a magnet.	14(a), 14(c), 14(d)
44. Separating funnel is a means to separate all liquid-liquid mixtures.	24(c)
45. Solutions of liquid dissolved in another liquid can be separated into components by decantation.	24(d)
46. The component stayed in the separating funnel is the one having higher density.	25(b)
47. Distillation can be used to get components of liquid-liquid solutions separately.	24(a)
48. All heterogeneous mixtures can be separated through the difference among size of particles.	25(a)
49. Since the distance among molecules of the distilled liquid become bigger, the distillate has smaller density	25(d)
50. The distillation column contains only vapors of low-boiling component.	15(b)
51. The vapor at the bottom of the distillation column is rich in the low-boiling component.	15(c)
52. The vapor reaching the top of the distillation column is rich in the higher-boiling component.	15(d)
53. Filtering can be used only to separate solid-liquid heterogeneous mixtures.	22(a)
54. When water solutions of solids (e.g. salt, sugar) filtered, the solid always remains on the filter paper.	22(d)

The content covered in the MCT involved heterogeneous mixtures; homogeneous mixtures; components of solutions; dissolution process; types of solutions (i.e. saturated, unsaturated, super saturated, diluted, and concentrated solutions); the effect of temperature on dissolution of solids, liquids, and gases; the effect of pressure on dissolution of gases; the effects of stirring and surface area on the rate of dissolution; colligative properties of solutions (boiling point, freezing point, mass, density); and separation of mixtures (methods based on difference in size of particles, density, solubility, and boiling point). Table 3.6 indicates distribution of items included in MCT with respect to the content of the concepts of mixtures. The final form of the MCT was assigned to 180 students (i.e. the subjects of the study) as a pretest to recognize whether groups differ significantly on understanding the concepts of mixtures before treatment is conducted. The MCT was assigned to the participating students, furthermore, as a posttest to measure if there were significant differences among the groups exposed to variations of CL and TI with respect to students' understanding the concepts of mixtures.

Table 3.6 Content of the unit of mixtures covered by MCT

Concepts	Items
Nature of Mixtures	1, 2, 3
Dissolution Process	4, 5, 10, 20
Types of Solutions (Saturated, unsaturated, super saturated, diluted, concentrated solutions)	6, 7, 8, 13, 18, 19
Factors Affecting Solubility (Temperature, pressure, surface area of solute, stirring, amount of solute)	16, 17, 21, 23
Colligative Properties of Solutions (Boiling point, freezing point, mass, density)	9, 11
Separation of Mixtures	12, 14, 15, 22, 24, 25

3.4.2. Motivated Strategies for Learning Questionnaire (MSLQ)

The Motivated Strategies for Learning Questionnaire (MSLQ), a self-report tool grounded on the social cognitive theoretical framework, was developed by Pintrich, Smith, García, and McKeachie (1991) and was adapted into Turkish by Sungur (2004). The MSLQ was made up of 81 items scored on a seven-point likert scale, from 1 (not at all true of me) to 7 (very true of me). In particular, 31 of the 81 items were included in the motivation section with six sub-scales (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Self-Efficacy for Learning and Performance, Task Value, Control of Learning Beliefs, Test Anxiety), and the remaining 50 items were covered by the learning strategies section in nine sub-scales (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment Management, Effort Regulation, Peer Learning, Help Seeking).

Pintrich et al. (1991) suggested that researchers can use either every 15 scales involved in the MSLQ or only the scales of interest, due to flexibility gained by the modular nature of the specified scales. Accordingly, four sub-scales of the motivation section of Turkish version of the MSLQ are included within the scope of the present study (i.e. 23 items), namely Self-Efficacy for Learning and Performance (SELP), Task Value (TV), Control of Learning Beliefs (CLB), Test Anxiety (TA) (see Appendix E). Intrinsic and Extrinsic Goal Orientation scales of the MSLQ were excluded in order for exploring achievement goals more deeply by the means of the Achievement Goal Questionnaire (AGQ), designed especially to assess students' achievement goals (see Section 3.4.3).

The MSLQ was administered to college students by Pintrich et al. (1991) to analyze reliability coefficients of each sub-scale, and factor loadings of each sub-scale through performing Confirmatory Factor Analyses (CFA). Resulting absolute fit indices indicated a sound-structured model: the chi-squared to degrees of freedom ratio (χ^2/df) was 3.49, the goodness of fit index (GFI) was .77, the root mean residual (RMR) was .07, and the adjusted goodness of fit index (AGFI) was .73. While adapting the MSLQ into Turkish language, Sungur (2004) assigned questionnaire to 488 tenth and eleventh grade students in biology lessons. As compared to the English version, Sungur (2004) found reasonable values by conducting CFA, which were χ^2/df = 5.3, GFI = .77, RMR = .11. The Turkish version of the MSLQ, modified to chemistry lessons by minor variations, was piloted with 124 students to verify constructs by performing CFA using LISREL. The data were collected cross-sectionally by distributing the questionnaire to students at one time and calling them upon to be as sincere as possible by giving assurance to kept their responses confidential. The absolute fit indices drawn upon CFA were found as follows: χ^2/df = 1.92 , GFI = .78, RMR = .08. χ^2/df is used to assess model fit (Hu & Bentler, 1999). Values as high as 5 and values as low as 2 are suggested as an acceptable range for χ^2/df (Wheaton, Muthen, Alwin, & Summers, 1977). Hayduk (1987), furthermore, stated that χ^2/df values closer to zero well define the difference between the sample and fitted covariance matrices. GFI values range from 0 to 1 with a cut-off point of .9 are recommended for models fitting well (Hayduk, 1987). RMR values as high as .08 define a good fit of data with the model (Hu & Bentler, 1999). Although all the fit indices found in the present study do not fit well enough to imply a good model, the values can be interpreted as reasonable when compared to the results of English and Sungur (2004) versions, as indicated in the Table 3.7. The differences of values among the English version, Sungur (2004) version, and the present study can be attributed to the nature of motivational constructs that have a potential to change in different contexts (Pintrich et al., 1991). In the Table 3.7, ENG stands for the version of Pintrich et al. (1991), and the abbreviations of TUR indicate the version of Sungur (2004) and the present study, respectively.

Table 3.7 Comparison of the fit indices for the motivation section of the MSLQ

	χ^2/df	GFI	RMR
ENG	3.49	.77	.07
TUR (Sungur, 2004)	5.3	.77	.11
TUR (Present Study)	1.92	.78	.08

Besides to fit statistics, Lambda ksi (LX) estimates were computed to see whether the constructs were defined well, that is, if the values of LX estimate were .8 or greater (Pintrich et al., 1991). Table 3.8 presents LX estimates for the interested sub-scales of the motivation section, where SELP stands for Self-Efficacy for Learning and Performance, TV for Task Value, CLB for Control of Learning Beliefs, and TA for Test Anxiety. Eventhough some of the indicators did not well-define the specified sub-scales, the values can be acceptable when compared to the values of the version of Pintrich et al. (1991), which was indicated as the English version in the Table 3.8.

Table 3.8 Lambda ksi estimates for the specified sub-scales of the MSLQ

	Indicator	LX Estimate of English Version	LX Estimate of Present Study
SELP	q1	.83	.75
	q4	.77	.78
	q6	.70	.71
	q9	.89	.85
	q12	.63	.70
	q16	.71	.77
	q19	.86	.79
	q23	.87	.81
TV	q3	.57	.57
	q7	.88	.65
	q11	.84	.78
	q13	.86	.81
	q18	.88	.72
	q21	.64	.70
CLB	q2	.57	.69
	q5	.47	.73
	q14	.38	.44
	q17	.84	.63
TA	q8	.60	.60
	q10	.76	.77
	q15	.42	.48
	q20	.62	.67
	q22	.88	.44

Table 3.9 introduces Cronbach's alpha values across each sub-scale within the scope of the present study for the English version, the Turkish version, and the present study.

Table 3.9 Comparison of reliability coefficients of the specified sub-scales of the MSLQ

	SELP	TV	CLB	TA
ENG	.93	.90	.68	.80
TUR (Sungur, 2004)	.89	.87	.62	.62
TUR (Present Study)	.90	.82	.61	.67

As can be seen in the Table 3.9, the Cronbach's alpha values of the CLB and TA were lower than the values of the SELP and TV, whereas they can be interpreted as reasonable when compared to the versions of Pintrich et al. (1991) and Sungur (2004). Studies may report different reliability values as a result of having distinct sample. Therefore, the reason of minor changes can be attributed to the characteristics of subjects of the present study. The MSLQ was assigned to 180 grade nine students to measure their motivation before treatment is commenced as a pretest, and after treatment is completed as a posttest to assess whether students' motivation differ significantly when they exposed to variations of cooperative learning and traditional instruction.

3.4.3. Achievement Goal Questionnaire (AGQ)

The Achievement Goal Questionnaire (AGQ), a 15-item instrument scored on a five-point likert scale from 1 (strongly disagree) to 5 (strongly agree), was developed by Elliot and McGregor (2001) to assess students' goal orientations. The AGQ was made up of four sub-scales, which are Mastery Approach Goals (MAP), Mastery Avoidance Goals (MAV), Performance Approach Goals (PAP), and Performance Avoidance Goals (PAV).

The AGQ was administered to 180 undergraduate students to check whether the model fit well with the sampled data and if the responses given to the questionnaire was reliable. Elliot and McGregor (2001) performed CFA which revealed that the data fit the model well (RMSEA = .04, GFI = .99, CFI = .99). The Cronbach's alpha coefficients were computed for MAP, MAV, PAP, and PAV as .87, .89, .92, and .83, respectively (see Table 3.12).

The AGQ was adapted into Turkish by Şenler and Sungur (2007). The researchers validated the questionnaire by assigning the instrument to 616 students attending elementary schools. Şenler and Sungur (2007) performed CFA and the following fit indices were presented: RMSEA = .06, GFI = .92, CFI = .90, SRMR = .07. The Cronbach's alpha coefficients were computed as .81 for MAP, .65 for MAV, .69 for PAP, and .64 for PAV (see Table 3.12).

The AGQ was piloted through administering the Turkish version of the questionnaire (see Appendix F) to 124 students to check for factor loadings of the AGQ, LX estimates of the items across each sub-scale, and reliability values of the sub-scales. The fit statistics drawn upon CFA were as follows: RMSEA = .07, GFI = .88, CFI = .97. RMSEA assesses how well the model fit the sampled data (Hu & Bentler, 1999) and RMSEA values close to .06 with an upper limit of .07 represent a good fit. GFI values range from 0 to 1 with a cut-off point of .9 are recommended for models fitting well (Hayduk, 1987). CFI is an incremental fit indece that tests the assumption of the sample covariance matrix is uncorrelated with latent variables (Hooper, Coughlan, & Mullen, 2008), and CFI values closer to 1 with a minimum value of .90 indicate a good fit. As shown in the Table 3.10, although not all the fit indices found in the present study show well fit, the results of the present study can be interpreted as reasonable as compared to the values found by the English and Şenler and Sungur (2007) versions. The small differences among the English version, Şenler and Sungur (2007) version, and the present study can be attributed to contextual factors that have potential to affect students' goal orientations (Pintrich, 2000). In the Table 3.10, ENG stands for the version of Elliot and McGregor (2001), and the abbreviations of TUR indicate the version of Şenler and Sungur (2007) and the present study, respectively.

Table 3.10 Comparison of the fit statistics of the AGQ

	RMSEA	GFI	CFI
ENG	.04	.99	.99
TUR (Şenler and Sungur, 2007)	.06	.92	.90
TUR (Present Study)	.07	.88	.97

Besides to fit statistics, Lambda ksi (LX) estimates were computed to see whether the constructs were defined well. In the Table 3.11, where all of the LX values were above .50, MAP stands for Mastery Approach Goals, MAV stands for Mastery Avoidance Goals, PAP stands for Performance Approach Goals, and PAV stands for Performance Avoidance Goals.

Table 3.11 Lambda ksi estimates for the sub-scales of the AGQ

	Indicator	LX Estimate of Present Study
MAP	q1	.50
	q4	.97
	q6	.54
MAV	q8	.77
	q10	.82
	q12	.57
PAP	q3	.80
	q7	.86
	q11	.68
PAV	q2	.65
	q5	.69
	q9	.69
	q13	.53
	q14	.73
	q15	.54

Table 3.12 compares the Cronbach's alpha reliability coefficients of the study carried out by Elliot and McGregor (2001), the study conducted by Şenler and Sungur (2007), and the present study. The Cronbach's alpha reliability coefficients of MAP, MAV, PAP, and PAV were computed as .65, .73, .76, and .78, respectively. As compared to the coefficients of the adapted version of the AGQ, the values can be accepted as reasonable. The reason of changes in the reliability coefficients can be attributed to the different characteristics of subjects sampled in the studies. The AGQ was assigned to 180 grade nine students to measure their motivation before treatment is commenced as a pretest, and after treatment is completed as a posttest to assess whether students' motivation differ significantly when they exposed to variations of cooperative learning and traditional instruction.

Table 3.12 Comparison of reliability coefficients across the sub-scales of the AGQ

	MAP	MAV	PAP	PAV
ENG	.87	.89	.92	.83
TUR (Şenler and Sungur, 2007)	.81	.65	.69	.64
TUR (Present Study)	.65	.73	.76	.78

3.4.4. Semi-Structured Interviews

The purpose of conducting semi-structured interviews was to gain insight considering students' conceptions about the concepts of mixtures after they have treated with CLCC, CLCC(-), or TI. The students to be interviewed were selected purposively on the basis of the post-MCT scores. More specifically, students' mean scores on the post-MCT and standard deviations were computed across each treatment conditions, and two students scored a half standard deviation around the mean score were selected as the medium-achieving students, two students scored a half standard deviation below the mean score were selected as the low-achieving students, and two students scored a half standard deviation above the mean score were selected as the high-achieving students (Akkuş, Günel, & Hand, 2007). Six students from each of the SCLG, UCLG, and CG generated a total of 36 students to be interviewed (i.e. there were six classes of interest). Conducting interviews with students who were instructed by CLCC, CLCC(-), or TI gave opportunity to compare students' reasoning when they have received instruction with different teaching methods, and to realize whether or not students overcome alternative conceptions they hold before treatments are conducted. Interview questions were prepared by the researcher through taking into account the common alternative conceptions about the concepts of mixtures reported in the related literature and revealed in the post-MCT (see Appendix G). In other words, the interview protocol was designed according to students' performances on the post-MCT, the items that caused most of the students to challenge were asked to learn reasons of low understanding. Each individual interview took approximately 30 minutes which was audio-taped, transcribed, and coded in order to be able to gather students' conceptions under general themes (see section 4.4).

3.4.5. Classroom Observation Checklist

The classroom observation checklist was developed by the researcher to verify treatments. In other words, the researcher observed each treatment group systematically by filling classroom observation checklist out to be able to conclude that SCLG were instructed by the CLCC, UCLG were instructed by the CLCC(-), and CG were instructed by the TI. The checklist was made up of 25 items regarding the basics of cooperative learning, the steps of STAD, the conditions of conceptual change, and procedures related to TI (see Appendix H). 14 items were prepared to assess the CLCC treatment (items 1, 3, 5, 6, 9, 10, 13, 15, 16, 17, 19, 20, 21, 22), and four items were related to the CLCC(-) treatment (items 11, 12, 14, 25). The remaining seven items were common for two different treatments, that is, five items covered the implementations of the CLCC and CLCC(-) (items 2, 4, 7, 8, 18), and two items covered the common procedures between the CLCC(-) and TI (items 23, 24). The items were scored in each treatment group by the researcher as "yes" if the content of the sentence was observed in the class, and selected "no" when the content of the sentence was not observed. Furthermore, the items of the group observation checlist, which was completed by the teacher, were incorporated into the classroom observation checklist to collect evidence for treatment fidelity.

3.5. Instructional Materials

The study is conducted over eight weeks in the spring semester of 2011-2012. In the first and the last week of the study, the pretests and posttests were assigned to students to collect data about their understanding the concepts of mixtures and their motivation. In the middle six-week period (i.e. 12 lessons), on the other hand, the sampled students took instructions based on either cooperative learning based on conceptual change approach or traditional instruction. In contrast to CG, the lessons in the SCLG and UCLG were carried out through applying cooperative learning by the means of STAD (see Sections 3.7.1 and 3.7.2). Lesson plans, teaching activities, and quizzes were prepared to regulate the discourse of lessons in the SCLG and UCLG. Meanwhile, teaching activities and quizzes were distributed to students in the CG as a practice to be done at home. Group observation form and what happened in the group questionnaire were prepared solely for the CLCC treatment carried out within the structured cooperative learning groups (SCLG) to structure basics of an effective cooperative learning. The former was completed by the teacher while observing groups of students in the SCLG to satisfy whole-class processing, and the latter was administered to the groups of students in the SCLG to meet the small group processing element of an efficient CL practice. In brief, lesson plans, teaching activities, quizzes, group observation checklist, and what happened in the group questionnaire were used as instructional materials, all of which were explained below, respectively.

3.5.1. Lesson Plans

Lesson plans were prepared to inform the teacher about the content and the way of processing that content in lessons took part in the SCLG and UCLG. More specifically, lesson plans included the name of the unit and topic, the duration, the objectives, the contents, the materials, the information about what to do in each step of the STAD, and issues related to evaluation. Eventhough lesson plans covered plenty of information about the whole lesson, they were useful especially in the teacher presentation step of the STAD. The study consisted of six lesson plans, each of which was designed to cover procedures for two-lesson hours (see Appendix I). Among six weekly lesson plans, four of them were related to classification of mixtures, and the last two of them were related to separation of mixtures (see Table 3.13).

3.5.2. Teaching Activities

Teaching activities were generated specifically to be used by students in the SCLG and UCLG while they were studying at their teams. In other words, teaching activities met the team study step of the STAD. In addition to fulfilling the requirement of the STAD, teaching activities served to make students to experience dissatisfaction, which is the first condition of conceptual change to happen. Students were dissatisfied at the beginning of the activities by introducing common alternative conceptions about the concepts of mixtures and expected to answer questions at the end of the activities correctly by the means of vigirous group discussions. In other words, teaching activities were prepared through taking the conditions of conceptual change into account, which are dissatisfaction, intelligibility, plausibility, and fruitfulness. Specifically, the specified alternative conceptions were introduced again by asking conceptual questions at the end of the activities to provide intelligibility and plausibility, and by asking examples related to daily life to ensure fruitfulness. Table 3.13 presents the contents of lesson plans and the corresponding teaching activities assigned to students in the SCLG and UCLG.

Table 3.13 The contents of lesson plans and teaching activities

Lesson Plans	Teaching Activities
Lesson Plan 1 (The Nature and Properties of Mixtures)	Teaching Activity 1 (The Physical and Chemical Composition of Mixtures) Teaching Activity 2 (The Properties of Mixtures)
Lesson Plan 2 (The Dissolution Process and Components of Solutions)	Teaching Activity 3 (The Dissolution Process) Teaching Activity 4 (Solutions and Components)
Lesson Plan 3 (Types of Solutions and Factors Affecting Solubility)	Teaching Activity 5 (Types of Solutions) Teaching Activity 6 (Effect of Pressure on the Solubility of Gases)
Lesson Plan 4 (Factors Affecting Solubility)	Teaching Activity 7 (Effect of Temperature on the Solubility of Solids and Gases) Teaching Activity 8 (Effect of Stirring and Surface Area on Solubility)
Lesson Plan 5 (Colligative Properties and Separation Methods of Mixtures)	Teaching Activity 9 (Colligative Properties of Mixtures) Teaching Activity 10 (Separation Methods of Mixtures based on Size of Particles)
Lesson Plan 6 (Separation Methods of Mixtures)	Teaching Activity 11 (Separation Methods of Mixtures based on Density and Solubility) Teaching Activity 12 (Separation Methods of Mixtures based on Boiling Point)

As indicated in the Table 3.13, the study involved 12 teaching activities (see Appendix J) in which three of them were related to separation methods of mixtures (i.e. 10, 11, and 12), a neglected aspect of mixtures by researchers. Since the relevant literature does not present plenty of alternative conceptions about how mixtures are separated, the possible alternative conceptions anticipated by the researcher were included in those activities. The other nine activities, on the other hand, covered common alternative conceptions regarding mixtures reported in the literature. Among nine activities, four of them (i.e. first, second, third, and fifth) were prepared by using the drawings of activities reported in the related literature (Sanger, 2000; Papageorgiou, 2002; Pınarbaşı & Canpolat, 2003; Çalık, 2006).

3.5.3. Quizzes

Quizzes were developed by the researcher to be assigned to students in the SCLG and UCLG for assessing individual accountability, which is the third step of the STAD at the same time. The study included three quizzes (see Appendix K), that is, students were tested individually once two-week period due to timing constraints. The contents of quizzes were determined by assuming that students have learned the concepts covered by four teaching activities. In particular, the first quiz was related to physical and chemical composition and properties of mixtures, dissolution process and components of solutions; the second quiz covered types of solutions and factors affecting solubility; and the third quiz included colligative properties and separation methods of mixtures. Quizzes involved open-ended, fill in the blanks, matching and true/false types of questions which were scored out of 100. The scores gained through quizzes were computed by the researcher as individual improvement scores by subtracting the initial base score from the score gained in the quiz (see Sections 3.7.1 and 3.7.2).

3.5.4. Group Observation Form

The group observation form was developed by the researcher in order to provide an effective application of CLCC by making the teacher responsible for filling the scale out at the end of each lesson within the SCLG (see Section 3.7.1). The form involved seven items regarding various types of positive interdependence, individual accountability, promotive interaction, interpersonal and small group skills, and group processing (see Appendix L). In particular, the items of the group observation form were designed in a manner to control whether students in the SCLG realized how to work efficiently in their groups. The teacher rated items according to the frequency of occurence as never, sometimes, and always (i.e. three-point likert type scale), and he shared what were observed by students as a whole-class processing. By assessing students' behaviors while they were working in groups and giving simultaneous feedback to make them know how they have processed, students' motivation for learning and working as a group and their sense of self-efficacy for learning and performance were assumed to be enhanced (Johnson & Johnson, 1994). Group observation form was used in order for regulating the CLCC treatment instead of a means for drawing upon statistical analyses.

3.5.5. What Happened in the Group Questionnaire (WHGQ)

The WHGQ was used to regulate group processing in the SCLG, one of the basics of cooperative learning. However, it was distributed to groups of students to be completed at the end of each lesson rather than the teacher. The purpose of administering WHGQ to the SCLG students was to discover students' perceptions about how well they have worked in their groups. More specifically, WHGQ included items related especially to interpersonal and small group skills, or in other words, teamwork skills. While filling WHGQ out, students revised the events that were beneficial for them to achieve group's goal and the experiences that made them to feel troubles. In fact, the main function of WHGQ was to assure small group processing, one of the most crucial element of CL (Johnson & Johnson, 1999). WHGQ was developed by Gillies and Ashman (1996) on the basis of previous surveys conducted on cooperative learning. The questionnaire consisted of 15 items in five-point likert type scale in which students in the SCLG had a chance to score their choice among completely disagree (coded as 1) to completely agree (coded as 5) (see Appendix M). Similar to the group observation form, the data collected by the means of WHGQ were used to ensure effective applications of the CLCC treatment, not to perform statistical analyses.

3.6. Procedure

At the very beginning of this study, the researcher reviewed science and chemistry education literature. As a result of general review of litereture, the researcher decided on the research field and clarified research problems. The keywords were established (see Appendix A), which were used while reviewing the related literature on the following databases: Social Science Citation Index (SSCI), Educational Resources Information Center (ERIC), Ebscohost, Middle East Technical University Dissertations and Theses, TUBITAK Ulakbim, ProQuest Dissertations and Theses, and Turkish Higher Education Council Dissertations and Theses.

The chemistry unit was decided as mixtures and the content of mixtures at different grade levels were analyzed by the means of the chemistry program. Since the content of mixtures at grade nine covers both classification and separation of mixtures, the sample was selected from grade nine students. Mixtures Concept Test (MCT) was developed to assess grade nine students' understanding the concepts of mixtures by listing the objectives according to the ninth grade chemistry education program, and identifying the common alternative conceptions from the related literature. Besides to the MCT, instructional materials were established to regulate implementation within three different experimental conditions (i.e. structured cooperative learning groups, unstructured cooperative learning groups, control groups). After consulting experts and a chemistry teacher about the content and clarity of the pre-established instruments and teaching materials, the MCT was piloted. Not only MCT, but also MSLQ and AGQ were piloted to confirm factor loadings with the data drawn upon the sampled students. After analyzing the results of the first pilot test, the MCT was administered second time to have a more reliable test measuring students' conceptual understanding.

Had piloted MCT, MSLQ, and AGQ, the Research Center for Applied Ethics in the Middle East Technical University and the Directorate of National Education in Isparta were applied to take necessary permissions about the treatment of the study. After examinations, both of the institutions declared appropriateness of the study. This study did not damage students physically or psychologically. The purpose of the study was explained to students without giving details in order not to violate results of the study by inserting the Hawthorne effect (see Section 3.9), at the beginning of the study. Moreover, all sorts of data collected from the students were kept confidential by not sharing the data with any other people, not asking for the names of the students but the identity numbers, and designating the scoring procedure as to be done by the researcher.

Three months before treatment commenced, an appointment was got with the teacher to introduce the purpose and procedure of the study. The teacher was informed on Cooperative Learning, Student Teams-Achievement Division (STAD), conceptual change conditions, Cooperative Learning based on Conceptual Change (CLCC) by the means of STAD, instruments and instructional materials developed for the study. The first meeting was held more general compared to future meetings in order not to make the teacher to be worried about implementation of the cooperative learning considering the likelihood of being unfamiliar with the procedures of student-centered teaching methods. At the end of the first meeting, the teacher was provided a handout to be examined in detail including the basic elements of CL; the steps of STAD; the conditions of conceptual change; the differences in procedures between the SCLG and UCLG; the role of the teacher; the expectations from the students; purpose of the study; and instruments and instructional materials to be used during treatments (see Appendix N). Two weeks after the first meeting, the teacher was revisited to discuss this time on details of treatment across each group. The researcher and the teacher revised instructional materials, instruments, and procedures. Every questions of the teacher regarding treatment were answered and the teacher started to use CL when the unit of chemical changes was taught, the unit just before the concepts of mixtures. This preliminary effort helped the teacher internalize his own responsibilities during CL and made the students to be accustomed to CL practices. By this way, the teacher believed that he was ready to conduct the treatment as planned as possible.

After all of these preliminary works, the MCT, MSLQ, and AGQ were assigned to students as pretests, and treatments were conducted just one week after pretests. The students were posttested after six-week. All sorts of data collected during treatment were analyzed and the theses was put into words. Figure 3.1 indicates the flowchart of the present study.

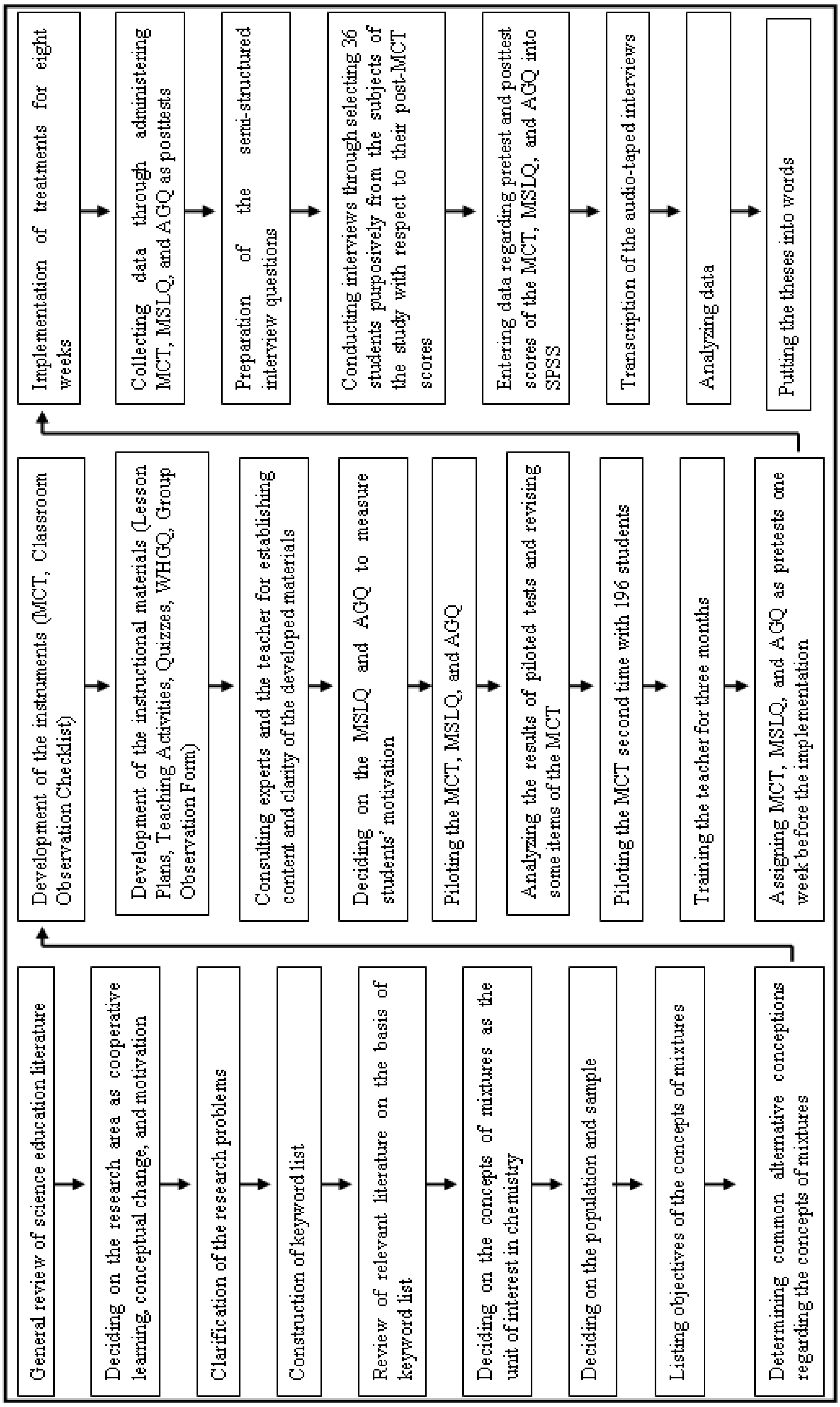


Figure 3.1 Flowchart of the Study

3.7. Implementation of Treatments

The above section made the whole process of the study apparent from the very beginning to the end. This section, furthermore, presents particularly the eight-week period of treatments in the structured cooperative learning groups (SCLG), unstructured cooperative learning groups (UCLG), and control groups (CG), separately. Before explaining the specific procedures took place in each group, it seems logical to mention about the first and the last lessons of treatment since common procedures were carried out in each group. In the first lesson, all of the sampled students were pretested primarily by using the MSLQ and AGQ to assess their motivation, and then the MCT was administered to measure students' understanding the concepts of mixtures. The reason of assigning initially the MSLQ and AGQ was to control possible negative feelings students might have after completing the MCT. In other words, the content of the MCT was made up of conceptual questions that might become unfamiliar to students and they might feel learned helplessness about the concepts of mixtures at the beginning of the unit, which might cause the results drawn upon MSLQ and AGQ to lessen. Similar to pretest administration, all of the students were assigned the MSLQ, AGQ, and MCT in the same sequence as posttests to determine the effect of treatment on their understanding the concept of mixtures and motivation. Treatment fidelity was provided by observing each treatment group through filling the classroom observation checklist out and by training the teacher about how to implement treatments for three months before the study was conducted.

3.7.1. Treatment in the Structured Cooperative Learning Groups

The 60 students (i.e. two classes) within the SCLG were instructed with Cooperative Learning based on Conceptual Change (CLCC) by the means of Student Teams-Achievement Divisions (STAD), one of the methods of cooperative learning.

Preliminary teacher training was provided since students' level of understanding is argued to be greater when teachers are trained on the procedures of cooperative learning (Lou, Abrami, Spence, Poulsen, Chambers, & d'Apollonia, 1996), as noted in the above section. In the following lesson of the first week, the teacher trained students in the SCLG in turn about the nature of cooperative learning, basic elements of cooperative learning, the steps of STAD method of cooperative learning, purpose of the study, the expectations from them while they were working in groups, interpersonal and small group skills required for efficient cooperation and interaction. In particular, the teacher explained that cooperative learning require two distinct type of skills: taskwork and teamwork. To achieve taskwork, members of a group should realize that they can achieve their learning goals if and only if all the members of their group also attain their goals, which cannot be realized unless members act as a group by internalizing the social skills. The teacher extended which social skills to be used within groups as efficient communication, conflict management, listening to each other, giving and receiving help, sharing leadership, trust-building, respecting each other, sharing resources, taking turn, and democratic decision making. Not only listing, the teacher motivated students to use mentioned small group skills, frequently. At the end of social skill training, the groups were announced by the teacher which were determined purposively by the researcher and the teacher. More specifically, there were seven small groups in each of the SCLG consisting of four or five members (i.e. the number of students in each class was 30 and there were five four-membered and two five-membered small groups). The composition of groups were determined according to students' gender and ability that was defined with respect to students' last semester chemistry course grades. Accordingly, the teacher-selected small groups were heterogeneous in terms of gender and ability of students that involved one high-, two medium-, and one low-performing, sex-balanced students of four or five-member. Had been informed on the groups, the students were required to come together and gave their group a name, which ensured positive identity interdependence among members of the groups. Groups were advised to sit together and establish eye contact with each other in order for to encourage and facilitate each other's effort to complete assigned tasks, which ensured both positive environmental interdependence and promotive interaction. Encouraging and praising each other's effort to learn assured greater mastery, higher motivation to work together, and better personal relationships. Moreover, individuals were assigned a base score according to their pre-MCT scores for computing individual improvement scores. More specifically, the researcher adjusted 25-item MCT as it was 30-item by scoring each item as 1.2 points, as suggested by Slavin (1996). For example, a student who gave 15 correct answers in the pre-MCT was assigned 18 points by multiplying the number of correct answer with 1.2. Students in each class of the SCLG were ranked according to the adjusted scores and the first three students were assigned a base score of 20, the following three students were assigned a base score of 19, and the same procedure was applied until each student in the class has an initial base score. The pre-determined base scores were shared only by the teacher to be used when computing improvement scores of students, which were calculated as subtracting the base scores from scores gained in the quiz. Evaluating students' excellence through improvement scores is beneficial for an efficient cooperative learning because they permit students to compete only with their own scores (i.e. improvement scores were the criteria for evaluation) and to work in an environment where all individuals have equal rights.

Had completed all of the preliminary requirements, the instruction started by the presentation of the teacher about the first concept of mixtures (i.e. the physical and chemical composition of mixtures), since the regular cycle of the STAD begins with class presentation. The teacher covered the concepts of the relevant activity and quiz by lecturing and discussion to help students work well within their groups by developing their knowledge base and get high scores from the assigned individual quiz. During the class presentation, which continued up to 15 minutes or half an hour depending on the intensity of the concepts, the teacher asked critical questions to make students to think profoundly about the reasons of scientific events instead of explaining concepts directly. Although students were dissatisfied primarily when they were studying in teams on teaching activities, the teacher prepared necessary background for conceptual learning of scientific concepts during presentation.

Following teacher presentation, the students work on the teaching activities within their pre-assigned groups. As noted, students were aware of the importance of conceptual learning when they come together with their teammates in order to be able to complete activities, which were prepared according to the common alternative conceptions students have regarding the concepts of mixtures. Actually, the most important component of the STAD was the team work since the basics of cooperative learning and the conditions of conceptual change were structured mainly at this step (explained below in detail while reporting a sample lesson by the use of CLCC). The primary purpose of team study was to be sure that the assigned material is mastered by each member of the team in such a way that everybody will complete items of the quiz perfectly that would be given after team study was completed. Completing worksheets or achieving group goals required group members to work as a group instead of working alone because students were trying to overcome knowledge that made them dissatisfy, the first and the most crucial condition for conceptual change to happen. While they were trying to resolve questions, students challenged each other's conceptions by sharing their own thoughts. In other words, there were two sources for making students to experience dissatisfaction: the questions in the activities and the viewpoints of teammates. The only function of team study was not to challenge each other's conceptions, but also assist each other's understanding of the scientific phenomena by giving and receiving elaborated help. Students were called for personal responsibility for completing the activity as a group, which ensured positive goal interdependence and individual accountability. The following manipulations were done to well-structure types of positive interdependence and individual accountability: members gave a name to their groups; members sit in a group order; each member of the group was assigned complementary roles as checker, encourager, reporter, and reader; four-member heterogeneous groups were formed; each group was assigned only two worksheets; students were tested individually; a common grade was assigned to members of a group; team with the highest score was announced in the bulletin board; members were encouraged to celebrate joint excellence.

The purpose of assigning roles to students was twofold: to help members realize each member's contribution was as crucial as their owns for accomplishing the group goal and regulating intragroup interaction that assured positive role interdependence, and to make each member responsible for completing groups' goals that ensured individual accountability. The important issue about role assignments was rotating roles within each activity, that is, every members experienced all of the specified roles, respectively. The role of checker, for instance, was established to check whether each member has mastered on the assigned task or whether each member's contribution accounted for completing worksheets. Students who were assigned the role of encourager, on the other hand, supported and praised each member's share work that resulted in greater enthusisam for and commitment to complete worksheets. Students did not know who would present the answers of groups, that is, the teacher selected students to report their answers which provided individual accountability since every students had a chance to be selected as a reporter. The teacher was advised to select students who seemed reluctant to contribute to team work when they were working with their teammates. The positive resource interdependence was structured through assigning two worksheets per each group, which made students to share materials to complete joint goals. Sharing materials entailed members to think aloud and discuss on the solution of questions that provided promotive interaction and cooperation which in turn enhanced group cohesion.

Following team study, students took individual quizzes including the contents of the completed four activites. During quizzes, members were not allowed to help each other because the aim of testing students was to assess on their individual accountability while studying within teams and to evaluate their understanding of the scientific concepts instructed by the teacher and studied with teammates. It was observed by the researcher that students try to contribute to groups' goal by learning concepts as much as possible and doing well in quizzes. The quizzes were collected, scored, and announced as the individual improvement scores through which the team scores were computed. The team that showed the highest improvement was announced in the bulletin board as the winner team where the members were assigned a common grade. In the case of more than one team sharing the highest score, all of the teams were announced as the winner teams. Moreover, in the case of five-membered groups, the team score was adjusted as there were four members as in most of the other groups (i.e. five groups were four-membered and two groups were five-membered). As the final step, the teacher encouraged winner teams to celebrate joint efforts. In brief, the scoring system of the STAD promotes intragroup cooperation and intergroup competition since the team that indicated the greatest improvement was announced as the winner team in which all of the members received the same grade, which assured the positive reward/celebration interdependence and the positive outside enemy interdependence.

When students finished worksheets (or students delivered individual tests), the small group processing and the whole-group processing were carried out. Students constructively discussed on how well they have worked together while completing the assigned task. In particular, members filled the WHGQ as a group by discussing the items of the questionnaire which was consisted of basic elements of cooperative learning. The researcher observed that students gave attention to small group processing by activating their higher order thinking skills, such as reflective and metacognitive thinking, and by using interpersonal and small group skills, such as conflict management. Apart from students, the teacher filled the group observation checklist out to fulfill the necessities of whole-group processing through observing students while they were working in their groups. The items of the group observation form covered basics of cooperative learning and the teacher recorded the frequency of behaviors to determine whether students in SCLG acted as intended. The results drawn upon the checklist were shared by groups at the end of each lesson to provide whole-class processing. For example, the teacher announced that the members of the "Atom" group were aware of the teammates who have not understood the difference between saturated and super saturated solutions, or the members of the "Orbital" group applied frequently to me when they have experienced disagreements and you should try to resolve disagreements through discussing initially among each other for the following lessons. The researcher observed that students tried to change unintended behaviors and worked with greater enthusiasm in the following lessons by the means of the teacher's feedback, which verified the function of the group observation form. Moreover, the teacher asked for the answers of questions included in worksheets by selecting one of the members of the groups (i.e. reporter). At this stage, the teacher tried to determine whether every individual students have learned the concepts covered by the lesson since the underlying purpose of cooperative learning is to increase individual student's level of understanding. At the end of the lesson, the teacher required students to explain learned concepts in their own words, assessed if students understood the concepts and made necassary connections with previous concepts, and tested whether students were able to internalize learned concepts to be used in different contexts, all of which were performed to make the scientific concepts intelligible, plausible, and fruitful. Besides to understanding, the teacher checked whether groups have used the social skills necessary for an effective cooperation and motivated students to frequent use of teamwork skills, as taught at the beginning of the study. The lessons were finished by collecting each group's worksheet to be graded for the following lesson. A sample lesson, giving idea on how were the lessons carried out by the CLCC in the SCLG, was introduced below.

The content of the third lesson was related to the dissolution process in which the purposes were to make students to learn the process of dissolution, to comprehend the difference between dissolution and melting, and to realize dissolution process requires a physical change. Besides to the objectives, the teacher was aware of the common alternative conceptions students have about the dissolution process, the sequence of the STAD method of cooperative learning, and the materials to be used during the lesson, all of which were introduced in the relevant lesson plan (see Appendix I for the second lesson plan). The teacher started the lesson by stating the content and the aims to be achieved at the end of that lesson. Moreover, the fundamental importance of dissolution in real life situations were emphasized through giving examples, like gas output when the cover of gaseous liquids are opened, decompression, dialysis, and industrial applications of mixtures. The primary function of the teacher presentation was to provide necessary knowledge base about the concepts of mixtures to be enhanced in team studies. Instead of explaining scientific concepts directly, the teacher asked conceptual questions to make students think about the reasons of scientific events without giving correct answers of them, such as:

- Does a new substance form as a result of dissolving salt into water?
- What happens to salt when added to water?
- Do you think that salt disappears when mixed with water since it becomes invisible?
- Do you think that salt melts after put into water?
- Is salt is absorbed by water during dissolution?

Majority of the students stated that they have never thought about what happens to salt when added to water. The teacher created a discussion environment for a few minutes and gave the definition of dissolution as the amount of matter dissolved in 100 ml solvent at constant temperature and pressure. In addition to the well-known definition of dissolution, the teacher tried to explain how dissolution takes place on the conceptual basis by drawing particulate representations of various solutions on the board. For instance, the teacher told that the particles of salt and water interact vigirously when they are mixed together to form the homogeneous mixture and represented the solution composed of salt and water as in the Figure 3.2. The speed of that interaction can be increased by stirring or making salt smaller, whereas none of the specified factors are required for salt to be dissolved in water which is related to the nature of these substances (the rule of “like dissolves like” was the topic of the following lesson). Although the knowledge provided by the teacher were the topics of the following lessons, the teacher mentioned them to construct knowledge-base for the future concepts and to ensure conceptual understanding of the dissolution process at the microscopic level. Right after explaining the dissolution process, the teacher posed the concept of melting through stating that it describes the process where a solid changes to liquid by taking heat. To sum up, the teacher tried to present the concepts in a manner to make students to understand the reason of scientific events.

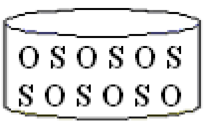


Figure 3.2 Representation of salt dissolved in water

After 15-minute teacher presentation, the students were advised to take group order for studying on the worksheet with their teammates. The worksheet questioned the concept of how to represent sugar added into water (see Appendix J for the third teaching activity). It was assumed that there were five representations drawed by students (Figure 3.3) and the groups were required to discuss on which drawing(s) represents correct appearance of sugar added into water. The groups, furthermore, required to explain their reasons of specifying each of the particular drawing as correct or incorrect.

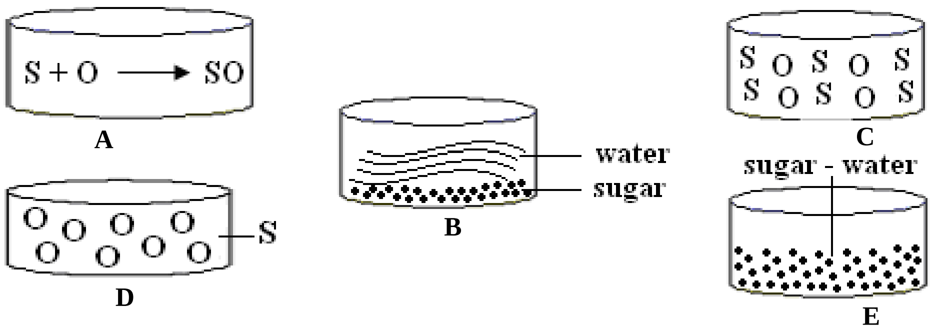


Figure 3.3 Teaching activity regarding the dissolution process

As indicated in the Figure 3.3, the drawings included one correct choice (i.e. the beaker B) and four possible alternative conceptions regarding the dissolution process (Prieto et al., 1989; Abraham et al., 1992; Abraham et al., 1994; Ebenezer & Erickson, 1996; Valanides, 2000a; Çalık & Ayas, 2005a; Uzuntiryaki & Geban, 2005; Çalık, 2006). The alternative conceptions to be tested with the third worksheet were: “dissolving is a process of combining two or more substances chemically” as presented in the beaker A, “Solute disappears/melts/evaporates during dissolution” as indicated in the beaker C, “all mixtures are heterogeneous in nature” as marked in the beaker D, and “a new substance forms as a result of dissolution” as shown in the beaker E. The primary purpose of preparing the worksheet was to make students to dissatisfy with their current cognitive structures by introducing common alternative conceptions about the dissolution process. Students tried to be dissatisfied because it is the first condition for alternative conceptions to be overcome. Had dissatisfied, students explore intelligible, plausible and fruitful knowledge for explaining the scientific phenomena, for which the current knowledge was not adequate. Apart from alternative conceptions included in the activity, students challenged each other’s conceptions while they were studying in teams to be able to complete the activity. SCLG were formed by well-structuring the basics of cooperative learning to create a learning environment where students cause others to think profoundly by sharing their own ideas. Members exerted efforts to learn and to be sure that every members of their group learned the activity. Furthermore, the teacher filled the group observation checklist out by observing the groups while they were studying on the worksheet and asked certain questions to increase the quality and quantity of discussions managed constructively by members having divergent roles to complete the worksheet. The following questions can be reported as sample questions asked by the teacher while students were studying in their teams:

- Where is the sugar in the beaker C?
- Do you think sugar-water is a new substance?
- Can it be possible for sugar to precipitate at the bottom of the beaker D?
- What kind of mixture does it in the beaker D?

After explaining their reasons of specifying each of the particular drawing as correct or incorrect, students were further asked to express the following questions:

- How dissolution takes place?
- What melting means?
- Can we symbolize sugar-water solution with a chemical formula? Why?
- Does sugar-water is a new substance that differ from its components? Why?
- What kind of mixture do we have when sugar added to tea?
- How can you explain the precipitate present at the bottom of the cup of tea?

The reason of putting these questions into the activity was to test students’ conceptual understanding after they have discussed potential alternative conceptions with their teammates. Students did not only challenge each other’s conceptions but also provided elaborated help and assistance to each other to make challenging knowledge more intelligible and plausible. The last two questions in the worksheet ensured fruitfulness of new knowledge since they required groups to transfer what they have mastered to real life contexts. It can readily be said that the team study step of the STAD met all of the conditions of conceptual change and basics of cooperative learning except small group processing which is the basic to be structured at the end of the lesson (see Table 3.14 for the order of treatment and their corresponding function for structuring the basics of CLCC treatment).

Following team study, students took individual quizzes in which members were not allowed to help each other. The content of the quiz involved the concepts learned during teacher presentation and team study (see Appendix K for the first quiz). In addition to forming four-member groups, assigning interconnected roles, and selecting randomly an individual to report answers of the group, students were tested individually to assess how accountable they were. After collecting quiz sheets, students completed the WHGQ through reflecting on the quality of their interaction and cooperation as a group. The WHGQ included items related to social skills students have been trained on at the beginning of the study. One of the group's members, for instance, complained about limited democracy when they were filling worksheets out. Under such a circumstance, the teacher carefully observed how teammates would resolve such a problem, whereas did not intervene simultaneously. After a week, the teacher experienced that the group members were working well together by listening to each other, taking turn, and sharing leadership. At the end of the lesson, the teacher provided feedback to whole class according to the records of the group observation checklist and motivated all students to frequent use of interpersonal and small group skills. As well as social skills, the teacher checked whether each student understood the content of the lesson meaningfully through asking students the definition of the dissolution process, the difference between dissolution and melting, and the daily life examples of dissolution. Although mentioned sevaral times, the teacher summarized the concepts of interest and associated them with concrete examples to make the new knowledge intelligible, plausible, and fruitful.

Collected worksheets related to the dissolution process were distributed groups in the following first lesson to make them see what they have done incorrectly and to learn the scientifically correct knowledge. Moreover, individual improvement scores and team scores based on individual quizzes were announced in the bulletin board. The team showed the greatest improvement was recognized as the winner team whose members were assigned a common grade. Table 3.14 summarizes CLCC treatment by the means of STAD took place in the SCLG and to what they served in terms of the basics of cooperative learning, and the steps of the STAD, chronologically.

Table 3.14 Chronological order of the treatment in the SCLG and the corresponding outcome

Treatment	Outcome(s)
Students were trained on social skills	Interpersonal and Small Group Skills
Four-member heterogeneous groups were formed by the teacher	Individual Accountability Heterogeneity
Students gave a name to their groups	Positive Identity Interdependence
The seating arrangement was done according to the group order	Face-to-Face Promotive Interaction Positive Environmental Interdependence
Each member of groups was assigned a base score	Equal Rights
The teacher presented the content	STAD
Students worked on activities within groups	STAD
The teacher motivated students to use social skills while they were studying in teams	Interpersonal and Small Group Skills
Students tried to master the activity and be sure that every members of the group have mastered the activity	Positive Goal Interdependence
Students challenged each other's conclusion, gave and received help	Promotive Interaction Interpersonal and Small Group Skills
Each member was assigned complementary roles that were changed in each activity	Positive Role Interdependence
The reporter was randomly selected by the teacher	Individual Accountability
Each group was assigned two worksheets	Positive Resource Interdependence
Students were tested individually	Individual Accountability STAD
Individual improvement scores were computed	STAD
Each member of the group was assigned a common grade	Positive Reward Interdependence
The team(s) showed highest improvement was made public by the means of bulletin board	Positive Outside Enemy Interdependence
The teacher encouraged the winner team to celebrate joint efforts	Positive Celebration Interdependence STAD
Groups filled the WHGQ out	Small Group Processing
The teacher shared the records held by the means of the group observation checklist	Whole-Group Processing Individual Accountability
The teacher asked random questions	Individual Accountability

3.7.2. Treatment in the Unstructured Cooperative Learning Groups

The 60 students (i.e. two classes) within the UCLG were instructed with Cooperative Learning based on Conceptual Change without Well-Structuring the Basics of Cooperative Learning (CLCC(-)) by the means of the STAD.

Similar to students in the SCLG, students in the UCLG were instructed about the nature of cooperative learning and STAD. However, there was a great difference between the two trainings, that is, the teacher informed students in the UCLG in general without exerting any efforts to the basics of cooperative learning. In brief, UCLG did not receive social skill training, in the first lesson. Students told that they would work in groups up to the end of the concepts of mixtures. On the contrary to the SCLG, students in the UCLG selected their own teammates which caused groups to be homogeneous in terms of gender and ability. Moreover, students prefer to work with their close friends. After forming groups, students were advised to sit together in the group order while they were studying on activities. Similar to SCLG, each member of groups was assigned a base score to be used when computing individual improvement scores gained through individual quizzes.

The lessons were proceeded in the UCLG as in the SCLG, that is, STAD was used as the cooperative learning method within both of the treatment groups and the STAD has a regular cycle of five major components namely class presentation, team study, individual quizzes, individual improvement scores, and team recognition. Besides to the way the lessons were carried out, the students in the UCLG were tried to be dissatisfied with their current cognitive structures through administering the same teaching activities to teams (explained below in detail while reporting a sample lesson by the use of CLCC(-)). In brief, SCLG and UCLG did not differ in the steps of the STAD and the conditions of conceptual change, whereas the basics of cooperative learning were not well-structured in the UCLG, in contrast to SCLG.

In UCLG, team study was perceived by the members as a compulsory practice that they have to obey, which was directed by a permanent leader. There were not any efforts to structure positive goal interdependence and any other types of positive interdependence which prevent promotive interaction, in turn. For example, students were not assigned complementary and changing roles but determining solely a permanent leader of the group and worksheets were assigned according to the number of students per group (i.e. four or five) so they did not share any material or information with each other. Instead of studying as a group, each member tried to learn the assigned material for his/her own right, not for other members of the group. When team study completed, individual students took the same quizzes with that of SCLG students, which ensured individual accountability. However, this does not mean that individual accountability was structured completely because individual tests are only one way of establishing individual accountability. To be able to well-structure individual accountability, the students might have been assigned the role of checker or random oral examinations, or the teacher might have observed the groups while they were working within their teams. None of the specified ways were incorporated in the UCLG. The individual quizzes were collected and scored by the researcher on the basis of individual improvement system. However, team scores were not computed because an individual who showed the greatest improvement was made public in the bulletin board rather than a group. In other words, members of a group did not interdepend each other since individuals were rewarded based on their own performance, which is the predominant reward structure within traditional learning groups (Slavin & Cooper, 1999). The success was celebrated solely by the individual performed highest improvement. Moreover, students did not reflect on the quality of team study at the end of each lesson, that is, there were no small group processing. The teacher observed groups unsystematically without filling the group observation checklist out. At the end of the lesson, the teacher required students to explain learned concepts in their own words, assessed if students understood the concepts and made necassary connections with previous concepts, and tested whether students were able to internalize learned concepts to be used in different contexts, all of which were performed to make the scientific concepts intelligible, plausible, and fruitful. In brief, the frame of unstructured cooperative learning group favored individualistic learning with talking in such a manner that each individiual is accountable only for ownself, assessed and rewarded individually instead of group as a whole. The lesson about the dissolution process was presented below as a sample lesson carried out by the CLCC(-) in the UCLG.

In the UCLG, the same discourse and sequence was followed while lessons were carried out as in the SCLG since both of which were instructed by the means of STAD method of cooperative learning, but the way of structuring basics of cooperative learning differed markedly. As noted in the CLCC treatment, the objectives of the third lesson in the CLCC(-) treatment were to make students to learn the process of dissolution, to comprehend the difference between dissolution and melting, and to realize dissolution process requires a physical change. In particular, the teacher started the lesson by stating the content and the aims to be achieved at the end of that lesson, and the essential importance of dissolution process in real life situations. The main function of the teacher presentation was to develop students' knowledge base. Instead of explaining scientific concepts directly, the teacher asked conceptual questions to make students think about the reasons of scientific events without giving correct answers of them, such as "what happens to salt when added to water?", "do you think that salt melts after put into water?". The teacher created a discussion environment for a few minutes and gave the definition of dissolution as the amount of matter dissolved in 100 ml solvent at constant temperature and pressure. In addition to the well-known definition of dissolution, the teacher tried to explain how dissolution takes place on the conceptual basis by drawing particulate representations of various solutions on the board. For instance, the teacher told that the particles of salt and water interact vigirously when they are mixed together to form the homogeneous mixture and represented the solution composed of salt and water (see Figure 3.2). The speed of that interaction can be increased by stirring or making salt smaller, whereas none of the specified factors are required for salt to be dissolved in water which is related to the nature of these substances (the rule of "like dissolves like" was the topic of the following lesson). Although the knowledge provided by the teacher were the topics of the following lessons, the teacher mentioned them to construct knowledge-base for the future concepts and to ensure conceptual understanding of the dissolution process at the microscopic level. Right after explaining the dissolution process, the teacher posed the concept of melting through stating that it describes the process where a solid changes to liquid by taking heat. To sum up, the teacher tried to present the concepts in a manner to make students to understand the reason of scientific events.

After 15-minute teacher presentation, the students were advised to take group order for studying on the worksheet with their teammates and the same worksheet asking how to represent sugar added into water was assigned to groups. The primary purpose of preparing the worksheet was to make students to dissatisfy with their current cognitive structures by introducing common alternative conceptions about the dissolution process. Students tried to be dissatisfied because it is the first condition for alternative conceptions to be overcome. Had dissatisfied, students explore intelligible, plausible and fruitful knowledge for explaining the scientific phenomena, for which the current knowledge was not adequate. The teacher asked critical questions while students were studying in their teams, such as "can it be possible for sugar to precipitate at the bottom of the beaker D?", "where is the sugar in the beaker C?". After explaining their reasons of specifying each of the particular drawing as correct or incorrect, students were further asked to express the following questions: "how dissolution takes place?", "what melting means?", "what kind of mixture do we have when sugar added to tea?".

The reason of putting these questions into the activity was to test students' conceptual understanding after they have discussed potential alternative conceptions with their teammates. The last question in the worksheet ensured fruitfulness of new knowledge since it required groups to transfer what they have mastered to real life contexts. It can readily be said that the team study step of the STAD met all of the conditions of conceptual change but not most of the basics of cooperative learning (see Table 3.15 for the order of treatment and their corresponding function for the CLCC(-) treatment). For instance, members committed little to each other's understanding the concepts, whereas tried to understand the concepts for their own since all members would be tested individually. The teacher walked among groups while they were trying to complete the worksheet and observed how groups work together without filling the group observation checklist. During team studies, members of the same groups did not interact and cooperate effectively because they were not trained on social skills. Actually, members were good at personal relationships, whereas not good at academic discourse. In other words, members did not promote each others' learning since any efforts were made to structure positive interdependence.

Students were tested individually after they have completed team study as in the CLCC treatment, which met the individual accountability element of cooperative learning. However, apart from individual test, which is actually one of the steps of the STAD, any efforts were made to well-establish individual accountability (see Table 3.15). Therefore, it can be said that there were limited individual accountability in the CLCC(-) treatment. Had collected quiz sheets, the teacher asked for volunteers to report their groups' answers to the worksheet. At the end of the lesson, the teacher checked whether students understood the content of the lesson meaningfully through asking students the definition of the dissolution process, the difference between dissolution and melting, and the daily life examples of dissolution. Although mentioned sevaral times, the teacher summarized the concepts of interest and associated them with concrete examples to make the new knowledge intelligible, plausible, and fruitful.

Next lesson, the completed quizzes were distributed to the owner of the quiz, not to the group as in the CLCC treatment. Instead of computing team scores based on individual improvement scores, individual improvement scores were made public in the bulletin board. The individual showed the greatest improvement was recognized as the winner and members were assigned a grade according to their own improvement scores. Table 3.15 presents steps of CLCC(-) by the means of STAD and the meanings of the procedures in terms of the basics of cooperative learning, and the steps of the STAD, chronologically.

Table 3.15 Chronological order of the treatment in the UCLG and the corresponding outcome

Treatment	Outcome(s)
Students were not trained on social skills	No Interpersonal and Small Group Skills
Four-member groups were formed by the students	Individual Accountability Homogeneity
Students did not give a name to their groups	No Positive Identity Interdependence
The seating arrangement was done according to the group order	Face-to-Face Promotive Interaction Positive Environmental Interdependence
Each member of groups was assigned a base score	Equal Rights
The teacher presented the content	STAD
Students worked on activities within groups	STAD
Students tried only to master the activity for their own	No Positive Goal Interdependence
Students did not commit each other's learning	No Promotive Interaction
One member in each group was assigned the permanent leadership role	No Positive Role Interdependence
Voluntary members reported their group's answers	Limited Individual Accountability
Each group was assigned four worksheets	No Positive Resource Interdependence
Students were tested individually	Individual Accountability STAD
Individual improvement scores were computed	STAD
Members of a group received different grades	No Positive Reward Interdependence
The individual(s) showed greatest improvement was made public by the means of bulletin board and celebrated personal efforts	No Positive Celebration Interdependence STAD
Groups did not reflect on the quality of working in a group	No Group Processing

3.7.3. Treatment in the Control Groups

The 60 students (i.e. two classes) within the CG were instructed with TI, which included direct instruction and teacher guided-discussion. The teacher explained the content in detail while the students were listening and taking notes. The aim of the teacher was to cover as much content as possible in a lecture hour without considering the side of the students. In other words, the teacher expressed all of the scientific knowledge directly and asked lower level questions (i.e. factual and knowledge level questions) to students. The way of interaction was one dimensional. There were limited interaction between the teacher and the students, whereas no interaction among the students because student-student interactions were perceived as noise which results in disciplinary problems between the teacher and the students. The role of the teacher was the expert or authority who knew every bits of knowledge regarding the mixtures. The students, on the other hand, listened to their teacher carefully by taking notes to be studied before exams. The students in the CG did not work in groups on worksheets, but they were assigned the worksheets and quizzes as homeworks to be studied at home. The teacher gave answers of the worksheets throughly and students did not question themselves when they were confused with an unfamiliar concept. In brief, the teacher did not show any efforts to overcome students' alternative conceptions and the instruction favored rote learning rather than meaningful learning which requires students to link previous and new knowledge. The lesson about the dissolution process was presented below as a sample lesson carried out by the TI in the CG.

The same objectives were pre-determined for the third lesson in the CG, which were to make students to learn the process of dissolution, to comprehend the difference between dissolution and melting, and to realize dissolution process requires a physical change. Eventhough the same aims, the students in the CG were instructed by the TI where students learned individually. There were not any efforts for structuring the basics of cooperative learning, the steps of STAD, or the conditions of conceptual change. In particular, the teacher began the third lesson by directly giving the description of the dissolution process as the amount of matter dissolved in 100 ml solvent at constant temperature and pressure. Just after explaining the dissolution process, the teacher passed through the process of melting and stated that it is a physical change taking place by giving heat to solids. Then, the teacher expected students to give examples of solutions. Accordingly, students gave salt-water, sugar-water, alcohol-water as examples of solutions. Although students gave only well-known solutions of water, the teacher did not extend examples but passed to draw a graph indicating the amounts of dissolved NaCl, KNO_3, $NaNO_3$, and KCl at different temperature values (see Figure 3.4). The teacher asked following questions to the students:

- What will be the amount of dissolved matter when the amount of solute is lowered up to half of the initial amount?
- What will be the amount of dissolved matter when the amount of solvent is raised up to twice of the initial amount?

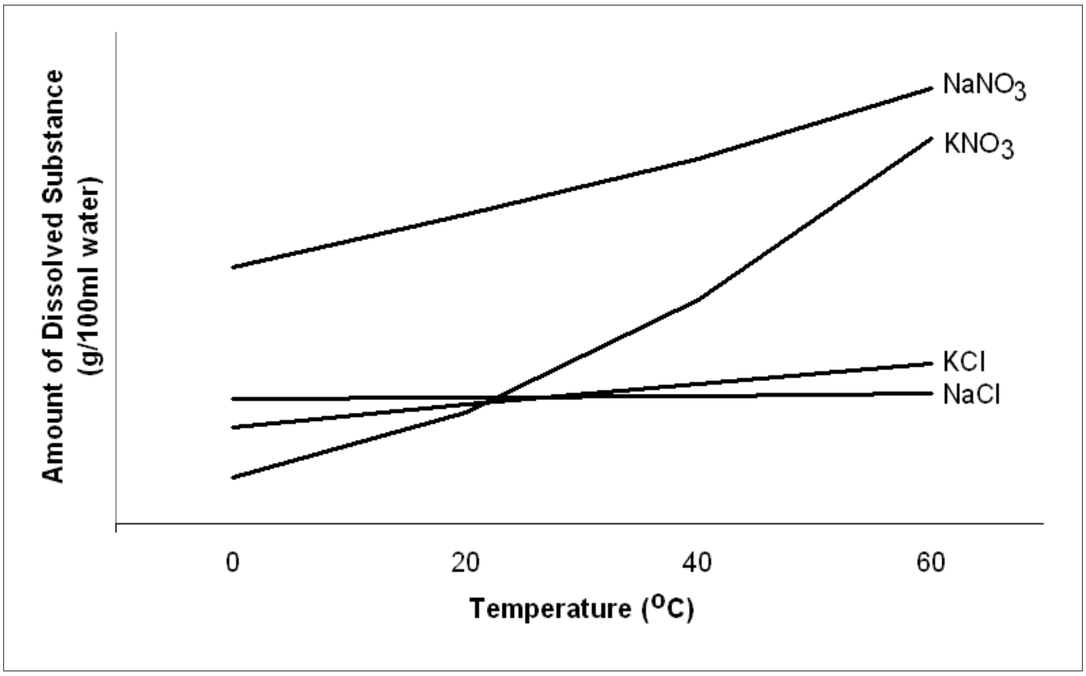


Figure 3.4 The amount of dissolved substances at different temperatures

The activities and quizzes were assigned to students to be solved at home by working alone, the answers of which were given readily by the teacher in the next lesson. The teacher asked questions to the voluntary and successful students that were factual and knowledge-level in nature. The lesson completed with offering if there were any questions related to the dissolution process.

3.8. Analyses of Data

As noted in the section 3.4, two types of data were collected by the specified instruments, which were quantitative and qualitative data. Quantitative data were collected to analyze the first and second research questions and qualitative data were gathered to examine the third research question:

1. Is there a statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures?

2. Is there a statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' motivation (Self-Efficacy for Learning and Performance, Task Value, Control of Learning Beliefs, Test Anxiety, Mastery Approach Goals, Mastery Avoidance Goals, Performance Approach Goals, Performance Avoidance Goals)?

3. What are grade nine students' conceptions about the concepts of mixtures?

The quantitative data were analyzed statistically by using SPSS 20 for Windows. Data list of SPSS involved type of instruction, gender, age, last semester chemistry course grade, mother education level, father education level, pretest and posttest scores of the participating students. Four of the students (2.2 %) were excluded from the data list since they have not taken any of the pretests and posttests. The data collected from the remaining 176 students were analyzed with descriptive and inferential statistics. The IV of the study was the type of instruction with its three levels and the DVs were students' understanding the concepts of mixtures, SELP, TV, CLB, TA, MAP, MAV, PAP, and PAV. Due to collective DVs, Multivariate Analysis of Variance (MANOVA) was performed initially for pretest scores of all of the nine DVs to control whether there was a significant mean difference among students in the SCLG, UCLG, and CG with respect to their understanding the concepts of mixtures and motivation. Although the results indicated that there were not statistically significant mean difference among the groups with respect to pretest scores (see Section 4.1.2), the correlations among pretest scores were computed as they were potential variables that may increase error variance. Stevens (2009) reported that pretest scores can be assigned as covariates to diminish error variance if they are continuous variables, correlated below .80 with each other, and correlated significantly with the dependent variable, eventhough groups did not differ significantly on pretest scores. Pretest scores were continuous in nature and they were correlated below .80 with each other, whereas they had not significant correlations with most of the other DVs. Therefore, the statistical technique for analyzing posttest scores was justified as MANOVA, that tested whether significant differences exist among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures and their motivation (i.e. the first and second research problems). The qualitative data, furthermore, were assembled to analyze students' conceptions about the concepts of mixtures, profoundly (i.e. the third research problem). Semi-structured interviews were audio-taped, transcribed, and coded in order to be able to gather students' conceptions under general themes (see section 4.4).

3.9. Internal Validity

The greater the internal validity of an experimental study, the greater the control of extraneous variables that might have a potential to threaten the results of the study. In other words, researchers conducting an experimental study desire to investigate only the effect of independent variable(s) on dependent variable(s), which actually indicates strength of the study (Fraenkel & Wallen, 2003). This section presents possible threats to internal validity in an experimental study, subject characteristics, mortality, location, instrumentation, testing, history, maturation, attitude of subjects, regression, implementation, and the ways of minimizing their formation in the present study, respectively.

In general, researchers manipulate independent variable(s) and compare the effect of the manipulated variable across different groups on dependent variable(s) to investigate cause-and-effect relationships in experimental research studies. However, the only way to compare groups on certain variables is to have groups that are similar on the measured variable, before experiment is conducted. If possible, randomization is the best way to equate subjects on certain characteristics. Random assignment of subjects to various treatment groups was not possible in this study due to administrative constraints, whereas intact classes were assigned to the treatment groups randomly. In addition to randomization, using Analysis of Covariance (ANCOVA or MANCOVA) can be a way to eliminate threats due to subject characteristics. The participating students' pretest scores were evaluated whether or not they are appropriate to be covariates, but they did not significantly correlate with the posttest scores. Accordingly, Multivariate Analysis of Variance (MANOVA) was conducted to realize whether there was significant differences among the groups. The results of MANOVA confirmed that the subjects were similar in terms of their pretest scores. Moreover, the students were similar on various demographic characteristics, such as last semester chemistry course grades, gender, age, and education levels of parents. To sum up, the potential effect of the subject characteristics threat was diminished by conducting MANOVA which indicated that students resemble each other in terms of pretest scores, and by collecting data about potential characteristics of subjects that might affect the results of the present study.

Mortality may threaten results of the study if there is loss of subjects during treatment. Fraenkel and Wallen (2003) advised that outcome of the study might be affected by the mortality threat if there is more than 10 percent of drop outs. In this study, only four of the 180 students were absent during either pretests or posttests, who were excluded from the datalist, accordingly. Since the number of students excluded from the study was approximately two percent, the mortality threat was unlikely to affect the results of the study.

Location may threat the results of the study if the conditions students were exposed to were not standard (Fraenkel & Wallen, 2003). However, all of the sampled students were exposed to two-hour chemistry lessons per week and lecture hours were distributed throughly by the administration of the school, where treatments were carried out. To diminish the location threat, furthermore, not only SCLG, but also UCLG and CG students were instructed at the same settings.

Instrumentation may threaten the results of the study in three ways: data collector characteristics, data collector bias, and instrument decay (Fraenkel & Wallen, 2003). In this study, all of the treatments were conducted by the same chemistry teacher, who distributed measurement tools to students at regular lecture hours. Since all of the participating students were exposed to the same teacher, the data collector characteristics were unlikely to result in deviation of the results. Eventhough, all of the procedure and data collection were conducted by the teacher, scoring of the collected data was performed by the researcher. Moreover, the teacher was trained for three months before the study commenced to overcome any conscious or unconscious bias. Regarding the instrument decay, which might occurs if the instrument or the scoring procedures were altered after the study started, all of the data collection procedures and instruments were established before three months of the study commenced. It seems, therefore, that the instrumentation threat did not violate the outcome of the study.

The research design of the study incorporated implementation of pretests (see Section 3.1), that might cause the testing threat (Fraenkel & Wallen, 2003). However, since all of the three groups taken the same pretests, it affects all of them in the same direction, accordingly. In other words, not only SCLG, but also UCLG and CG students were assigned the same pretests. What is more, the students were posttested by the administration of the same tests for seven weeks later, a long period of time for remembering the conceptual questions. To conclude, the testing was not likely to affect the results of the study.

History may violate the results of a study when unplanned events happen while implementing the procedures of the study (Fraenkel & Wallen, 2003), which cannot be a threat for the present study since the researcher followed every lessons and did not observe such an event.

Maturation may intervene with the outcome of the study when subjects of the study become more mature as a result of time passed (Fraenkel & Wallen, 2003). The main purpose of the current study is to investigate grade nine students' understanding and motivation when they have received instruction with different teaching methods. None of the dependent variables were anticipated to change dramatically as a result of getting two months older. Moreover, since the study included three experimental conditions (i.e. SCLG, UCLG, CG) and the subjects were at the same ages (i.e. 14 to 16), any possible maturation threat would affect the students in the same direction.

Students' attitudes can be a threat when the intervention was viewed by students as a novel situation (Fraenkel & Wallen, 2003). Students in the SCLG and UCLG might feel themselves more novel than CG students, or students in the CG might believe in they are less novel as compared to SCLG and UCLG students. The situation known at the same time as the Hawthorne effect was minimized in this study by using already formed groups. In other words, the subjects of the study were not assigned to groups one-by-one, but intact groups were assigned to treatment groups, which lessened novelty of treatment. Moreover, the teacher instructed students by cooperative learning when he was teaching the unit just before the concepts of mixtures (i.e. chemical changes). The aim of the previous cooperative learning practice was twofold: making the teacher to be able to implement cooperative learning and helping students be accustomed to be instructed by cooperative learning. When students view teaching methods except traditional instruction as normal, the novelty of treatment was to be lowered. Finally, all of the students were exposed to the same content as indicated by the objectives of the chemistry program. Therefore, the necessary precautions were tried to be taken to make observations independent.

Regression threat may happen when the extremely high or low performing subjects are selected (Fraenkel & Wallen, 2003). Regression threat was unlikely to occur in this study because there were comparison groups which were determined randomly. As noted previously, the subjects were not assigned to treatment groups randomly, whereas they were not significantly different in terms of their pretest scores.

Implementation threat might affect the results when the person who implement treatment favors one group over the others (Fraenkel & Wallen, 2003). In this study, a teacher implemented all procedures across each treatment group, who was informed on the instruments, instructional materials, and the aim of the study. The teacher was advised not to discriminate groups from each other by emphasizing the importance of CG. Furthermore, the treatment verification was provided by the means of the classroom observation checklist.

3.10. External Validity

External validity of the study is the extent of generalizing results of a particular study to appropriate populations (Fraenkel & Wallen, 2003). The target population of the present study was defined as all grade nine students attending Anatolian high schools in Isparta, that covers 15 schools involving 1500 students. The accessible population, furthermore, was described as all grade nine students attending Anatolian high schools in the center of Isparta, which includes six schools involving 780 students. Among six schools in the accessible population, one of the most crowded school consisting of 180 students constituted the sample of the study. Although there is not an exact answer to what will be the size of sample, the guideline suggested by Fraenkel and Wallen (2003) can be taken into account which states that a minimum of 30 students per treatment group is reasonable for experimental studies. Since 60 students were present per each of the three group and the sampled students forms 12 percent of the target population, the results of this study can readily be generalized to grade nine students enrolling Anatolian high schools in Isparta.

According to Fraenkel and Wallen (2003), researchers should well-define characteristics of subjects and environmental conditions, or the results should be replicated to be able to generalize the results of a specific study in the case of nonrandom selection of sample from population. Although sample size seems appropriate to generalize the results from the sample to the whole population, population generalizibility may be limited due to the nature of the method through which the sample was selected. More specifically, since the sample of the study was selected by convenience sampling method, the researcher should define characteristics of sample and setting, cautiously. Of the sample of 180 students, 98 of them were females and 78 of them were males (i.e. four of the students were excluded from the data set because of their absenteeism). The students were instructed by the same chemistry teacher in an Anatolian high school in Isparta in the spring semester of 2011-2012 over eight weeks in the unit of mixtures. The ages of the participating students ranged from 14 to 16 and the average last semester chemistry course grades of the students were 3.4. Regarding socio-economic status of students, majority of the students' mothers possessed high school degrees, whereas most of their fathers had university degrees. Apart from grade nine students attending Anatolian high schools in Isparta, the results of the present study can be generalized to similar subjects and settings.

3.11. Assumptions and Limitations of the Study

3.11.1. Assumptions of the Study

- The observations were independent.
- The subjects of the study completed all of the assigned instruments sincerely and seriously.
- The conditions were standard while students were filling the instruments out.
- The teacher implemented procedures as intended within three of the treatment groups without introducing conscious or unconscious bias.
- Structuring cooperative learning practices accompanied with conceptual change approach was the unique cause of difference in explaining students' understanding the concepts of mixtures and their motivation.

3.11.2. Limitations of the Study

- The present study was limited to grade nine students attending an Anatolian high school in the center of Isparta.
- The study was limited to the "Mixtures" unit in chemistry.
- The treatment of the study was not piloted before actual implementation.
- Independence of observations assumption of the MANOVA might have been violated since students in the structured cooperative learning groups and unstructured cooperative learning groups worked in groups.
- Although reasonable values of fit statistics were computed by the Confirmatory Factor Analyses, they were not within the acceptable limits.
- Nonrandomization was limited the study, whereas intact groups were randomly assigned to SCLG, UCLG, and CG.
- The treatment was verified solely by the observations of the researcher.

CHAPTER 4

RESULTS AND CONCLUSIONS

This chapter presents descriptive and inferential statistics of pretest and posttest scores of MCT, SELP, TV, CLB, TA, MAP, MAV, PAP, and PAV, analyses of percentages of responses on the post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV, analyses of responses of interview questions, and conclusions, respectively.

4.1. Statistical Analyses of Pretest Scores

In this section, descriptive statistics of pre-MCT, pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, and pre-PAV were introduced, initially. Then, MANOVA results of the specified dependent variables were presented which was conducted before the study started to investigate whether there was a significant mean difference among the SCLG, UCLG, and CG with respect to students' understanding the concepts of mixtures (i.e. pre-MCT) and their motivation (i.e. pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, and pre-PAV), at .05 significance level by using SPSS for Windows.

4.1.1. Descriptive Statistics of Pretest Scores

Although four students were excluded from datalist (two students from each of the SCLG and CG) before statistical analyses were carried out as noted in the section 3.8, three students who were missing while administering pretests only (two students in the SCLG and one student in the UCLG) were not excluded from datalist since they were present while administering posttests. Missing data were replaced with mean scores during statistical analyses as the percentage of missing students was smaller than 5 % of the total number (i.e. 1.7 % of 176 students). Table 4.1 exhibits number of students, mean values, standard deviations, skewness and kurtosis values, and minimum and maximum scores gained on the pre-MCT, pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, and pre-PAV in the SCLG, UCLG, and CG.

Table 4.1 presents that the mean values of the pre-MCT, pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, and pre-PAV scores were close to each other in the SCLG, UCLG, and CG, before the study commenced. In order to check whether pretest scores were normally distributed, the minimum and maximum scores gained on the pretests were compared with the values 3 SD below the mean values and 3 SD above the mean values of pretest scores since 99.7 % of the scores lie within -3 and +3 SD of the mean values (Hinkle, Wiersma, & Jurs, 1988). When the minimum and maximum scores were analyzed, it can be concluded that all of the minimum and maximum values were within the range of -3 and +3 SD, except maximum score of the pre-MCT in the CG and the minimum scores of the pre-TV and pre-CLB in the SCLG and CG, and the pre-MAP in the SCLG (the values beyond the range were displayed as shaded in the Table 4.1). The maximum score of the pre-MCT in the CG was 3.19 SD above the mean, the minimum scores of the pre-TV were 3.22 SD and 3.02 SD below the mean in the SCLG and CG, the minimum scores of the pre-CLB were 3.39 SD and 3.50 SD below the mean in the SCLG and CG, and the minimum score of the pre-MAP was 3.56 SD below the mean in the SCLG. Since the specified values mark slight variations from the range of -3 and +3 SD, they can be interpreted as acceptable. Beyond minimum and maximum scores, skewness and kurtosis values imply whether the distribution of scores are normal and the scores within the range of -2 and +2 is accepted as normal (George & Mallery, 2001). As can be inferred from the Table 4.1, the pretest scores were normally distributed since all of the skewness and kurtosis values of the pre-MCT, pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, and pre-PAV scores in the SCLG, UCLG, and CG were between the range of +2 and -2.

Table 4.1 Descriptive statistics of the pretest scores across groups

	N	Mean	SD	Skewness	Kurtosis	Min	Max
pre-MCT							
SCLG	56	11.32	3.05	-0.35	-0.41	5.00	17.00
UCLG	59	11.36	2.83	-0.13	-0.47	5.00	17.00
CG	58	10.59	2.95	0.62	0.79	4.00	20.00
pre-SELP							
SCLG	56	37.65	9.81	-0.58	0.44	11.00	55.00
UCLG	59	37.15	9.47	-0.13	-0.25	14.00	55.00
CG	58	35.09	10.28	-0.22	-0.78	12.00	51.00
pre-TV							
SCLG	56	28.09	6.85	-0.53	0.98	6.00	42.00
UCLG	59	29.39	7.71	-0.44	-0.37	8.00	42.00
CG	58	28.53	7.13	-0.76	0.79	7.00	41.00
pre-CLB							
SCLG	56	21.05	5.03	-1.07	1.45	4.00	28.00
UCLG	59	20.94	4.56	-0.21	-0.34	9.00	28.00
CG	58	20.97	4.56	-1.09	1.52	5.00	28.00
pre-TA							
SCLG	56	22.61	7.16	-0.18	-1.09	9.00	35.00
UCLG	59	22.97	6.51	-0.57	0.22	5.00	35.00
CG	58	23.67	5.89	0.01	-0.13	10.00	35.00
pre-MAP							
SCLG	56	11.73	2.45	-1.03	1.62	3.00	15.00
UCLG	59	11.93	2.71	-0.83	0.63	4.00	15.00
CG	58	11.91	2.35	-0.57	-0.20	6.00	15.00
pre-MAV							
SCLG	56	9.32	3.28	0.05	-0.91	3.00	15.00
UCLG	59	9.75	3.17	-0.08	-0.50	3.00	15.00
CG	58	9.69	2.88	-0.55	0.50	3.00	15.00
pre-PAP							
SCLG	56	10.54	3.04	-0.49	-0.15	3.00	15.00
UCLG	59	10.37	3.45	-0.37	-0.76	3.00	15.00
CG	58	11.48	2.87	-0.74	0.10	3.00	15.00
pre-PAV							
SCLG	56	17.16	6.35	0.13	-0.85	6.00	30.00
UCLG	59	18.12	4.64	0.07	0.84	6.00	30.00
CG	58	19.34	5.60	-0.03	-1.02	8.00	30.00

4.1.2. Inferential Statistics of Pretest Scores

MANOVA was conducted to investigate the sampled students' understanding the concepts of mixtures and their motivation through collecting data by the means of the MCT, MSLQ, and AGQ, before the study was implemented. The assumptions of MANOVA would be tested prior to introducing results of the preliminary analyses, which are normality, equality of variance, equality of covariance matrices, and independency of observations (Stevens, 2009). Both the univariate and multivariate normality were checked for pretest scores. The univariate normality was identified by computing skewness and kurtosis values of the pre-MCT, pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, and pre-PAV scores in the SCLG, UCLG, and CG. As noted in the section 4.1.1, all of the skewness and kurtosis values of the pretest scores were between the range of +2 and -2 across groups. The multivariate normality was checked by computing the maximum value for mahalanobis distance, which should be lower than the critical value established according to number of dependent variables of studies. Pallant (2001) introduced the critical value for nine dependent variables as 27.88 that is slightly lower than 28.38, the maximum value for mahalanobis distance for pretest scores (p. 221). Although the maximum value for mahalanobis distance was higher than the critical value, univariate normality might be an indicator for the multivariate normality (Stevens, 2009). Accordingly, it can be assumed that the normality assumption of MANOVA was satisfied. Table 4.2 presents the results of the Levene's test for the pre-MCT, pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, and pre-PAV, which should be non-significant to be concluded as the error variances of the specified variables are equal across groups. As shown in the Table 4.2, all of the pretest scores were non-significant except pre-PAV, which was significant at .05 significance level. However, since the pre-PAV scores were distributed normally and the groups were almost equal in size (Stevens, 2009), it can be concluded that the equality of variance assumption of MANOVA was met.

Table 4.2 Levene's test of equality of error variances

	F	df1	df2	Sig.
Pre-MCT	.027	2.000	170.000	.973
Pre-SELP	.518	2.000	170.000	.596
Pre-TV	1.053	2.000	170.000	.351
Pre-CLB	.069	2.000	170.000	.933
Pre-TA	2.180	2.000	170.000	.116
Pre-MAP	1.086	2.000	170.000	.340
Pre-MAV	1.675	2.000	170.000	.190
Pre-PAP	1.149	2.000	170.000	.319
Pre-PAV	6.090	2.000	170.000	.003

Table 4.3 informs about the significance value of Box's M test which should be greater than .001 to be able to satisfy the equality of covariance matrices assumption of MANOVA (Pallant, 2001). Therefore, it can be concluded that covariance matrices of the pretest scores were equal across groups ($F(90, 78894.45) = 1.37$, $p = .01$).

Table 4.3 Box's test of equality of covariance matrices

Box's M	132.91
F	1.37
df1	90
df2	78894.45
Sig.	.01

It was assumed that the observations were independent since any violations of it might limit the results of the study, severely. Since the present study implemented cooperative learning as one of the instructional methods, group means were used as the unit of analyses instead of individual students to cope with the independency of observations assumption of MANOVA, carefully (Stevens, 2009). In addition, the researcher observed all lessons in the groups and tried to be sure that all students answered the assigned tests by themselves. Furthermore, the teacher was warned about independency of observations during lessons and test administrations.

Had been satisfied the assumptions of MANOVA, the results of the analyses of pretest scores can be introduced. Table 4.4 exhibits the overall results of MANOVA for the pre-MCT, pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, and pre-PAV. Based on the results shown in the Table 4.4, it can be concluded that there were not significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures and their motivation, prior to treatment (Wilks' λ = .91, $F(18, 324) = .89$, $p = .60$). According to Cohen's guidelines, the value of partial eta squared fell into small effect size category since Cohen suggested that .01 indicates a small effect size, .06 shows a medium effect size and .14 displays a large effect size (as cited in Pallant, 2001).

Table 4.4 The overall results of MANOVA for pretest scores

	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
GROUP	.91	.89	18.00	324.00	.60	.05	.65

4.2. Statistical Analyses of Posttest Scores

In this section, descriptive statistics of post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV were introduced, first. Then, MANOVA results of the specified dependent variables were presented which was conducted after the study completed to investigate the first and second research problems:

- Is there a statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures (i.e. post-MCT)?
- Is there a statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' motivation (i.e. post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV)?

4.2.1. Descriptive Statistics of Posttest Scores

There were no missing data while posttests were administered. Table 4.5 indicates number of students, mean values, standard deviations, skewness and kurtosis values, and minimum and maximum scores gained on the post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV in the SCLG, UCLG, and CG.

Table 4.5 Descriptive statistics of the posttest scores across groups

	N	Mean	SD	Skewness	Kurtosis	Min	Max
post-MCT							
SCLG	58	21.91	2.44	-0.46	-0.94	17.00	25.00
UCLG	60	14.52	4.56	0.82	-0.05	8.00	25.00
CG	58	15.41	3.92	0.92	0.14	10.00	25.00
post-SELP							
SCLG	58	42.00	7.38	-0.35	0.95	21.00	56.00
UCLG	60	39.25	8.46	-0.73	0.54	15.00	55.00
CG	58	36.79	10.73	-0.15	-0.43	15.00	56.00
post-TV							
SCLG	58	34.81	3.33	0.42	-0.44	29.00	42.00
UCLG	60	24.32	3.45	0.67	0.69	18.00	34.00
CG	58	17.69	2.47	-0.58	0.19	11.00	22.00
post-CLB							
SCLG	58	24.48	2.01	-0.14	-0.26	19.00	28.00
UCLG	60	13.48	2.46	0.19	-1.00	10.00	18.00
CG	58	12.43	2.90	0.11	-0.19	6.00	19.00
post-TA							
SCLG	58	17.28	3.11	0.09	-0.29	11.00	26.00
UCLG	60	29.58	2.79	-0.98	1.16	21.00	34.00
CG	58	29.07	2.16	0.79	0.44	25.00	35.00
post-MAP							
SCLG	58	11.14	1.39	0.11	-0.91	9.00	14.00
UCLG	60	8.77	1.49	-0.32	0.23	5.00	12.00
CG	58	7.90	2.10	-0.31	-0.56	3.00	12.00
post-MAV							
SCLG	58	8.71	1.76	-0.84	0.02	4.00	11.00
UCLG	60	8.65	1.78	-0.45	-0.63	5.00	11.00
CG	58	12.79	1.58	-0.79	0.19	9.00	15.00
post-PAP							
SCLG	58	8.62	1.53	-0.05	-0.15	5.00	12.00
UCLG	60	12.97	1.56	-0.63	-0.69	10.00	15.00
CG	58	9.33	1.90	-0.01	-0.10	5.00	14.00
post-PAV							
SCLG	58	13.76	2.81	0.14	-0.07	8.00	20.00
UCLG	60	19.98	2.55	0.43	0.49	15.00	27.00
CG	58	25.84	2.08	0.02	-0.41	22.00	30.00

As can be inferred from the Table 4.5, there were apparent differences among the mean values of SCLG, UCLG and CG in terms of posttest scores. In particular, patterns of the post-MCT and post-CLB scores were similar in which the mean values in the SCLG (the mean value of the post-MCT was 21.91 with the SD of 2.44, the mean value of the post-CLB was 24.48 with the SD of 2.01) were greater than the mean values in the UCLG (the mean value of the post-MCT was 14.52 with the SD of 4.56, the mean value of the post-CLB was 13.48 with the SD of 2.46) and the mean values in the CG (the mean value of the post-MCT was 15.41 with the SD of 3.92, the mean value of the post-CLB was 12.43 with the SD of 2.90), which were close to each other. On the contrary, the mean value of the post-TA scores in the SCLG (mean: 17.28, SD: 3.11) was lower than the mean values of the post-TA scores in the UCLG (mean: 29.58, SD: 2.79) and the mean value in the CG (mean: 29.07, SD: 2.16), which were close to each other. Patterns of the post-TV and post-MAP scores were similar in which the mean values in the SCLG (the mean value of the post-TV was 34.81 with the SD of 3.33, the mean value of the post-MAP was 11.14 with the SD of 1.39) were greater than the mean values in the UCLG (the mean value of the post-TV was 24.32 with the SD of 3.45, the mean value of the post-MAP was 8.77 with the SD of 1.49), which were greater than the mean values in the CG (the mean value of the post-TV was 17.69 with the SD of 2.47, the mean value of the post-MAP was 7.90 with the SD of 2.10). In fact, the same pattern with those of post-TV and post-MAP took place for the post-SELP scores, whereas the mean values slightly varied in the case of post-SELP, that is, the mean value of the post-SELP was 42.00 with the SD of 7.38 in the SCLG, the mean value of the post-SELP was 39.25 with the SD of 8.46 in the UCLG, and the mean value of the post-SELP was 36.79 with the SD of 10.73 in the CG. In contrast to the cases of post-TV, post-MAP, and post-SELP, the mean value of the post-PAV scores in the SCLG (mean: 13.76, SD: 2.81) was lower as compared to the mean values of the post-PAV scores in the UCLG (mean: 19.98, SD: 2.55), which in turn lower than the mean values of the post-PAV scores in the CG (mean: 25.84, SD: 2.08). The mean value of the post-MAV scores in the SCLG (mean: 8.71, SD: 1.76) were close to the mean value of the post-MAV scores in the UCLG (mean: 8.65, SD: 1.78), both of which were lower than the mean value of the post-MAV scores in the CG (mean: 12.79, SD: 1.58). Finally, the mean value of the post-PAP scores in the SCLG (mean: 8.62, SD: 1.53) were close to the mean value of the post-PAP scores in the CG (mean: 9.33, SD: 1.90), both of which were lower than the mean value of the post-MAV scores in the UCLG (mean: 12.97, SD: 1.56).

In order to check whether posttest scores were normally distributed, the minimum and maximum scores gained on the posttests were compared with the values 3 SD below the mean values and 3 SD above the mean values of pretest scores since 99.7 % of the scores lie within -3 and +3 SD of the mean values (Hinkle et al., 1988). When the minimum and maximum scores were analyzed, it can be concluded that all of the minimum and maximum values were within the range of -3 and +3 SD. Beyond minimum and maximum scores, skewness and kurtosis values imply whether the distribution of scores are normal and the scores within the range of -2 and +2 is accepted as normal (George & Mallery, 2001). As can be inferred from the Table 4.5, the posttest scores were normally distributed since all of the skewness and kurtosis values of the post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV scores in the SCLG, UCLG, and CG were between the range of +2 and -2.

4.2.2. Inferential Statistics of Posttest Scores

The first and second research problems were tested through conducting MANOVA with the following null hypotheses:

- There is no statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures (i.e. post-MCT).
- There is no statistically significant population mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' motivation (i.e. post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, post-PAV).

Before reporting the results of posttest scores drawn upon MANOVA, normality, equality of variance, equality of covariance matrices, and independency of observations would be tested (Stevens, 2009). Univariate and multivariate normality were controlled both of which indicated that the distribution of posttest scores were normal. The former was identified by computing skewness and kurtosis values of the post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV scores in the SCLG, UCLG, and CG. As mentioned in the section 4.2.1, all of the skewness and kurtosis values of the posttest scores were between the range of +2 and -2 across groups. The latter was determined by interpreting mahalanobis distance which is indicated in the Table 4.6. To be able to conclude that there were no multivariate outliers, the maximum value for mahalanobis distance should be lower than the critical value established according to number of dependent variables of studies. The maximum value of mahalanobis distance was 23.56 (shaded in the Table 4.6), which was compared with 27.88, the critical value for nine dependent variables of the current study as presented by Pallant (2001, p. 221). Since the maximum value of mahalanobis distance was lower than the critical value for nine dependent variables, it can be concluded that multivariate normality assumption of MANOVA was satisfied.

Table 4.6 Mahalanobis distance

	Minimum	Maximum	Mean	SD	N
Predicted Value	.66	3.57	2.00	.79	176
Std. Predicted Value	-1.70	1.2	.00	1.00	176
Std. Error of Predicted Value	.03	.08	.05	.01	176
Adjusted Predicted Value	.64	3.60	2.00	.79	176
Residual	-.57	.69	.00	.22	176
Std. Residual	-2.54	3.09	.00	.97	176
Stud. Residual	-2.62	3.23	.00	1.00	176
Deleted Residual	-.60	.75	.00	.23	176
Stud. Deleted Residual	-2.67	3.33	.00	1.01	176
Mahal. Distance	1.77	23.56	8.95	3.41	176
Cook's Distance	.00	.10	.01	.01	176
Centered Leverage Value	.01	.14	.05	.02	176

Table 4.7 presents the results of the Levene's test for the post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV, which should be non-significant to be concluded as the error variances of the specified variables are equal across groups. As shown in the Table 4.7, only the post-MAV, post-PAP and post-PAV scores allow to fail to reject the null hypotheses and meet the equality of variance assumption of MANOVA. The post-MCT, post-SELP, post-TV, post-CLB, post-TA, and post-MAP scores were significant at the .05 significance level and variances of the specified variables were not equal across groups. However, since scores of the mentioned variables were normally distributed, the groups were almost equal in size (Stevens, 2009), and the F values were not so large, the equality of variance assumption of MANOVA can be considered as satisfied (George & Mallery, 2001).

Table 4.7 Levene's test of equality of error variances

	F	df1	df2	Sig.
Post-MCT	7.534	2	173	.001
Post-SELP	4.982	2	173	.008
Post-TV	3.433	2	173	.034
Post-CLB	3.823	2	173	.024
Post-TA	5.494	2	173	.005
Post-MAP	6.397	2	173	.002
Post-MAV	1.134	2	173	.324
Post-PAP	1.199	2	173	.304
Post-PAV	1.910	2	173	.151

Regarding the equality of covariance matrices assumption of MANOVA, the Box's M test should be checked which should be greater than .001 to fail to reject the null hypotheses stating covariance matrices of the dependent variables are equal across groups (Pallant, 2001). As indicated in the Table 4.8, the value was significant at the .05 significance level that might be a sign for unequal covariance matrices across groups ($F(90, 81838,31) = 2.01$, $p = .00$). However, since the groups were almost equal in size, the sample size was large enough, and the significance value was close to the cut-off point suggested by Pallant (2001) (i.e. .001), the equality of covariance matrices assumption of MANOVA can be considered as satisfied.

Table 4.8 Box's test of equality of covariance matrices

Box's M	194.84
F	2.01
df1	90
df2	81838.31
Sig.	.00

It was assumed that the observations were independent since any violations of it might limit the results of the study, severely. Since the present study implemented cooperative learning as one of the instructional methods, group means were used as the unit of analyses instead of individual students to cope with the independency of observations assumption of MANOVA, carefully (Stevens, 2009). In addition, the researcher observed all lessons in the groups and tried to be sure that all students answered the assigned tests by themselves. Furthermore, the teacher was warned about independency of observations during lessons and test administrations.

After revising the assumptions of MANOVA, the results of the analyses of posttest scores can be introduced. Table 4.9 marks the overall results of MANOVA for the post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV. According to the Table 4.9, there were significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures and their motivation (Wilks' $\lambda = .01$, $F(18, 330) = 165.72$, $p = .00$). The partial eta squared value was .90 which represents a very large effect size according to Cohen's guidelines offering small effect size for .01, medium effect size for .06 and large effect size for .14 (as cited in Pallant, 2001). More specifically, 90 % of the total variance of dependent variables could be attributed to the independent variable (i.e. type of instruction). Besides to the effect size, power was computed as 1.00 which could be an evidence to conclude that the probability of making Type II error (i.e. finding significant effect when the effect is actually non-significant) was controlled. To sum up, the difference among the groups had a practical significance which could be attributed to type of instruction that explained 90 % of the total variance of post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV.

Table 4.9 The overall results of MANOVA for posttest scores

	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
GROUP	.01	165.72	18.00	330.00	.00	.90	1.00

Table 4.10 introduces the results of MANOVA across dependent variables to be able to see on which dependent variable groups had significant differences. Based on the significance values presented in the Table 4.10, it can be concluded that there were significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction in terms of their post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV scores. In addition, all of the partial eta squared values, except the one belongs to post-SELP which indicating a small effect size, implied that the difference among the groups had a large practical significance. Power of dependent variables, furthermore, were greater than .80 which can be viewed as the results of the present study were safe enough with regard to the Type II error rate.

Table 4.10 The results of MANOVA across each dependent variable

	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
Post-MCT	67.50	2.00	173.00	.00	.44	1.00
Post-SELP	4.90	2.00	173.00	.01	.05	.80
Post-TV	445.20	2.00	173.00	.00	.84	1.00
Post-CLB	421.29	2.00	173.00	.00	.83	1.00
Post-TA	383.03	2.00	173.00	.00	.82	1.00
Post-MAP	57.37	2.00	173.00	.00	.40	1.00
Post-MAV	112.77	2.00	173.00	.00	.57	1.00
Post-PAP	115.64	2.00	173.00	.00	.57	1.00
Post-PAV	339.02	2.00	173.00	.00	.80	1.00

The differences among the mean values of SCLG, UCLG and CG in terms of posttest scores were reported in the section 4.2.1, this section furthermore explains whether or not the specified differences among the mean values of posttest scores in the SCLG, UCLG and CG were significant. Table 4.11 presents follow up comparisons of posttest scores among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction to be able to understand in which of the groups dependent variables had significant differences. The following paragraphs were intended to make mean differences among treatment groups on each dependent variable apparent by referring the Table 4.11, where mean differences give information about which treatment group has higher mean scores on the interested dependent variable and significance values inform about whether or not those mean differences are significant.

Table 4.11 Pairwise comparisons of posttest scores across groups

	(I) 1: SCLG, 2: UCLG, 3: CG	(J) 1: SCLG, 2: UCLG, 3: CG	Mean Difference (I-J)	Sig.
Post-MCT	1	2	7.40	.00
		3	6.50	.00
	2	1	-7.40	.00
		3	-.90	.59
	3	1	-6.50	.00
		2	.90	.59
Post-SELP	1	2	2.75	.29
		3	5.21	.01
	2	1	-2.75	.29
		3	2.46	.42
	3	1	-5.21	.01
		2	-2.46	.42
Post-TV	1	2	10.49	.00
		3	17.12	.00
	2	1	-10.49	.00
		3	6.63	.00
	3	1	-17.12	.00
		2	-6.63	.00
Post-CLB	1	2	10.10	.00
		3	12.05	.00
	2	1	-10.10	.00
		3	1.05	.07
	3	1	-12.05	.00
		2	-1.05	.07
Post-TA	1	2	-12.31	.00
		3	-11.79	.00
	2	1	12.31	.00
		3	.51	.92
	3	1	11.79	.00
		2	-.51	.92
Post-MAP	1	2	2.37	.00
		3	3.24	.00
	2	1	-2.37	.00
		3	.87	.02
	3	1	-3.24	.00
		2	-.87	.02
Post-MAV	1	2	.06	1.00
		3	-4.09	.00
	2	1	-.06	1.00
		3	-4.14	.00
	3	1	4.09	.00
		2	4.14	.00
Post-PAP	1	2	-4.35	.00
		3	-.71	.07
	2	1	4.35	.00
		3	3.64	.00
	3	1	.71	.07
		2	-3.64	.00
Post-PAV	1	2	-6.22	.00
		3	-12.09	.00
	2	1	6.22	.00
		3	-5.86	.00
	3	1	12.09	.00
		2	5.86	.00

There were significant mean differences between students in the SCLG-UCLG and SCLG-CG with respect to their post-MCT scores, in the favor of students in the SCLG in each case with 7.40 points and 6.50 points mean differences, respectively. Although post-MCT scores of students in the CG were .90 points higher than those of students in the UCLG, the mean difference was not statistically significant. To conclude, students in the SCLG understood the concepts of mixtures better as compared to students in the UCLG and CG.

There was a significant mean difference between students in the SCLG-CG with respect to their post-SELP scores, favoring students in the SCLG with a 5.21 points mean difference. On the contrary, there were not significant mean differences between students in the SCLG-UCLG and UCLG-CG in terms of their post-SELP scores, although post-SELP scores of students in the SCLG were 2.75 points higher than those of students in the UCLG, and post-SELP scores of students in the UCLG were 2.46 points higher than those of students in the CG. To conclude, students in the SCLG had higher self-efficacy for learning and performance as compared to students in the CG.

There were significant mean differences between students in the SCLG-UCLG and SCLG-CG in terms of their post-TV scores, in the favor of students in the SCLG in each case with 10.49 points and 17.12 points mean differences, respectively. Furthermore, there was significant mean difference between students in the UCLG and CG in terms of their post-TV scores, favoring students in the UCLG with a 6.63 point mean difference. To conclude, students in the SCLG had higher task value than students in the UCLG and CG, and students in the UCLG had higher task value than students in the CG.

Similar to the situation in the post-MCT, there were significant mean differences between students in the SCLG-UCLG and SCLG-CG with respect to their post-CLB scores, favoring students in the SCLG in each case with 10.10 points and 12.05 points mean differences, respectively. Eventhough post-CLB scores of students in the UCLG were 1.05 points higher than those of students in the CG, the mean difference was not statistically significant. To conclude, students in the SCLG had higher control of learning beliefs as compared to students in the UCLG and CG.

There were significant mean differences between students in the SCLG-UCLG and SCLG-CG with respect to their post-TA scores, in the favor of students in the UCLG with a 12.31 points mean difference, and in the favor of students in the CG with a 11.79 points mean difference, respectively. Although post-TA scores of students in the UCLG were .51 points higher than those of students in the CG, the mean difference was not statistically significant. To conclude, students in the UCLG and CG had higher test anxiety as compared to students in the SCLG.

Similar to the situation in the post-TV, there were significant mean differences between students in the SCLG-UCLG and SCLG-CG with respect to their post-MAP scores, in the favor of SCLG in each case with 2.37 points and 3.24 points mean differences, respectively. Furthermore, there was significant mean difference between students in the UCLG and CG in terms of their post-MAP scores, favoring students in the UCLG with a .87 point mean difference. To conclude, students in the SCLG oriented mastery approach goals more than students in the UCLG and CG, and students in the UCLG oriented mastery approach goals more than students in the CG.

There were significant mean differences between students in the SCLG-CG and UCLG-CG with respect to their post-MAV scores, favoring students in the CG in each case with 4.09 points and 4.14 points mean differences, respectively. Although post-MAV scores of students in the SCLG were .06 points higher as compared to those of students in the UCLG, the difference was not statistically significant. To conclude, students in the CG adapted mastery avoidance goals more than students in the SCLG and UCLG.

There were significant mean differences between students in the SCLG-UCLG and UCLG-CG with respect to their post-PAP scores, favoring students in the UCLG in each case with 4.35 points and 3.64 points mean differences, respectively. Although post-PAP scores of students in the CG were .71 points higher as compared to those of students in the SCLG, the difference was not statistically significant. To conclude, students in the UCLG adapted performance approach goals more than students in the SCLG and CG.

There were significant mean differences between students in the SCLG-CG and UCLG-CG with respect to their post-PAV scores, in the favor of CG in each case with 12.09 points and 5.86 points mean differences, respectively. Furthermore, there was significant mean difference between students in the SCLG and UCLG in terms of their post-PAV scores, favoring students in the UCLG with a 6.22 point mean difference. To conclude, students in the CG oriented performance avoidance goals more than students in the SCLG and UCLG, and students in the UCLG oriented performance avoidance goals more than students in the SCLG.

4.3. Analyses of Percentages of Responses

In this section, percentages of responses on the selected items of the post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV were presented to analyze students' understanding the concepts of mixtures and to characterize their motivational beliefs and goal orientations.

4.3.1. The Percentages of Responses on the Post-MCT

The above section revealed that there was a significant mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures. This section, furthermore, introduces details of the difference among the SCLG, UCLG, and CG students' understanding the concepts of mixtures by examining the percentages of students' correct responses for each of the 25 item on the post-MCT, as indicated in the Figure 4.1.

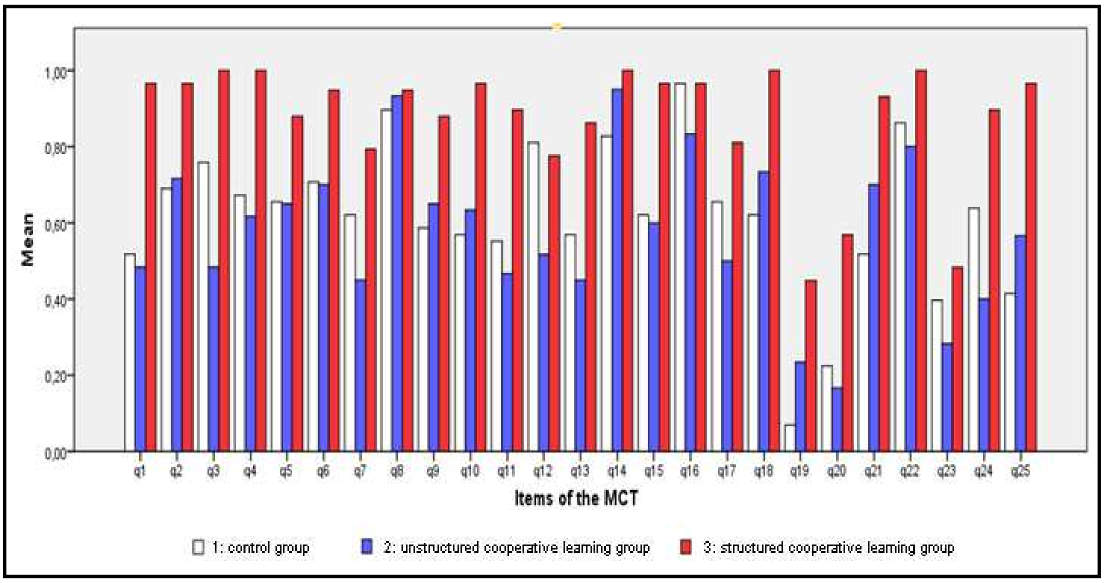
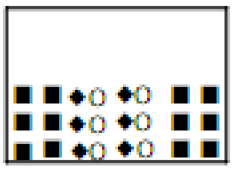


Figure 4.1 Percentages of responses on the post-MCT across groups

As shown in the Figure 4.1, students in the UCLG and CG had lower percentages of correct response as compared to students in the SCLG on the items of the MCT, except the 12th and 16th items. In the item 12, students in the CG had higher percentages of correct response than students in the SCLG and UCLG, and in the item 16, students in the SCLG and CG had same percentages of correct response which was higher than students in the UCLG. Among the items, where students in SCLG, UCLG, and CG had great mean differences, the items 1, 5, 6, 7, 11, 15, 17, 20, 23 and 24 were determined to be discuss in detail. Besides to mean differences among groups, the items were selected purposively in a manner to introduce samples from various contents covered in the MCT, as presented in the Table 3.6.

Item 1 was situated in the MCT to investigate students' conceptions about the nature of mixtures on the basis of a particulate drawing. The percentages of correct responses were higher in the first-tier (100.0 % of students in the SCLG, 71.2 % of students in the UCLG, 80.0 % of students in the CG), as compared to the percentages of correct responses in the second-tier of the item where students were asked the reason of classifying the drawing as a pure substance, a heterogeneous mixture, or a homogeneous mixture in the first-tier. Hence the responses were accepted as correct if both of the two-tiers were answered as correctly, total percentages of correct responses were different generally for the two-tier items. 96.6 %, 48.3 %, and 51.7 % of students in the SCLG, UCLG, and CG answered the item correctly by classifying the physical composition of the drawing as a heterogeneous mixture and stating the reason as different types of molecules are not randomly mixed. Only 1.7 % of students in the UCLG classified the drawing as a pure substance who thought most probably that "mixtures are pure substances" as the reason of viewing the drawing as a pure substance, which is a common alternative conception found by Stains and Talanquer (2007). The percentages of students indicated that the drawing belongs to a homogeneous mixture (27.1 % of students in the UCLG and 20.0 % of students in the CG), on the other hand, were higher than the percentages of students who thought that the drawing represents a pure substance. The possible reason of considering the drawing as a homogeneous mixture might be the alternative conception of "all mixtures are homogeneous", that is consistent with the findings of the study conducted by Coştu et al. (2007). Although most of the students considered that the drawing represents a heterogeneous mixture, a few students in the CG attributed the reason of choice to "all mixtures are heterogeneous in nature". Therefore, it was apparent that students, who determined that the drawing belongs to a heterogeneous mixture, exhibited the reason as different types of molecules are not randomly mixed, which was the correct alternative. Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 1 were presented in the Table 4.12.

Table 4.12 Percentages of alternatives across groups for the item 1

 The physical composition of the above drawing is a (1) Pure substance *(2) Heterogeneous mixture (3) Homogeneous mixture Because	Response Percentage		
	SCLG	UCLG	CG
a. All mixtures are heterogeneous in nature	0	0	5.1
b. Mixtures are pure substances	0	3.3	0
*c. Different types of molecules are not randomly mixed	96.6	76.7	69.0
d. All mixtures are homogeneous	3.4	20.0	25.9

Item 5 assessed students' conceptions about how dissolution process takes place. As presented in the Table 4.13, 87.9 % of students in the SCLG, 65.0 % of students in the UCLG, and 65.5 % of students in the CG answered the question correctly by stating that dissolution is the process of forming homogeneous mixture as a result of vigirous interaction between the particles of solute and solvent.

“A new substance forms as a result of dissolution” was the most common alternative conception hold by students in the UCLG (23.1 %) and CG (23.8 %), which is in consistent with the findings of Ebenezer and Erickson (1996) and Uzuntiryaki and Geban (2005). Eventhough none of the students in the SCLG thought that a new substance forms as a result of dissolution, approximately 12 % of them viewed the dissolution as a process in which “solid disappears in liquids” or “solute is absorbed by solvent”. Similar percentages of students, furthermore, possessed the specified alternative conceptions in the UCLG (about 12 %) and CG (about 11%), which is consistent with alternative conceptions found previously by Prieto et al. (1989), Abraham et al. (1992), and Uzuntiryaki and Geban (2005). Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 5 were presented in the Table 4.13.

Table 4.13 Percentages of alternatives across groups for the item 5

Which of the following is true for the dissolution process?	Response Percentage		
	SCLG	UCLG	CG
a. Solid disappears in liquid during dissolution	6.9	6.8	5.2
b. Solute is absorbed by solvent during dissolution	5.2	5.1	5.5
c. A new substance forms as a result of dissolution	0	23.1	23.8
*d. Homogeneous mixture is formed as a result of vigirous interaction between the particles of solute and solvent	87.9	65.0	65.5

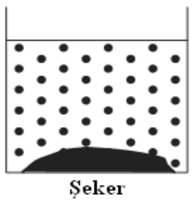
Item 6 was included in the MCT to measure whether students were aware of the difference between concentrated and saturated, and saturated and super saturated solutions. As shown in the Table 4.14, 94.8 %, 70.0 % and 70.7 % of students in the SCLG, UCLG and CG answered the item correctly by expressing that the solubility of sugar-water mixture is lower than 0.18 at 25 ^{o}C. Although majority of students within the SCLG computed the solubility of the given mixture correctly, 5.2 % of students in the SCLG, 20.0 % of students in the UCLG, and 22.4 % of students in the CG stated that the mass of the mixture is 118 gram at 25 ^{o}C. It is obvious from these percentages that students viewed “undissolved solute as a component of solution” since they took undissolved solute into consideration while calculating the mass of the sugar-water solution, that was in accord with the findings of Pınarbaşı and Canpolat (2003). Moreover, 10.0 % of students in the UCLG and 4.9 % of students in the CG were not able to differentiate between saturated and super saturated solution and described super saturated solutions as “the one containing undissolved solute”, as reported by Pınarbaşı and Canpolat (2003). It is worth to mention that solely 2.0 % of students in the CG considered that “concentrated and saturated solutions are the same”, which is a widespread alternative conception reported in the relevant literature (e.g. Çalık (2006)). Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 6 were presented in the Table 4.14.

Table 4.14 Percentages of alternatives across groups for the item 6

18 gram sugar is added to 100 gram water at 25 ^{o}C temperature. After a while, it is observed that certain amount of sugar settled down at the bottom of the beaker. Which of the following is true for the sugar-water mixture?	Response Percentage		
	SCLG	UCLG	CG
a. It is a concentrated solution	0	0	2.0
*b. The solubility of the mixture is lower than 0.18 at 25 ^{o}C	94.8	70.0	70.7
c. The mass of the mixture is 118 gram at 25 ^{o}C	5.2	20.0	22.4
d. It is a super saturated solution since there is undissolved sugar at the bottom	0	10.0	4.9

Students’ conceptions regarding whether or not undissolved sugar is a component of the sugar-water solution were tested by the means of 7th item, one of the two-tier questions included in the MCT. The percentages of correct responses were higher in the first-tier (89.7 % of students in the SCLG, 67.9 % of students in the UCLG, 73.7 % of students in the CG), as compared to the percentages of correct responses in the second-tier of the item where students’ reasoning about whether or not undissolved sugar is a component of the solution was asked. 79.3 %, 45.0 %, and 62.1 % of students in the SCLG, UCLG, and CG answered both tiers correctly by reporting that undissolved sugar is not a component of the sugar-water solution since the solution dissolved maximum amount of substance to be dissolved. However, many students in all groups were confused with undissolved sugar which was viewed as an indicator of super saturated solutions. As indicated in the Table 4.15, only 3.0 % of students in the UCLG attributed the reason of undissolved sugar to lack of stirring process, which was detected by Blanco and Prieto (1997), Valanides (2000a), and Çalık and Ayas (2005b). Fortunately, none of the students hold the idea that “sugar dissolves if the water is hot otherwise, sugar settles down”, an alternative conception reported by Blanco and Prieto (1997). Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 7 were presented in the Table 4.15.

Table 4.15 Percentages of alternatives across groups for the item 7



Sugar settled down at the bottom of the beaker (1) is a component of the solution * (2) is not a component of the solution Because	Response Percentage		
	SCLG	UCLG	CG
a. Super saturated solutions contain precipitate at the bottom	20.6	47.0	34.5
b. Dissolution does not occur unless stirring process is taken place	0	3.0	0
*c. The solution dissolved maximum amount of substance to be dissolved	79.4	50.0	65.5
d. Sugar settled down since water is not hot	0	0	0

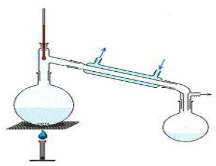
Item 11 was involved in the MCT to examine students’ conceptions about the conservation of mass after dissolution happened. 89.7 % of students in the SCLG, 62.1 % of students in the UCLG, and 72.4 % of students in the CG answered the first-tier of the item correctly by stating that mass of the alcohol-water solution is not less than total masses of alcohol and water. Moreover, as indicated in the Table 4.16, 89.7 %, 56.6 %, and 57.1 % of students in the SCLG, UCLG, and CG attributed the reason of viewing the first-tier as false to the fact that all of the added amount of alcohol is dissolved in water. The alternatives b and c of the 11th item were prepared by taking into account the students who marked the first-tier as true, whereas exclusively the idea of “solute disappears when dissolution takes place” challenged students. 10.3 % of students in the SCLG, 43.4 % of students in the UCLG, and 42.9 % of students in the CG believed that alcohol disappears when dissolution occurs that results in thinking mass of the alcohol-water solution is less than total masses of alcohol and water, that is in harmony with the findings of Abraham et al. (1992). It was clear from the percentages of responses that students have troubles with the law of conservation of mass when they had alternative conceptions related to the dissolution process. Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 11 were presented in the Table 4.16.

Table 4.16 Percentages of alternatives across groups for the item 11

Alcohol is added to water and the beaker is closed by the means of watch glass. As all of the added amount of alcohol is dissolved in water, mass of the alcohol-water solution is less than total masses of alcohol and water. (1) True *(2) False Because	Response Percentage		
	SCLG	UCLG	CG
a. Alcohol gains weight after dissolution	0	0	0
b. Alcohol disappears when dissolution occurs	10.3	43.4	42.9
c. Alcohol has no weight after dissolution	0	0	0
*d. All of the added amount of alcohol is dissolved in water	89.7	56.6	57.1

Apart from dissolution process and types of solutions, item 15 was associated with the separation of mixtures. Students were presented a fractional distillation set up and asked the properties of the mixture that can be separated into components by the means of the specified apparatus. Although students in all of the three groups showed development as compared to percentages of pre-MCT scores, students in the SCLG performed three times better on the post-MCT (96.6 %) than pre-MCT scores (36.2 %) by noting that fractional distillation is used to separate liquid-liquid homogeneous mixtures with respect to boiling point differences. Besides to students in the SCLG, 60.0 % of students in the UCLG and 62.1 % of students in the CG gave correct answer to the 15th item, as introduced in the Table 4.17. Eventhough distillation column contains vapors of both liquids, the vapor at the bottom of the distillation column is rich in higher-boiling component, whereas the vapor at the top of the distillation column is rich in lower-boiling component. 3.4 %, 40.0 %, and 37.9 % of students in the SCLG, UCLG, and CG, however, hold alternative conceptions related to vapors of which component fill distillation column out, that is consistent with the findings of Mukesh (2001). Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 15 were presented in the Table 4.17.

Table 4.17 Percentages of alternatives across groups for the item 15

 Which of the following is true for the mixture that can be separated into components by the means of the above set up?	Response Percentage		
	SCLG	UCLG	CG
*a. It is a liquid-liquid homogeneous mixture that can be separated into its components with respect to boiling point differences	96.6	60.0	62.1
b. The distillation column contains only vapors of lower-boiling component	0	10.1	10.3
c. The vapor at the bottom of the distillation column is rich in the lower-boiling component	0	0	3.4
d. The vapor reaching the top of the distillation column is rich in the higher-boiling component	3.4	29.9	24.2

Item 17 was prepared to assess whether students were able to distinguish between solubility and speed of solubility. 81.0 % of students in the SCLG, 50.0 % of students in the UCLG, and 65.5 % of students in the CG realized that surface area of solute and stirring process do not affect solubility of sugar in water. The students, who comprehend the unique factor affecting solubility of solids in liquids as the temperature, gave correct answer to the 17th item. However, as presented in the Table 4.18, 11.6 % and 19.0 % of students in the UCLG and CG thought that "the amount of dissolved sugar depends on the surface area of sugar", which is a common alternative conception found also by Çalık (2003). Moreover, 13.8 % of students in the SCLG, 31.7 % of students in the UCLG, and 10.3 % of students in the CG believed that "the amount of dissolved sugar increases as sugar-water solution is stirred", detected meanwhile by Blanco and Prieto (1997). In addition, some of the students in all of the three groups suggested that "the amount of dissolved sugar is greater when sugar is crushed since it does not dissolve but melts", which was pre-determined by Çalık (2005). Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 17 were presented in the Table 4.18.

Table 4.18 Percentages of alternatives across groups for the item 17

20 gram sugar is added to each of the three beaker containing 100 ml water at constant temperature. Uncrushed sugar is added to the beaker A, crushed sugar is added to the beakers B and C, and the beaker C is stirred up, additionally. Accordingly, the amount of dissolved sugar in the beakers are *(1) Same (2) Different Because	Response Percentage		
	SCLG	UCLG	CG
a. Surface areas of sugar are different	0	11.6	19.0
*b. Temperature is constant	82.8	55.0	65.5
c. Crushed sugar melts	3.4	1.7	5.2
d. The beaker C is stirred up	13.8	31.7	10.3

Similar to the 5th item, item 20 tested students' conceptions about how dissolution process happens by asking in the first-tier whether or not alcohol-water and paint-thinner mixtures are homogeneous, and by questioning students' reasoning in the second-tier. 56.9 % of students in the SCLG, 16.7 % of students in the UCLG, and 22.4 % of students in the CG answered the item correctly by stating both of the specified mixtures were homogeneous since alcohol dissolves in water and paint dissolves in thinner. Total correct percentages of responses implied that nearly half of the students in the SCLG and solely quarter of the students in the UCLG and CG gave correct answer to the 20th item. As shown in the Table 4.19, the most widespread alternative conception among students (22.4 %, 71.7 %, and 63.8 % of students in the SCLG, UCLG, and CG) was "water is the solvent of all solutions", which might cause handling the paint-thinner mixture as a heterogeneous mixture. The mentioned alternative conception can be described alternatively as "water plays the major role in the dissolution process", which is in accord with the findings of Uzuntiryaki and Geban (2005) and Çalık (2003). Not as much as the alternative conception noted above, but 20.7 % of students in the SCLG, 6.7 % of students in the UCLG, and 12.1 % of students in the CG believed that "physical properties of solute determine whether or not dissolution occurs", as found previously by Abraham et al. (1992), Abraham et al. (1994), Ebenezer and Erickson (1996), Valanides (2000a), and Uzuntiryaki and Geban (2005). Moreover, nearly six students in the UCLG and CG were confused with dissolving and melting, whose current conceptions were inadequate to explain liquid-liquid solutions since liquids do not melt. Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 20 were presented in the Table 4.19.

Table 4.19 Percentages of alternatives across groups for the item 20

The mixtures of alcohol-water and paint-thinner are homogeneous *(1) True (2) False Because	Response Percentage		
	SCLG	UCLG	CG
*a. Alcohol dissolves in water and paint dissolves in thinner	56.9	18.3	22.4
b. Water is the solvent of all solutions	22.4	71.7	63.8
c. Paint cannot be dissolved due to its high density	20.7	6.7	12.1
d. Neither alcohol nor paint melt	0	3.3	1.7

Unlike the item 17 which was related to the factors affecting speed of solubility, item 23 was incorporated into MCT to examine students' conceptions about the effect of temperature on the solubility of solids or liquids. Students were required to predict the phase of the substance X by noting that there is a direct relation between the solubility of the X substance and temperature. After realized that the X substance was either a solid or a liquid, students should have deduced the way of lowering solubility to make the specified substance to crystallize. Only 48.3 %, 28.3 %, and 39.7 % of students in the SCLG, UCLG, and CG answered the item correctly through specifying that the temperature should be lowered to crystallize the saturated solution of X since solubility of solids and liquids decrease as temperature decreases. As presented in the Table 4.20, the most common alternative conception was detected as "solid solute dissolves if the solvent is hot otherwise, solute settles down", which is in harmony with the findings of Blanco and Prieto (1997). Moreover, 1.8 % of students in the CG believed that "the solubility stays constant while temperature of the solution decreases", consistent with the results of Uzuntiryaki and Geban (2005). Furthermore, 1.7 % of students in the UCLG were not able to predict the phase of the X substance as a solid or a liquid but a gas, and declared that "temperature does not affect dissolution of gases in liquids since the ratio is stable for all gases", as the alternative conception detected previously by Çalık et al. (2007). It was obvious that some of the students assimilated new knowledge into their scheme of the expansion coefficient of gases. Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 23 were presented in the Table 4.20.

Table 4.20 Percentages of alternatives across groups for the item 23

There is a direct relation between the solubility of the X substance in water and temperature. To make the saturated solution of the X substance to crystallize, the temperature of the solution should be *(1) Lowered (2) Raised Because	Response Percentage		
	SCLG	UCLG	CG
*a. Solubility of solids and liquids decrease as temperature decreases	65.5	69.0	76.8
b. Solubility stays constant while temperature of the solution decreases	0	0	1.8
c. Water should be hot to make the saturated solution of the X substance to crystallize	34.5	29.3	21.4
d. Temperature does not affect dissolution of gases in liquids since the ratio is stable for all gases	0	1.7	0

Similar to the 15th item, the item 24 was related to separation of mixtures which included a table presenting various physical properties of acetone and water and asked how to get acetone and water separately from the acetone-water mixture. As indicated in the Table 4.21, 89.7 %, 40.0 %, and 63.8 % of students in the SCLG, UCLG, and CG answered the item correctly by stating that acetone and water can be get separately by fractional distillation method based on boiling point differences. Approximately 10 % of all students suggested decantation as the most suitable method to get acetone and water separately from the acetone-water mixture, which could be a sign of the alternative conception of “solutions of liquid dissolved in another liquid can be separated into components by decantation”. Moreover, nearly 8 % of all students proposed that “distillation can be used to get components of liquid-liquid solutions separately” without paying attention to the difference between fractional distillation and distillation. Water could be recycled through distillation of acetone-water mixture, whereas both acetone and water were gained separately if the specified mixture was distilled fractionally. Percentages of responses given to each alternative by students in the SCLG, UCLG, and CG for the item 24 were presented in the Table 4.21.

Table 4.21 Percentages of alternatives across groups for the item 24

Substances	**Density (g/cm^3)**	**Boiling Point (^oC)**	**Freezing Point (^oC)**	**Molecular Weight (g/mol)**	**Polarity**
Acetone	0,79	56	-95,4	58	Polar
Water	1	100	0	18	Polar

The above table presents some of the physical properties of acetone and water. Which of the following method can be used to get acetone and water separately from the acetone-water mixture?	Response Percentage		
	SCLG	UCLG	CG
a. Distillation	1.4	5.0	1.8
*b. Fractional distillation	89.7	40.0	63.8
c. Crystallization	7.4	49.0	32.0
d. Decantation	1.5	6.0	2.4

In contrast to the items noted above, the item 12 was answered correctly more by students in the CG as compared to students did in the SCLG and UCLG. More specifically, 77.6 % of students in the SCLG, 51.7 % of students in the UCLG, and 81.0 % of students in the CG provided correct answer to the item 12 by stating that the substance K can be separated when water is added first and then the mixture is filtered. The item 16, furthermore, was answered correctly by the same percentage of students in the SCLG and CG (i.e. 96.6 % of students in each of the SCLG and CG), which was higher than the percentages of correct responses of students in the UCLG (i.e. 83.3 %). Excluding items 12 and 16, students in the SCLG understood all of the remaining 23 items better than students in the UCLG and CG, as depicted in the Figure 4.1. Correspondingly, it can be concluded that CLCC treatment resulted in significantly better understanding of the concepts of mixtures, as compared to CLCC(-) and TI treatments. In other words, alternative conceptions about the concepts of mixtures were overcome most effectively when the basics of cooperative learning are well-structured, otherwise, cooperative learning based on conceptual change practices could not result in higher mastery and lower alternative conceptions than traditional instruction, even could cause lower understanding and higher alternative conceptions. Although they possessed lower alternative conceptions, students in the SCLG had scientifically incorrect conceptions like students in the UCLG and CG, which can be inferred from the Figure 4.1 (e.g. 8, 12, 14, 16, 19, 20, 22). Therefore, the results of the present study proved that alternative conceptions are resistant to change even after instruction, as suggested by the related literature (Wandersee, Mintzes, & Novak, 1994; Taber, 2001).

The percentages of students' correct responses for each item on the post-MCT are located in the Appendix O.

4.3.2. The Percentages of Responses on the Post-SELP, Post-TV, Post-CLB, Post-TA, Post-MAP, Post-MAV, Post-PAP, and Post-PAV

As presented in the Table 4.5, there were apparent differences among the mean values of SCLG, UCLG and CG in terms of post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV. In the section 4.2.2, furthermore, it was concluded that there was a significant mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' motivation. The purpose of this section was to share percentages of responses across groups to the randomly selected items of the specified sub-scales of MSLQ and AGQ, which gave a chance to characterize motivational beliefs and goal orientations of students in the SCLG, UCLG, and CG.

Students, who scored the items of the SELP with high rates in the seven-point likert type scale, had higher expectancy for success and were more confident in their own skills to accomplish a task. As presented in the Table 4.22, the 12th item (i.e. I am confident I can learn the basic concepts taught in chemistry) was rated by 89.7 %, 68.3 %, and 60.9 % of students in the SCLG, UCLG, and CG as 5, 6, and 7. Eventhough the percentages of responses to the 12th item were as if there were great mean difference between students in the SCLG and UCLG, there was not a significant mean difference between students in the SCLG and UCLG with respect to their post-SELP scores as noted in the section 4.2.2. On the contrary, there was a significant mean difference between students in the SCLG and CG when all of the eight items under the sub-scale of SELP (i.e. 1, 4, 6, 9, 12, 16, 19, 23) were taken into consideration, in the favor of students in the SCLG. Therefore, it can be concluded that students who were instructed by CLCC had higher expectancies for success and were more confident in their own skills to learn concepts of chemistry, as compared to students taught by TI. As indicated in the Table 4.22, the 13th item (i.e. I think the course material in chemistry is useful for me to learn) was rated by 93.1 % of students in the SCLG, 58.3 % of students in the UCLG, and only 1.7 % of students in the CG as 5, 6, and 7. The percentages of responses to the 13th item were in accord with the findings when all of the six items under the sub-scale of TV (i.e. 3, 7, 11, 13, 18, 21) were taken into account, as reported in the section 4.2.2. Specifically, there were significant mean differences among SCLG, UCLG, and CG with regard to post-TV scores, favoring students in the SCLG to UCLG and CG, and favoring students in the UCLG to CG. Correspondingly, it can be concluded that students instructed by CLCC viewed the concepts of chemistry as more useful, important, and valuable than students exposed to CLCC(-) and TI. Moreover, students taught by CLCC(-) viewed the concepts of chemistry as more useful, important, and valuable than students exposed to TI. As shown in the Table 4.22, the 5th item (i.e. if I do not understand the material in chemistry, it is because I did not try hard enough) was rated by 94.9 %, 11.7 %, and 8.6 % of students in the SCLG, UCLG, and CG as 5, 6, and 7. As can be referred from the content of the sampled item, students scored the item higher when they believed that they have control over their own learning that causes students to show more efforts to learn academically. The percentages of responses to the 5th item were in harmony with the findings when all of the four items under the sub-scale of CLB (2, 5, 14, 17) were taken into consideration, as reported in the section 4.2.2. Particularly, there were significant mean differences between students in the SCLG-UCLG and SCLG-CG, in the favor of students in the SCLG in each case. Accordingly, it can be concluded that students exposed to CLCC felt greater control over their own learning and showed greater commitment to learn the concepts of chemistry, as compared to students instructed by CLCC(-) and TI. The final sub-scale of MSLQ within the scope of the present study was TA which was exampled by the 8th item (i.e. when I take a test in chemistry I think about how poorly I am doing compared with other students). As presented in the Table 4.22, the item 8 was rated by 15.5 %, 93.3 %, and 91.4 % of students in the SCLG, UCLG, and CG as 5, 6, and 7. The percentages of responses to the 8th item were consistent with the findings when all of the five items under the sub-scale of TA (8, 10, 15, 20, 22) were taken into account, as reported in the section 4.2.2. More specifically, there were significant mean differences between students in the SCLG-UCLG and SCLG-CG, in the favor of students in the UCLG to SCLG and in the favor of students in the CG to SCLG. In contrast to situations in the specified sub-scales of MSLQ, students in the SCLG had lower scores on post-TA than students in the UCLG and CG. Then, it can be concluded that students instructed by CLCC(-) and TI possessed more negative thoughts while they were taking chemistry tests, as compared to students exposed to CLCC. Percentages of responses across groups to the sampled items of the interested sub-scales of MSLQ were presented in the Table 4.22.

Table 4.22 Percentages of responses across groups to the selected items of MSLQ

Sub-Scales of MSLQ	Item	Groups	1	2	3	4	5	6	7
SELP	12	SCLG	0	0	3.4	6.9	20.7	36.2	32.8
		UCLG	0	1.7	8.3	21.7	21.7	25.0	21.6
		CG	0	6.9	8.6	27.6	36.2	6.9	13.8
TV	13	SCLG	0	0	1.7	5.2	37.9	25.9	29.3
		UCLG	1.7	1.7	13.3	25.0	30.0	25.0	3.3
		CG	12.1	22.4	44.8	19.0	0	1.7	0
CLB	5	SCLG	0	0	1.7	3.4	19.0	39.7	36.2
		UCLG	5.0	23.3	28.3	31.7	10.0	1.7	0
		CG	10.3	12.1	38.0	31.0	5.2	1.7	1.7
TA	8	SCLG	10.3	8.6	32.8	32.8	12.1	1.7	1.7
		UCLG	0	0	1.7	5.0	18.3	35.0	40.0
		CG	0	0	1.7	6.9	34.5	37.9	19.0

Besides the specified sub-scales of MSLQ, all of the four sub-scales of AGQ were exampled with one randomly selected item from each sub-scale to characterize goal orientations of students in the SCLG, UCLG, and CG. Higher scores on items belonging to MAP in the five-point likert type scale means that students focus on meaningful learning of concepts of interest to be satisfied on the basis of intra-personal standards. As shown in the Table 4.23, the 1st item (i.e. it is important for me to understand the content of chemistry as thoroughly as possible) was rated by 93.1 % of students in the SCLG, 11.6 % of students in the UCLG, and 48.2 % of students in the CG as 4 and 5. Cumulation of points of 4 and 5 in AGQ were reported as high ratings to adjust points of 5, 6, and 7 in MSLQ, cumulation of which were noted as high ratings in the above paragraph. Although the percentages of the 1st item indicated a difference between students in the UCLG and CG in the favor of students in the CG, there were significant mean differences between students in the UCLG and CG in the favor of students in the UCLG when all of the three items under the sub-scale of MAP (i.e. 1, 4, 6) were taken into account. Additionally, there were significant mean differences between students in the SCLG-UCLG and SCLG-CG, favoring SCLG in both cases. Correspondingly, it can be concluded that students instructed by CLCC focused more on meaningful learning to understand the concepts of chemistry deeply, as compared to students exposed to CLCC(-) and TI. Moreover, students taught by CLCC(-) focused more on meaningful learning to understand the concepts of chemistry deeply than students instructed by TI. As introduced in the Table 4.23, the 8th item (i.e. I worry that I may not learn all that I possibly could in chemistry) was rated by 44.9 % of students in the SCLG, 35.0 % of students in the UCLG, and 82.8 % of students in the CG as 4 and 5. As can be deduced from the content of the sampled item, students adapting mastery avoidance goals focus on avoiding any misunderstanding of concepts of interest to be satisfied on the basis of intra-personal standards. The percentages of responses to the 8th item were in accord with the findings when all of the three items under the sub-scale of MAV (i.e. 8, 10, 12) were taken into account, as reported in the section 4.2.2. Specifically, there were significant mean differences between students in the SCLG-CG and UCLG-CG, favoring students in the CG in each case. Therefore, it can be concluded that students exposed to TI focused on avoiding any misunderstanding of the concepts of chemistry more than students taught by CLCC and CLCC(-). As indicated in the Table 4.23, 36.2 %, 83.4 %, and 31.0 % of students in the SCLG, UCLG, and CG rated the 11th item (i.e. it is important for me to do better than other students) as 4 and 5. As can be understood from the content, students focusing on trying to be the best performer in comparison to others scored the 11th item with higher points. The percentages of responses to the 11th item were in harmony with the findings when all of the three items under the sub-scale of PAP (i.e. 3, 7, 11) were taken into consideration, as reported in the section 4.2.2. Particularly, there were significant mean differences between students in the SCLG-UCLG and UCLG-CG, favoring UCLG in both cases. Accordingly, it can be concluded that students instructed by CLCC(-) focused more on trying to be the best performer in chemistry lessons in comparison to others, as compared to students taught by CLCC and TI. As shown in the Table 4.23, the 14th item (i.e. my fear of performing poorly in chemistry compared to others is often what motivates me) was rated by 10.3 % of students in the SCLG, 41.7 % of students in the UCLG, and 81.1 % of students in the CG as 4 and 5. As can be deduced from the content of the 14th item, students adapted performance avoidance goals focus on trying not to perform worse than others. The percentages of responses to the 14th item were consistent with the findings when all of the six items under the sub-scale of PAV (i.e. 2, 5, 9, 13, 14, 15) were taken into account, as reported in the section 4.2.2. More specifically, there were significant mean differences among students in the SCLG, UCLG, and CG, in the favor of students in the CG to SCLG and UCLG, and in the favor of students in the UCLG to SCLG. Therefore, it can be concluded that students who instructed by TI focused more on trying not to perform worse in chemistry than others, as compared to students instructed by CLCC and CLCC(-). Moreover, students taught by CLCC(-) focused more on trying not to perform worse in chemistry than others, as compared to students instructed by CLCC. Percentages of responses across groups to the sampled items of the sub-scales of AGQ were presented in the Table 4.23.

Table 4.23 Percentages of responses across groups to the selected items of AGQ

Sub-Scales of AGQ	Item	Groups	1	2	3	4	5
MAP	1	SCLG	0	0	6.9	31.0	62.1
		UCLG	15.0	36.7	36.7	11.6	0
		CG	12.1	12.1	27.6	34.5	13.7
MAV	8	SCLG	6.8	12.1	36.2	39.7	5.2
		UCLG	3.3	20.0	41.7	30.0	5.0
		CG	0	1.7	15.5	36.2	46.6
PAP	11	SCLG	3.4	24.2	36.2	29.3	6.9
		UCLG	0	5.0	11.6	36.7	46.7
		CG	5.2	27.6	36.2	29.3	1.7
PAV	14	SCLG	22.4	29.3	38.0	8.6	1.7
		UCLG	5.0	20.0	33.3	35.0	6.7
		CG	0	3.4	15.5	44.9	36.2

4.4. Analyses of Responses of Interview Questions

In this section, responses given to the interview questions were introduced which were collected to analyze grade nine students' conceptions about the concepts of mixtures, the third research problem of the study. In other words, the purpose of conducting semi-structured interviews was to gain insight into students' conceptions about the concepts of mixtures after they have received instruction with CLCC, CLCC(-), or TI. Students to be interviewed were selected purposively according to scores they have gained in the post-MCT to have a sample that represents low-, medium-, and high-achieving students in the SCLG, UCLG, and CG. 12 students of distinct achievement levels from each of the three treatment group were selected to be interviewed. Besides representativeness, selecting students across groups gave a chance to compare students' reasoning after they have been treated with different teaching methods and to realize whether or not students overcome alternative conceptions they hold at the beginning of the study.

Interview questions were prepared by the researcher through taking into account the most common alternative conceptions about the concepts of mixtures revealed in the post-MCT in order to be able to inspect reasons of low understanding. Eventhough individual students were asked several follow-up questions when necessary, the semi-structured interview schedule included nine main questions (see Appendix G). Before conducting interviews with totally 36 students, the questions were piloted with three students from each of the treatment group to check whether questions were clear for students to understand and to inspect time required for an individual student to be interviewed. The interviews were audio-taped initially to be transcribed and the transcribed student responses were coded into several themes to generalize students' conceptions about the concepts of mixtures. As presented in the Table 4.24, students' responses were gathered under six general themes namely, nature of mixtures, dissolution process, properties of solutions, types of solutions, factors affecting solubility, and separation of mixtures.

Table 4.24 Frequency of students classified according to their understanding level of the concepts of mixtures across groups

	SCLG					UCLG					CG				
	SU	PU	PUAC	AC	NU	SU	PU	PUAC	AC	NU	SU	PU	PUAC	AC	NU
Nature of Mixtures															
• Classification of substance	6	4	2	-	-	2	-	4	5	1	1	5	3	3	-
• Classification of mixtures	5	4	2	1	-	-	2	5	5	-	1	2	4	5	-
Dissolution Process															
• Process of dissolution	5	3	4	-	-	2	3	5	2	-	2	4	4	2	-
Properties of Solutions															
• Boiling point of the solution	5	4	2	1	-	1	2	2	5	2	2	3	3	4	-
• Mass of the solution	4	5	1	1	1	1	3	3	5	-	2	4	3	3	-
Types of Solutions															
• Classification based on amount of dissolved substance	3	3	3	2	1	-	3	5	3	1	1	4	4	3	-
• Classification based on amount of added solute	4	4	3	1	-	2	2	4	4	-	3	4	2	2	1
Factors Affecting Solubility															
• Effect of stirring, Effect of surface area, Effect of temperature, Effect of changing amount of solvent	6	3	-	2	1	3	4	1	4	-	4	2	1	4	1
Separation of Mixtures															
• Evaporation, Filtration, Separating funnel, Distillation	8	1	1	1	1	3	3	1	3	2	4	2	1	3	2

As noted previously, interview questions were prepared to be able to have a close look at students' conceptions about the concepts of mixtures, which were assessed as the most challenging concepts by the post-MCT, through introducing a case related to a sugar-water solution. At first, students were introduced with part of the case which states that "At room temperature, six uncrushed sugar each of which weigh three grams are added to 100 gram water". Students were asked the first three interview questions based on the specified case, that is, the questions related to the nature of mixtures and dissolution process were asked with the mentioned case. To make students to answer the remaining six interview questions, the case was completed by stating that "At room temperature, six uncrushed sugar each of which weigh three grams are added to 100 gram water and stirred until no more sugar dissolves. After a while, three grams of sugar precipitated at the bottom of the beaker". In other words, the last six interview questions which were about properties and types of solutions, factors affecting solubility, and separation of mixtures, were answered on the basis of the given sugar-water solution.

Understanding levels of students were determined on the basis of criteria suggested by Abraham et al. (1992) to score open-ended questions. The responses were categorized under five understanding levels: Sound Understanding (SU) when students gave correct answer with a correct explanation; Partial Understanding (PU) when students gave correct answer with a partially correct explanation or without an explanation or incorrect answer with a correct or partially correct explanation; Partial Understanding with a specified Alternative Conception (PUAC) when students gave correct answer with an explanation involving a specific alternative conception; Alternative Conception (AC) when students gave incorrect answer with an explanation involving a specific alternative conception; and No Understanding (NU) when students gave incorrect answer without an explanation, students did not give answer or students gave irrelevant or confused answer. Students' responses were categorized under the specified understanding levels by the researcher and an expert to check whether decisions given by two scorers were consistent with each other. Comparing decisions of scorers about under which understanding level to categorize responses were consistent with each other. Table 4.25 summarizes criteria for responses to be categorized under the mentioned understanding levels of the concepts of mixtures.

Table 4.25 Criteria used to specify students' understanding levels of the concepts of mixtures

Understanding Level	Criteria for Scoring
Sound Understanding (SU)	Correct answer with a correct explanation
Partial Understanding (PU)	Correct answer with a partially correct explanation Correct answer without giving an explanation Incorrect answer with a correct or partially correct explanation
Partial Understanding with a Specific Alternative Conception (PUAC)	Correct answer with an explanation involving a specific alternative conception
Alternative Conception (AC)	Incorrect answer with an explanation involving a specific alternative conception
No Understanding (NU)	Incorrect answer without giving an explanation No answer Phraphrasing the question without giving an answer Irrelevant or confused answers

4.4.1. Nature of Mixtures

As noted previously, students were introduced with part of a case as “at room temperature, six uncrushed sugar each of which weigh three grams are added to 100 gram water” and they were asked two subsequent questions related to the case: what kind of a substance forms if they think classification of matter and the reason of their answer, and what kind of a mixture forms if they think classification of mixtures and the reason of their answer. Taking responses given to both questions in the nature of mixtures theme into consideration, it can be said that responses of most of the students in the SCLG were categorized under the SU or PU levels, while responses of most of the students in the UCLG and CG were categorized under the PUAC, AC, or NU levels. The following paragraphs explained responses given to each interview question related to the nature of mixtures in detail.

When students were asked what kind of a substance forms as a result of adding sugar into water, six students in the SCLG, two students in the UCLG, and one student in the CG gave correct answer with a correct explanation. Sample student responses specified as SU were as follow: “a mixture forms since the properties of sugar and water do not change”, “a mixture forms since it does not have a chemical formula”, “a mixture forms since there are different kinds of atoms and molecules in it”, and “a mixture forms since sugar and water can be separated without any chemical change”. In contrast to responses of students in the UCLG, responses of four students in the SCLG and five students in the CG were categorized under the PU level. More specifically, some of the students in the SCLG and CG answered the question correctly as “a mixture forms” whereas reasons they thought were partially correct or they did not explain the reason at all, or answered the question incorrectly with a correct or partially correct reasoning. One of the student in the SCLG, for instance, stated that “a mixture forms because mixtures are combination of two substances”. That response was assessed as PU since the explanation of classifying the substance as a mixture was limited, that is, although mixtures can be a combination of two substances they can be made up of more than two substances. Other responses under the PU category were shared by students in both groups, such as “a pure substance forms since it appears as there are only one substance” and “a compound forms since it involves different kinds of molecules”. Responses categorized as PUAC and AC were common in terms of involving a specific alternative conception about classification of matter, whereas the former specified the answers stating “a mixture forms” and the latter specified the answers stating another substances than a mixture. The following statements are examples of responses under the PUAC level (two students in the SCLG, four students in the UCLG, and three students in the CG): “a mixture forms because it is a pure substance”, “a mixture forms since taste changes when sugar is added to water”, and “a mixture forms since it involves two substances that are not pure”. Eventhough none of the students in the SCLG gave incorrect answer with a specific alternative conception, five students in the UCLG and three students in the CG classified the substance as either a compound or a pure substance. When responses of those students were analyzed, it was obvious that they confused mixtures with compounds and pure substances with homogeneous mixtures. Finally, one student in the UCLG stated that “a substance forms when sugar is added to water” and this response was classified as NU since the student phraphrased the question without giving any answer or explanation.

Related to the second interview question, most of the students in the UCLG and CG failed to classify the mixture of sugar and water and to explain the reason of the specified classification, in contrast to students in the SCLG who understood the difference between homogeneous and heterogeneous mixtures rather well. On the contrary to students in the SCLG where five students’ responses were categorized under the SU, none of the students in the UCLG and solely one student’s response in the CG was identified as correct answer and explanation. The student in the CG whose response was assessed as SU stated that “a homogeneous mixture forms since there are as if one substance in it”. Other SU level responses provided by students in the SCLG were as follows: “a homogeneous mixture forms because sugar is dissolved in water” and “a homogeneous mixture forms hence different types of particles are mixed randomly”. Four students in the SCLG, two students in the UCLG, and two students in the CG understood the kind of mixture partially by stating a homogeneous mixture forms without giving any explanation or by stating that “a homogeneous mixture forms since different kinds of molecules are mixed”, “a heterogeneous mixture forms because sugar is a soluble substance”, and “a heterogeneous mixture forms since different kinds of atoms are mixed randomly”. Specifically, the students who were able to classify the mixture as a homogeneous mixture were not aware of the difference between homogeneous and heterogeneous mixtures well because distribution of different kinds of atoms or molecules is a common theme between two types of mixtures but the crucial difference point is random distribution in homogeneous mixtures and patterned distribution in heterogeneous mixtures. Although they were successful in identifying the mixture as a homogeneous mixture, two students in the SCLG, five students in the UCLG, and four students in the CG explained the reason of identifying the mixture as a homogeneous mixture with a specific alternative conception by stating that "all mixtures are homogeneous in nature", "homogeneous mixtures are always in liquid state", and "water makes the mixture to be a homogeneous one". Moreover, one student in the SCLG, and five students in both of the UCLG and CG believed that "a heterogeneous mixture forms since all mixtures are heterogeneous in nature" and "a heterogeneous mixture forms because sugar molecules are mixed randomly in water".

Detected by students' responses categorized under the PUAC and AC levels of the nature of mixtures theme, the results of the present study showed that a few students in the SCLG and many students in both the UCLG and CG hold alternative conceptions about the nature of mixtures even after the instruction was completed, which can be interpreted as an evidence of persistent nature of alternative conceptions as claimed by the relevant literature (Osborne & Cosgrove, 1983). Table 4.26 summarizes alternative conceptions related to the nature of mixtures encountered in the current study, which were in accord with the findings of Sanger (2000), Valanides (2000a), Stains and Talanquer (2007), and Coştu et al. (2007).

Table 4.26 Alternative conceptions about the nature of mixtures

Mixtures are pure substances.
Mixtures involve two substances which are not pure.
Properties of components of a mixture change when they are mixed.
Mixtures and compounds are the same.
Homogeneous mixtures are pure substances.
All mixtures are homogeneous in nature.
Homogeneous mixtures are always in liquid state.
Mixtures containing water are homogeneous mixtures.
All mixtures are heterogeneous in nature.
Particles are mixed randomly in heterogeneous mixtures.

Sample interview excerpts from three students in each of the treatment group were presented below to reveal conceptions of students about the nature of mixtures (students labeled as S7, S10 and S3 represent students in the SCLG, students labeled as S16, S14 and S21 represent students in the UCLG, students labeled as S29, S32 and S35 represent students in the CG):

> Researcher: "At room temperature, six uncrushed sugar each of which weigh three grams are added to 100 gram water". What kind of a substance forms if you think classification of matter?
> S7: A mixture forms.
> S10: A compound forms.
> S3: A mixture forms.
> S16: A pure substance forms.
> S14: A mixture forms.
> S21: A mixture forms.
> S29: A pure substance forms.
> S32: A mixture forms.
> S35: A mixture forms.
> Researcher: What is the reason of your answer?
> S7: Mixtures are made up of different kinds of atoms and molecules.

S10: Compounds involve same kinds of atoms but different kinds of molecules which is same with the case of sugar is added to water.
Researcher: What do you (S10) think mixtures are composed of?
S10: Mixtures are made up of different kinds of atoms. Having different kinds of molecules is a property belongs to compounds only.
S3: Taste of water changes when sugar is added into water.
S16: Sugar and water seem like a unique substance although there were two substances. That is, sugar and water become a pure substance when they are mixed together.
S14: Neither sugar nor water are pure substances.
Researcher: Do mixtures are pure substances?
S14: Of course they are. I remember that we drawed a diagram in the previous years indicating mixtures under the pure substance category.
S21: We cannot represent sugar in water by a chemical formula.
S29: The substance appears as if there were one substance which is an indicator of pure substance.
S32: Mixtures are combination of two substances.
S35: Sugar mixed with water is a pure substance.
Researcher: What kind of a mixture forms if you think classification of mixtures?
S7: A homogeneous mixture forms.
S10: A heterogeneous mixture forms.
S3: Homogeneous mixture.
S16: A homogeneous mixture forms.
S14: Homogeneous mixture forms when sugar is poured into water.
S21: A homogeneous mixture forms.
S29: A heterogeneous mixture forms.
S32: Homogeneous mixture.
S35: Homogeneous mixture.
Researcher: What is the reason of your answer?
S7: The particles of sugar and water are mixed randomly and vigirously.
S10: Atoms of sugar mixed with atoms of water randomly.
S3: Mixtures are labeled as homogeneous when a substance is added to water. I mean water determines whether a mixture is homogeneous or heterogeneous.
S16: All mixtures are homogeneous in nature since homogeneous mixtures are pure substances. If it were heterogeneous, it could not be a pure substance anymore.
S14: Heterogeneous can be in any state but homogeneous mixtures are always in liquid state as sugar is no more solid when added to water.
S21: I am sure it is a homogeneous mixture like salt in water but I do not know the reason.
S29: All mixtures I know are heterogeneous in nature.
S32: I know it is homogeneous but cannot put into words the reason.
S35: Sugar is dissolved in water.

4.4.2. Dissolution Process

The case used to answer the first two interview questions was mentioned again since students were asked what happens when sugar is added to water and how it takes place, in the third question. Although most of the students' responses in the SCLG were categorized in the SU or PUAC levels, responses of students in the UCLG were distributed equally by cumulating more in the PUAC category, and responses of students in the CG were accommodated in the PU or PUAC levels. Specifically, five students in the SCLG and two students in each of the UCLG and CG gave correct answer with a correct explanation. The following statements are examples of responses categorized under SU level: "sugar dissolves in water to form sugar-water solution through vigirous interaction between particles of sugar and water", "sugar dissolves in water to form sugar-water solution which can be separated into sugar and water again without any change", "sugar dissolves in water to generate a homogeneous mixture by distribution of particles randomly", and "sugar dissolves in water to produce sugar-water solution by the actions of sugar as the solute and water as the solvent". Three students in each of the SCLG and UCLG and four students in the CG, on the other hand, were unable to realize what happens when sugar is added into water or to explain the process of dissolution of sugar in water. One of the students in the SCLG, for instance, stated that "sugar melts in water to form a solution". That response was assessed as PU because the student confused between dissolution and melting while he knows sugar and water are mixed to form a solution. "Sugar dissolves in water since a mixture forms when they are mixed together", "sugar dissolves in water since one of the component is water", and "sugar dissolves in water whereas I do not know how it dissolves" are other examples categorized under the PU level. Moreover, four students in each of the SCLG and CG and five students in the UCLG answered the question correctly by stating that "sugar dissolves in water", whereas the students explained the process of dissolution with a specific alternative conception. The following statements are examples of responses under the PUAC level: "sugar dissolves in water to form a new species by combining particles of them chemically", "sugar dissolves in water since mixtures containing water are homogeneous in nature", "sugar is responsible from dissolution no matter what the other substance is", "water is a solution", and "sugar accommodates at air species of water". Contrary to students in the SCLG, two students in each of the UCLG and CG were unable to inspect process of dissolution when sugar is added into water by declaring that "sugar disappears since it is absorbed by water", "sugar melts by turning into liquid sugar", "sugar melts in water since it is not visible anymore as in the case of adding sugar into tea" and "sugar precipitates at the bottom when it is mixed with water since sugar is denser than water and particles cannot meet". Finally, none of the interviewed students' (i.e. 36 students) responses were put into the NU category.

To sum up, some of the students in all of the treatment groups but especially in the UCLG and CG, were confused with dissolution and melting, and physical change and chemical change, that is in harmony with the findings of Prieto et al. (1989), Abraham et al. (1994), Ebenezer and Erickson (1996) and Uzuntiryaki and Geban (2005). Moreover, the source of some of the alternative conceptions related to dissolution process was identified as alternative conceptions related to the nature of mixtures. As summarized in the Table 4.27, many students attributed major roles to water as a solvent or to sugar as a solute, which are common with the findings of Abraham et al. (1994), Valanides (2000a) and Çalık (2003). One of the student in the UCLG viewed water as a solution as found previously by Ebenezer and Erickson (1996), that is another indicator of low understanding of the nature of mixtures.

Table 4.27 Alternative conceptions about the dissolution process

Sugar dissolved in water is a new substance.
Mixtures containing water are homogeneous in nature.
Sugar is responsible from dissolution no matter what the other substance is.
Water is a solution.
Sugar accommodates at air species of water.
Sugar disappears when mixed with water since it is absorbed by water.
Sugar melts and turns into liquid sugar when it is mixed with water.
Sugar melts in water since it is not visible anymore as in the case of adding sugar into tea.
Sugar precipitates at the bottom when it is mixed with water since sugar is denser than water.

Sample interview excerpts from three students in each of the SCLG, UCLG, and CG were presented below where students labeled as S5, S9 and S12 stands for students in the SCLG, students labeled as S17, S20 and S24 stands for students in the UCLG, and students labeled as S28, S34 and S36 stands for students in the CG:

Researcher: What happens when sugar is added to water?
S5: Sugar melts in water to form a solution.
S9: Sugar dissolves in water.
S12: Sugar dissolves in water.
S17: Sugar dissolves in water.
S20: Sugar dissolves in water since water is a solution.

Researcher: Do you (S20) think water is a solution.
S20: Yeah. Have not you heard about it?
Researcher: Then, can you (S20) define solute and solvent in the water solution?
S20: It is easy. Hydrogen is the solvent and oxygen is the solute.
Researcher: Why do you (S20) think so?
S20: Solvent is the substance present in larger amounts and solute is the substance present in smaller amounts, as in the formula of water (H_2O).
S24: Sugar precipitates at the bottom of the beaker.
S28: Sugar dissolves in water to form a new species.
S34: Sugar dissolves in water due to presence of sugar.
S36: Sugar dissolves in water.
Researcher: How the process takes place?
S5: Sugar melts by turning into liquid sugar.
S9: Particles of sugar and water interact vigirously to form sugar-water solution.
S12: Particles of sugar accommodate at air species of water.
S17: Sugar-water solution is formed by combining sugar and water physically.
Researcher: How can you (S17) sure that they combined physically?
S17: Sugar and water turn back to their initial forms without any change in their chemical identity.
S20: Water absorbs sugar which is the reason of disappearance of sugar after dissolution.
S24: When weighs or how can I say...densities of substances are different, the denser one precipitates at the bottom and particles of sugar and water do not meet.
S28: Particles of sugar and water are combined chemically and sugary water emerges as a result of that combination.
Researcher: Do sugar and water turn back to their initial forms?
S28: It is impossible since sugary water is another substance and there are no sugar or water anymore.
S34: Sugar has a capacity to be dissolved in another substance no matter what the other substance is.
S36: Sugar and water form a solution by the actions of sugar as the solute and water as the solvent.

4.4.3. Properties of Solutions

The case used while asking questions related to the nature of mixtures and dissolution process was completed by stating that "at room temperature, six uncrushed sugar each of which weigh three grams are added to 100 gram water and stirred until no more sugar dissolves. After a while, three grams of sugar precipitated at the bottom of the beaker". Students were required to answer the following six interview questions by the reference of the completed case. Students were asked two subsequent questions regarding the properties of solutions: what they expect when the boiling point of the solution is compared with the boiling point of pure water and the reason of their answer, and what is the mass of the solution at room temperature and the reason of their answer. When students' responses were examined through taking both questions into account, most of the students' responses in the SCLG fell into SU or PU levels (i.e. 18 students), whereas most of the students' responses in the UCLG and CG were put into PU, PUAC or AC levels (i.e. 20 students in each group). The following paragraphs explained responses given to each interview question related to the properties of solutions in detail.

When students were asked what they expect when the boiling point of the solution is compared with the boiling point of pure water, five students in the SCLG, one student in the UCLG, and two students in the CG gave correct answer with a correct explanation. The student in the UCLG whose response was categorized under the SU stated that "boiling point of the solution is higher than boiling point of pure water since sugar is an involatile substance". The most common answer assessed as correct answer with a correct explanation was "boiling point of the solution is higher than boiling point of pure water because vapor pressure of the solution is higher than that of pure water". Responses of four students in the SCLG, two students in the UCLG, and three students in the CG were categorized under the PU level. All of the students answered the question correctly by stating that "boiling point of the solution is higher than boiling point of pure water", whereas they were either unable to explain the reason of their answer or able to explain the reason of their answer partially. One of the student in the SCLG, for instance, told that "boiling point of the solution is higher than boiling point of pure water due to vapors of the sugar and water". Eventhough the student provided correct answer to the question with a partially correct explanation, she might had limited understanding about the nature of mixtures since she attributed incorrect roles to sugar and thought the properties of solution by taking properties of components of the solution separately. Although they replied correctly by stating that "boiling point of the solution is higher than boiling point of pure water", two students in each of the SCLG and UCLG and three students in the CG explained the reason of their answer with a specific alternative conception, such as "water boils first and then sugar boils" and "boiling point of sugar is higher than boiling point of water". In contrast to students in the SCLG where only one student's response was evaluated as AC, five students in the UCLG and four students in the CG gave incorrect answer with a specific alternative conception. The following statements are examples situated under the AC level: "boiling points of water and the solution are the same since sugar disappears during dissolution", boiling points of the solution and water cannot be compared unless boiling points of sugar and water are known", "boiling points of the solution and water are the same", and "boiling point of the solution is lower than boiling point of pure water because both boiling and freezing points of solutions are lower than those of pure water". Finally, two students in the UCLG thought that boiling point of water is higher than boiling point of the solution without explaining the reason of their answer, which was assessed as NU since they gave incorrect answer without any explanation.

Related to the second interview question in the properties of solutions theme, students were asked the mass of the solution at room temperature. The students were required to take three grams of undissolved sugar into account and compute the mass of the solution as 115 gram. Four students in the SCLG, one student in the UCLG, and two students in the CG gave correct answer with a correct explanation. The following statements are examples of students' responses categorized under the SU level: "mass of the solution is 115 gram since the solution is composed of 100 gram water and 15 gram sugar", "mass of the solution is 115 gram since undissolved sugar is not included in the sugar-water solution", and "mass of the solution is 115 gram because the solution is saturated with 15 gram sugar at room temperature". Since mass of the solution was 115 gram, responses of students who declared that mass of the solution is less than 118 gram, were evaluated as correct answer and categorized under SU level if explanation of answer was also correct. However, students' responses were put into PU level if they stated that mass of the solution is less than 118 gram with a partially correct explanation, but categorized under PUAC if explanation involved a specific alternative conception. "Mass of the solution is lower than 118 gram since it is not a concentrated solution", for instance, was put into the PU level because the answer was assessed as correct but the reason was irrelevant with that of the answer. The most common response provided by students in all of the SCLG, UCLG, and CG that was categorized under the PU level (i.e. 12 students) was "the mass of the solution is 118 gram since the mass of the solution is calculated by adding mass of the sugar and mass of the water". The reason of accommodating that response under the PU level was it included incorrect answer with a correct explanation. In other words, the mass of the solution is calculated by adding mass of the sugar and mass of the water, whereas those students were not able to comprehend that three grams of undissolved sugar is not a component of solution. Students should take the amount of dissolved sugar instead of amount of added sugar while calculating mass of the solution. Solely one student in the SCLG, three students in each of the UCLG and CG answered the question as mass of the solution is lower than 118 gram with a specific alternative conception. The following statements are examples of responses categorized under the PUAC level, "mass of the solution is lower than 118 gram because sugar loses weight when it is dissolved" and "mass of the solution is lower than 118 gram since sugar disappeared when dissolution takes place". Responses with an incorrect answer and with a specific alternative conception, on the other hand, were categorized under the AC level (one student in the SCLG, five students in the UCLG, and three students in the CG), like "mass of the solution equals to 100 gram since dissolved sugar has no weight" and "mass of the solution is greater than total masses of sugar and water as a result of gaining weight of sugar during dissolution". One student in the SCLG, furthermore, calculated mass of the solution as 118 gram without any explanation so her response was put into the NU level.

To conclude, a few students in the SCLG and many students in the UCLG and CG had alternative conceptions related to the properties of solutions. When students' responses categorized under the PUAC and AC levels in the properties of solutions theme were investigated, it was apperant that students have troubles mostly with the previous concepts. In other words, students' alternative conception cause them to have troubles with the following concepts, as claimed by the relevant literature (Hewson & Hewson, 1983). Specifically, many alternative conceptions summarized in the Table 4.28 were the results of alternative conceptions students had about the nature of matter and nature of mixtures. The following statement can be given as an example of alternative conception caused by the nature of matter: "higher boiling point of sugar than that of water". Moreover, it can be presented as an example related to alternative conception caused by the nature of mixtures: "mass of the solution is lower than total masses of sugar and water since sugar disappeared when dissolution takes place". Another point that should be mentioned was many students tend to take the amount of added sugar into account rather than the amount of dissolved sugar, which can be interpreted as some students were not aware of the components of solutions. In particular, students who stated that mass of the solution is 118 gram, had the common alternative conception of "undissolved solute is a component of solution", as found previously by Pınarbaşı and Canpolat (2003).

Table 4.28 Alternative conceptions about the properties of solutions

Boiling point of the solution is higher than boiling point of water because water boils first and then sugar boils in the sugar-water solution.
Boiling point of the solution is higher than boiling point of water since boiling point of sugar is higher than boiling point of water.
Boiling points of water and the solution are the same since sugar disappears during dissolution.
Boiling points of the solution and water cannot be compared unless boiling points of sugar and water are known.
Boiling points of the solution and water are the same.
Boiling point of the solution is lower than boiling point of pure water because both boiling and freezing points of solutions are lower than those of pure water.
Mass of the solution is lower than total masses of sugar and water because sugar loses weight when it is dissolved.
Mass of the solution is lower than total masses of sugar and water since sugar disappeared when dissolution takes place.
Mass of the solution equals to mass of water since dissolved sugar has no mass.
Mass of the solution is greater than total masses of sugar and water since sugar gains weight during dissolution.

Sample interview excerpts from three students in each of the SCLG, UCLG, and CG were presented below where students labeled as S2, S5 and S11 stands for students in the SCLG, students labeled as S18, S19 and S22 stands for students in the UCLG, and students labeled as S28, S33 and S35 stands for students in the CG:

> Researcher: What do you expect when the boiling point of the solution is compared with the boiling point of pure water?
> S2: The solution's boiling point is higher.
> S5: Boiling point of the solution is higher.
> S11: Boiling point of the solution and water are the same.
> S18: Boiling points cannot be compared.
> S19: Boiling point of the sugar-water solution is higher than that of pure water.
> S22: Water's boiling point is higher than the solution's.
> S28: Boiling point of the solution is lower.
> S33: Boiling point of the sugar-water solution is greater than water.
> S35: Boiling point of the solution is lower, of course.

Researcher: What is the reason of your answer?
S2: Boiling point is related to the equilibrium between internal and external pressure. Since both the solution and water are at the same place, the external pressure is the same. However, internal pressure...I mean vapor pressure of the sugar-water solution is higher than that of pure water.
S5: The solution contains two substances...sugar and water. However, water is one kind of substance. As a result, the solution has vapors of both sugar and water.
S11: Presence of sugar is not an important issue since it disappears while dissolving in water.
S18: Because we do not know boiling points of sugar and water.
S19: Sugar is an involatile substance and boiling point of solutions that involve an involatile substance are higher than that of pure water.
S22: I am certain that water has higher boiling point, it is a rule. I do not know how can I explain it in other words.
S28: Solutions that have lower boiling points boil before. I mean, the solution of sugar-water boils before than water.
S33: It is a natural outcome actually, that is, boiling point of sugar is higher than that of water and boiling point of the solution is higher than that of pure water.
S35: Both the boiling and freezing points of solutions are lower than those of water.
Researcher: What is the mass of the solution at room temperature?
S2: It is 115 gram.
S5: Mass equals 118 gram.
S11: Mass of the solution will be 100 gram.
S18: We cannot be sure about the exact value but it will be higher than 118 gram.
S19: Mass will be 115.
S22: I think, it is lower than 118 gram.
S28: Mass of the solution equals to 115 gram.
S33: It is lower than 118 gram.
S35: It will be lower than 118 gram.
Researcher: What is the reason of your answer?
S2: As the solution is composed of 100 gram water and 15 gram sugar.
S5: There is a formula for calculating mass of a solution, that is, mass of a solution equals to mass of solvent and mass of solute. Since there is 100 gram water as the solvent and 18 gram sugar as the solute, mass of the sugar-water mixture is 118 gram.
S11: 18 grams of sugar is dissolved but since dissolved sugar has no mass, mass of the solution equals to mass of the water, that is, 100 gram.
S18: When masses of sugar and water are added, mass of the solution is 118 gram. However, when added into water, sugar’s weight will increase. Therefore, mass of the solution is higher than 118 gram.
S19: It is not important to add 18 gram sugar inside since the solution becomes saturated with 15 gram of sugar at room temperature.
S22: Although there are 18 grams of sugar, certain amount of it will not be anymore after it dissolved in water. In other words, sugar loses some amounts of mass when dissolved in the solvent, which is water in this case.
S28: 3 grams of undissolved sugar is not included in the sugar-water solution.
S33: Sugar disappeared when dissolution occurs and there are less than 18 grams of sugar in the sugar-water solution.
S35: As the solution is a saturated, I mean, a concentrated one.

4.4.4. Types of Solutions

The case was mentioned before asking questions related to the types of solutions theme to make students to remember the sugar-water solution. Students were asked first to classify the solution according to the amount of dissolved substance and the reason of their answer, and then to classify the solutions (the solution B was prepared by adding eight uncrushed sugar each of which weigh three grams into 100 gram water at room temperature) according to the amount of added solute and the reason of their answer. When students’ responses were analyzed by taking both questions about the types of solutions into account, most of the students’ responses in the SCLG fell into SU, PU or

PUAC levels (i.e. 20 students), whereas most of the students' responses in the UCLG and CG were put into PU, PUAC or AC levels (i.e. 21 students in the UCLG and 19 students in the CG). The following paragraphs explained responses given to each interview question related to the types of solutions in detail.

None of the students in the UCLG, three students in the SCLG and one student in the CG were able to classify the solution according to the amount of dissolved substance with a correct explanation. The student in the CG whose response was categorized under the SU level stated that "it is a saturated solution since 100 gram water dissolves maximum amount of sugar at constant temperature". Similar statements provided by students in the SCLG were as follows: "it is a saturated solution because sugar is a solid and solubility of solids do not change unless temperature changes" and "100 gram water dissolves 15 gram sugar at room temperature which shows the solubility value that can be computed only for saturated solutions". Three students in each of the SCLG and UCLG and four students in the CG, on the other hand, provided correct answer with a partially correct explanation or incorrect answer with a correct or partially correct explanation. The following conceptions were categorized under the PU level: "it is a saturated solution since it involves sugar more than it can dissolve" and "it is a concentrated solution since 100 gram water dissolves maximum amount of sugar". As shown in the examples reported above, some students were not able to distinguish between saturated and supersaturated solutions (as in the first example), and between saturated and concentrated solutions (as in the second example). The most widespread answer among students in the UCLG and CG whose responses were categorized under the PUAC level was "it is a saturated solution containing 18 grams of sugar in it". That response can be thought as an evidence that those students did not realize the components of solutions since they viewed undissolved sugar as a component of solution, which is consistent with the findings of Pınarbaşı and Canpolat (2003). Two students in the SCLG and three students in each of the UCLG and CG, furthermore, gave incorrect answer with an explanation involving a specific alternative conception about the types of solutions. The following statements are examples drawn upon responses put into the AC level: "it is an unsaturated solution since its solubility is lower than 0.18 at room temperature", "it is a super saturated solution because three grams of sugar stays undissolved", "it is a super saturated solution since there is more sugar than water can dissolve", and "it is a heterogeneous mixture due to precipitate at the bottom of the beaker". Finally, responses of one student in each of the SCLG and UCLG fell into the NU level because the student in the SCLG did not give any answer and the student in the UCLG gave an irrelevant answer to the question by stating that "it is a homogeneous mixture since sugar dissolves in water".

Related to the second interview question in the types of solutions theme, students were asked to classify the solutions A and B according to the amount of added solute. The solution A was the solution mentioned in the case which was made up of six uncrushed sugar each of which weigh three grams and 100 gram water at room temperature. The solution B, on the other hand, was composed of eight uncrushed sugar each of which weigh three grams and 100 gram water at room temperature. Four students in the SCLG, two students in the UCLG, and three students in the CG gave correct answer with a correct explanation. The following two statements are examples of students' responses categorized under the SU level: "the solution containing more solute (solution B) is more concentrated than the solution containing less solute (solution A)" and "the solution A is diluted as compared to the solution B". Responses categorized under the PU level were those involving correct answer with a partially correct or incorrect explanation, such as "concentration of solutions are different relative to one another" or "the solution B is a concentrated one since temperature is constant". Other alternative to be categorized under the PU level was including incorrect answer with a correct or partially correct explanation, like "the solution A is a concentrated one because it contains less sugar". Eventhough they know that "the solution A is more diluted than the solution B" or "the solution B is more concentrated than the solution A", three students in the SCLG, four students in the UCLG, and two students in the CG explained the reason of their answer with a specific alternative conception. The following statements can be presented as examples of responses fell into the PUAC level: "the solution A is a diluted one because it cannot dissolve all of the added sugar", "the solution B is a concentrated one since it is more saturated than the solution A, that is, the solution B is a super saturated solution", and "the solution A is a diluted one since three grams of sugar remains undissolved at the bottom of the beaker". It was obvious that those students were confused with the types of solutions classified on the basis of the amount of dissolved solute (i.e. saturated, unsaturated and super saturated solutions) and the types of solutions classified according to the amount of added solute (i.e. diluted and concentrated solutions). Only one student in the SCLG, but four students in the UCLG and two students in the CG gave incorrect answer with an explanation containing a specific alternative conception. The student in the SCLG, for instance, stated that “one cannot classify solutions according to the amount of added sugar unless their solubility at room temperature are known”. Other conceptions categorized under the AC level were as follows: “the solution A is a concentrated one because saturated solutions are concentrated at the same time” and “the solution B is a super saturated solution since it is more concentrated than the solution A which is a saturated solution”. One student in the CG, on the other hand, did not give answer at all and the response was placed under the NU level, accordingly.

When responses categorized under the PUAC and AC levels in the types of solutions theme (nine students in the SCLG, 16 students in the UCLG, and 11 students in the CG) were investigated, it was apperant that students have troubles in classifying solutions according to the amount of dissolved sugar and the amount of added sugar. The most common problems were related to low understanding of the difference between saturated and super saturated solutions, saturated and concentrated solutions, and concentrated and super saturated solutions. Another concept that many students experience difficulty in understanding was the components of solutions. Actually, majority of students were able to identify solute and solvent, whereas they mostly did not explain components of the solution when it involves undissolved solute. In other words, most of the students were not able to identify whether or not undissolved solute is a component of the solution, that is in accord with previous studies in the related literature (e.g. Pınarbaşı & Canpolat, 2003). Table 4.29 summarizes widespread alternative conceptions identified during conducting interviews with students across groups.

Table 4.29 Alternative conceptions about the types of solutions

Undissolved sugar is a component of solution.
Unsaturated solutions contain undissolved solute at the bottom.
Super saturated solutions involve undissolved solute at the bottom.
Undissolved sugar is an evidence for classifying sugar-water as a heterogeneous mixture.
Solutions containing undissolved solute are diluted.
Saturated solution means concentrated solution.
The solution that is more concentrated than a saturated solution is a super saturated solution.

Sample interview excerpts from three students in each of the treatment group were presented below where students labeled as S5, S8 and S11 stands for students in the SCLG, students labeled as S14, S20 and S24 stands for students in the UCLG, and students labeled as S28, S30 and S34 stands for students in the CG:

> Researcher: Can you classify the solution according to the amount of dissolved substance?
> S5: It may be a super saturated solution.
> S8: Saturated one.
> S11: It is a saturated solution.
> S14: Homogeneous mixture.
> S20: It is a saturated solution.
> S24: Heterogeneous one.
> S28: Saturated solution.
> S30: It is a super saturated solution.
> S34: Concentrated solution.
> Researcher: What is the reason of your answer?
> S5: Three grams of sugar remains undissolved at the bottom of the beaker. Undissolved solute is a property of super saturated solutions, I think.

S8: Sugar is a solid and solubility of solids do not change unless temperature changes. 100 gram water dissolved 15 gram sugar which is the maximum amount at room temperature.
S11: Because, the solution involves sugar more than it can dissolve as in the case of saturated solutions.
S14: As you know sugar dissolves in water.
S20: As I see, it contains 18 grams of sugar in it.
Researcher: Do you (S20) think undissolved sugar is a component of the solution?
S20: I think so. All dissolved and undissolved sugar act as the solute of the solution.
S24: I did not see a solution containing undissolved sugar...I mean, it cannot be a solution but a heterogeneous mixture.
S28: 100 gram water dissolves maximum amount of sugar at constant temperature, that is, at room temperature.
S30: There is more sugar than water can dissolve. The solution would be saturated if 15 grams of sugar were added. However, it is super saturated since 18 grams of sugar was added into 100 gram water.
S34: 100 gram water dissolves maximum amount of sugar.
Researcher: Can you classify the solutions including six and eight uncrushed sugar each of which weigh three grams in 100 gram water (the solution A and B, respectively) according to the amount of added solute?
S5: Concentration of solutions are different relative to one another.
S8: The solution A is more diluted than the solution B.
S11: We cannot classify solutions.
S14: Solution A is a concentrated one.
S20: The solution A is a concentrated one.
S24: Solution A is diluted.
S28: The solution B is more concentrated than the solution A.
S30: Solution B is a super saturated solution.
S34: The beaker B contains concentrated solution.
Researcher: What is the reason of your answer?
S5: As I said concentrations of the beakers A and B are different since different amounts of sugar was added in each of the beaker.
S8: The solution A contains six uncrushed sugar in 100 gram water but the solution B contains eight uncrushed sugar in the same amount of water.
S11: As we do not know their solubilities at room temperature.
S14: Saturated solutions are concentrated at the same time.
S20: As it contains less sugar. As I know, solutions that involve less solute are described as concentrated solutions.
S24: Solution A cannot dissolve all of the added sugar so it is a diluted one.
S28: The solution B is more concentrated than the solution A because the solution B involves more solute as compared to the solution A. It is very easy I think.
S30: Since the solution B is more concentrated than the solution A which is a saturated one...I mean... To conclude, since the solution B is more concentrated than a saturated solution, it is labeled as super saturated solution.
S34: Solubility does not change unless temperature is changed.

4.4.5. Factors Affecting Solubility

Students were given four alternatives and asked which factor(s) affects solubility of the sugar-water solution as specified in the case beforehand. The alternatives among which students were required to select the correct answer involve stirring process, surface area of sugar, temperature, and changing amount of water. Responses about the factors affecting solubility theme were categorized under several understanding levels according to the answer students provided. More specifically, students' responses were put into PU, AC, or NU if they selected an alternative different than temperature as the factor affecting solubility of the solution and fell into SU, PU, or PUAC if they stated the temperature as the factor affecting solubility of the sugar-water solution. Assessment about under which level to categorize responses, on the other hand, was done by analyzing explanations about the reason of answers. In particular, responses were categorized under the SU level when students specified temperature as the factor affecting solubility of the solution with a correct explanation. Students' responses were categorized under the PU level when they specified stirring, surface area of sugar or changing amount of water with a correct or partially correct explanation related to the answer, or when they specified temperature with a partially correct explanation. PUAC and AC levels are common in terms of including an explanation with a specific alternative conception, whereas responses were put into the former when students specified temperature as the factor affecting solubility, and responses were put into the latter when students selected other factors than temperature as the factor affecting solubility of the solution. Responses were assessed as NU when students gave irrelevant answer or incorrect answer without any explanation. When students' responses on the question about the factors affecting solubility were compared across groups, it was clear that most of the students' responses in the SCLG fell into the SU or PU levels (i.e. 10 students), whereas most of the students' responses in the UCLG were put into the PU or AC levels (i.e. 8 students), and most of the students' responses in the CG fell into the SU or AC levels (i.e. 8 students). The following paragraphs explained responses given to each alternative related to the factors affecting solubility in detail.

Responses of one student in each of the SCLG and UCLG were categorized under the PU level because they selected the effect of stirring as the factor affecting solubility of the sugar-water solution with a correct explanation regarding stirring. The student in the SCLG, for instance, stated that "stirring affects solubility of sugar because particles gain velocity as the solution is stirred up". Moreover, one student in each of the UCLG and CG selected stirring as the answer with a specific alternative conception. The following statements are responses of those students categorized under the AC level: "certain amount of sugar stays at the bottom without dissolved if we do not stir the solution" and "the sugar precipitated at the bottom would dissolve if one continues to stir the solution".

Responses of one student in each of the SCLG, UCLG, and CG were categorized under the PU level because they selected the effect of surface area of sugar as the factor affecting solubility of the sugar-water solution with a correct explanation regarding surface area. The student in the UCLG, for example, stated that "adding 18 gram crushed sugar instead of six uncrushed sugar increases solubility of the solution since water interact with more area when sugar is in crushed form". Other responses about the effect of surface area were categorized under the AC level which were stated by one student in the SCLG, and two students in each of the UCLG and CG. The following statement is an example of the SCLG student's response under the AC level: "the amount of dissolved sugar increases as surface area is increased by making sugar crushed".

Responses of students, who specified temperature as the factor affecting solubility of the solution, were categorized under each of the understanding level except the AC and NU levels since those categories require incorrect answer. Responses of six students in the SCLG, three students in the UCLG, and four students in the CG included correct answer with a correct explanation. The following statements are examples of responses categorized under the SU level: "temperature is the unique factor affecting solubility of solids", "although stirring and surface area influence speed of solubility, temperature affects solubility of the sugar-water solution", "temperature and pressure are the factors affecting solubility but since sugar is a solid, the effect of pressure is excluded from the scope", "increase in temperature results in increase in kinetic energy of particles and as kinetic energy of particles increases, solubility increases", "factors in a and b alternatives (i.e. stirring and surface area) affect just speed of solubility, the factor in d (i.e. changing amount of water) affects concentration of the solution, but temperature affects solubility", "as temperature increases, solubility of sugar in water increases", and "the motion of particles increases as temperature increases which cause more interaction among particles of sugar and water". Eventhough they specified temperature as the factor affecting solubility, one student in each of the SCLG, UCLG, and CG could not explain the reason of their answer and those responses were accommodated in the PU level. Moreover, one student in each of the UCLG and CG specified temperature with an explanation involving a specific alternative conception. Response of the student in the CG categorized under the PUAC level was "solubility of sugar increases as temperature is increased because solids can dissolve in liquids when the liquid is hot". Another statement fell into the PUAC level was provided by the student in the UCLG was "temperature has the power of increasing solubility of solids, liquids, and gases".

Two students in each of the treatment groups selected changing amount of water as the factor affecting solubility of the solution. Among those six students, one student's response was categorized under the PU level, three students' responses were categorized under the AC level (one student in each of the SCLG, UCLG, and CG), and two students' responses were categorized under the NU level (one student in each of the SCLG and CG). Response of the student in the UCLG assessed as PU level was "the solution becomes unsaturated and diluted when half of the water is evaporated". The reason of placing that answer under the PU level was it involves incorrect answer with a partially correct explanation, which is the criteria for accommodating an answer under the PU level (see Table 4.25). It was obvious from the response that the student had troubles with the distinction between solubility and concentration of solutions. The following statements, furthermore, are examples of responses fell into the AC level: "the amount of dissolved sugar increases when the amount of solvent is decreased" and "evaporating 50 gram of water increases solubility of the solution because there are same amount of sugar in lower amount of water". Finally, two students gave incorrect answer without any explanation and their responses were put into the NU level, such as "all of the four factors you introduced affect solubility".

When responses categorized under the PUAC and AC levels in the factors affecting solubility theme (one student in the SCLG and five students in each of the UCLG and CG) were examined, it can be concluded that majority of the students understood factors affecting solubility well as compared to other concepts related to mixtures. Many students especially in the UCLG, on the other hand, were unable to differentiate factors affecting speed of solubility, solubility, and concentration of solutions. Table 4.30 covers alternative conceptions students hold related to factors affecting solubility, which are in consistent with the findings of Blanco and Prieto (1997), Valanides (2000a), and Çalık (2005).

Table 4.30 Alternative conceptions about the factors affecting solubility

Certain amount of sugar stays at the bottom without dissolved if we do not stir the solution.
Sugar precipitated at the bottom dissolves if one continues to stir the sugar-water solution.
The amount of dissolved sugar increases as surface area is increased by making sugar crushed.
Solubility of sugar increases as temperature is increased because solids can dissolve in liquids when the liquid is hot.
Temperature has the power of increasing solubility of solids, liquids, and gases.
The amount of dissolved sugar increases when the amount of water is decreased because there are same amount of sugar in lower amount of water.

Sample interview excerpts from three students in each of the SCLG, UCLG, and CG were presented below where students labeled as S3, S7 and S12 stands for students in the SCLG, students labeled as S15, S22 and S24 stands for students in the UCLG, and students labeled as S25, S34 and S36 stands for students in the CG:

Researcher: Which of the following(s) affects solubility of the sugar-water solution?
S3: Temperature affects solubility of sugar in water.
S7: Stirring the solution.
S12: Adding crushed sugar affects the solubility.
S15: Adding 18 gram crushed sugar instead of six uncrushed sugar influences the solubility of the solution.
S22: Increasing temperature to 50 ^{o}C.
S24: Adding same amount of crushed sugar instead of uncrushed sugar.
S25: I think, temperature.
S34: Stirring up the solution will increase its solubility.
S36: Temperature increase.
Researcher: What is the reason of your answer?

S3: Because, temperature is the unique factor affecting solubility of solids, like sugar.
S7: Particles gain velocity as the solution is stirred up.
S12: The amount of dissolved sugar increases as surface area is increased by making sugar crushed.
S15: Since water has a chance to interact with more area when sugar is in crushed form.
S22: As temperature is increased, kinetic energy of particles increase and as kinetic energy of particles increase, solubility of the solution increases.
S24: The amount of dissolved sugar and so the solubility of sugar is higher when 18 gram crushed sugar is added instead of uncrushed sugar because crushed form of sugar melts more easily.
S25: Sugar is a solid and solids dissolve when water is hot.
Researcher: What about when water is cooled?
S25: Think the case of tea please. Of course, sugar precipitates if tea is cold.
S34: As mentioned in te case, there is three grams of sugar at the bottom although the solution is stirred. But, I believe that undissolved sugar would also dissolve if one continues to stir the soultion.
S36: Among these alternatives, solely temperature affects solubility of the sugar-water solution. Factors in a and b (i.e. stirring and surface area of sugar) affect speed of the solution and the factor in d (i.e. changing amount of water) affects concentration of the solution.

4.4.6. Separation of Mixtures

Students were given four alternatives and asked which method(s) can be used to separate sugar and water from the solution specified in the case before. The alternatives among which students were required to select the correct answer involve evaporation, filtration, separating funnel, and distillation. Responses about the separation of mixtures theme were categorized under several understanding levels according to the answer students provided. More specifically, students' responses were put into PU, AC, or NU if they selected an alternative different than distillation as the method to separate sugar and water and fell into SU, PU, or PUAC if they stated distillation as the method to separate sugar and water from the solution. Assessment about under which level to categorize responses, on the other hand, was done by analyzing explanations about the reason of answers. In particular, responses were categorized under the SU level when students specified distillation as the method to separate sugar and water with a correct explanation. Students' responses were categorized under the PU level when they specified evaporation, filtration or separating funnel with a correct or partially correct explanation related to the answer, or when they specified distillation with a partially correct explanation. PUAC and AC levels are common in terms of including an explanation with a specific alternative conception, whereas responses were put into the former when students specified distillation as the method to separate sugar and water, and responses were put into the latter when students selected other methods than distillation as the method to separate the components of the solution. Responses were assessed as NU when students gave irrelevant answer or incorrect answer without any explanation. When students' responses on the question about the separation of mixtures were compared across groups, it was clear that most of the students' responses in the SCLG fell into the SU level (i.e. eight students), whereas most of the students' responses in the UCLG and CG distributed nearly equal among various levels of understanding. The following paragraphs explained responses given to each alternative related to the separation of mixtures in detail.

Totally, four students selected evaporation as the method to separate sugar and water from the solution. While two students' responses were categorized under the PU level (one student in each of the SCLG and UCLG), two students' responses were placed under the NU level (one student in each of the UCLG and CG). The student in the SCLG whose response included incorrect answer with a correct explanation related to evaporation, for instance, stated that "sugar and water can be get separately by evaporation since it makes water to escape". The student in the UCLG whose response was categorized under the PU level, on the other hand, declared that "the sugar-water solution can be separated by evaporation as it does not affect sugar but causes water to separate". The following statements, furthermore, were categorized under the NU level: "I do not actually understand the difference between evaporation and distillation" and "are not evaporation and distillation the same methods".

One student in each of the SCLG and UCLG, and two students in the CG selected filtration as the method to separate sugar and water from the solution with an explanation involving a specific alternative conception. The most widespread explanation involving a specific alternative conception about filtration, specified by one student in each of the SCLG, UCLG, and CG, was "filtration is a method to separate solids from liquid solutions". It was obvious from the statement that some students did not take the nature of mixtures into account since filtration is a method to separate solid-liquid heterogeneous mixtures, but not homogeneous mixtures. Another response fell into the AC level provided by a student in the CG was "sugar and water can be separated from each other by filtration in which sugar stays on the filter paper and water goes on to the beaker".

Solely one student in the SCLG, two students in the UCLG and four students in the CG specified separating funnel as a means to separate sugar and water from the solution. Among these seven students, one student's response was put into the PU level (a student in the CG), three students' responses were put into the AC level (one student in the UCLG and two students in the CG), and three students' responses were put into the NU level (one student in each of the SCLG, UCLG, and CG). The student in the CG, whose response was categorized under the PU level, stated that "separating funnel can be used to separate mixtures according to their density differences". The following statements, on the other hand, were responses that fell into the AC level: "separating funnel is a vehicle to separate liquid-liquid mixtures and sugar turned into liquid after dissolved in water" and "sugar stays in separating funnel but water floats since sugar is denser than water". The following statements, furthermore, can be presented as examples of responses fell into the NU level: "separating funnel can be used to separate sugar and water but I do not remember the working principle of separating funnel", "I am sure separating funnel is used to separate sugar from water", and "can separating funnel be?".

Responses of students, who specified distillation as the method to separate sugar and water, were categorized under each of the understanding level except the AC and NU levels since those categories require incorrect answer. Eight students in the SCLG, three students in the UCLG, and four students in the CG gave correct answer by stating that "distillation can be used to separate sugar and water from the solution" with providing following explanations: "sugar is separated by evaporating water and water is get back by condensing vapor of water", "evaporation can be used to get sugar only but distillation is used to get sugar and water separately", and "the mixture under investigation is a solid-liquid homogeneous mixture and distillation is a method to separate components of that type of solutions". None of the students' responses in the SCLG, two students' responses in the UCLG and one student's response in the CG were categorized under the PU level. The student in the CG, for instance, stated that "distillation is used since it is related to boiling point differences". Other responses were provided by students in the UCLG were as follows: "distillation is used to separate sugar and water as their densities are far apart" and "distillation is used but I cannot remember the reason". Finally, one student in each of the treatment group gave correct answer with an explanation involving a specific alternative conception. The statements that put into the PUAC level were as follows: "distillation is used to separate liquid-liquid mixtures as in this case since sugar becomes liquid after dissolved in water", "distillation is used since sugar has higher boiling point than water", and "distillation is used because water boils at 100 ^{o}C and sugar stays in distillation column which involves substance having higher boiling point".

When responses categorized under the PUAC and AC levels in the separation of mixtures theme (two students in the SCLG and four students in each of the UCLG and CG) were examined, it can be concluded that many students had alternative conceptions even after the instruction was completed as reported in the related literature (Osborne & Cosgrove, 1983). Moreover, most of the alternative conceptions about the separation of mixtures were formed as a result of low understanding of the previous concepts of chemistry, especially the nature of matters. Table 4.31 presents alternative conceptions students had related to separation of mixtures.

Table 4.31 Alternative conceptions about the separation of mixtures

Filtration is a method to separate solids from liquid solutions.
Sugar and water can be separated from each other by filtration in which sugar stays on the filter paper and water goes on to the beaker.
Separating funnel is a general means to separate liquid-liquid mixtures.
Sugar stays in separating funnel but water floats since sugar is denser than water.
Distillation is a general method to separate liquid-liquid mixtures.
Sugar stays in the distillation column since it has higher boiling point than water.

Sample interview excerpts from three students in each of the treatment group were presented below where students labeled as S5, S10 and S12 represents students in the SCLG, students labeled as S15, S20 and S23 represents students in the UCLG, and students labeled as S27, S32 and S35 represents students in the CG:

> Researcher: Which method(s) can be used to separate sugar and water from the solution?
> S5: Distillation can be used to separate sugar and water from the solution.
> S10: We can separate sugar and water by filtration.
> S12: Distillation is used.
> S15: Distillation can be used to separate those substances.
> S20: Distillation.
> S23: Evaporation can be used to get sugar and water from the solution.
> S27: Distillation is used.
> S32: Filtration is a good method, I think.
> S35: Distillation can be a good choice.
> Researcher: What is the reason of your answer?
> S5: Sugar is separated by evaporating water and water is get back by condensing vapor of water.
> S10: Since filtration is a method to separate solids from liquids.
> S12: Because water boils at 100 ^{o}C and sugar stays in distillation column as it has higher boiling point than that of water.
> S15: Since sugar has higher boiling point than water.
> S20: Here is the evaporation can be thought as the challenging alternative but evaporation can be used to get sugar only. To get sugar and water separately, then, distillation can be used.
> S23: Evaporation does not affect sugar but causes water to escape. Correspondingly, sugar and water are separated.
> S27: The mixture under investigation is a solid-liquid homogeneous mixture and distillation is a method to separate components of that type of solutions
> S32: As sugar is a solid and water is a liquid, they can be separated from each other by filtration. Filtration is a method established to separate solids.
> Researcher: Then, which substance stays on filter paper?
> S32: Sugar stays on filter paper as it is a solid and water goes on as it is a liquid.
> S35: Distillation is used to separate liquid-liquid mixtures as in this case since sugar becomes liquid after dissolved in water.

Analyses of responses of interview questions revealed that students in the SCLG had fewer alternative conceptions about the concepts of mixtures as compared to students in the UCLG and CG. In other words, alternative conceptions about the concepts of mixture were overcome more effectively when students were instructed by CLCC instead of CLCC(-) and TI. Although much lower than students performed in the UCLG and CG, students in the SCLG had alternative conceptions related to the concepts of mixtures, which can be interpreted as an evidence of persistent nature of alternative conceptions as claimed by the relevant literature (Osborne & Cosgrove, 1983). To sum up, results drawn upon interviews verified results of percentages of students' correct responses on the post-MCT.

4.5. Conclusions

The conclusions of the study are presented below as a summary of the results.

- Analyses of pretest scores revealed that there were not statistically significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures and their motivation (Wilks' $\lambda = .91$, $F(18, 324) = .89$, $p = .60$), with a .05 effect size and .65 observed power.

- Analyses of posttest scores assured that there were statistically significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures and their motivation (Wilks' $\lambda = .01$, $F(18, 330) = 165.72$, $p = .00$), with a .90 effect size and 1.00 observed power.

- There was a statistically significant mean difference among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to their post-MCT scores, favoring students in the SCLG. To conclude, students in the SCLG understood the concepts of mixtures better as compared to students in the UCLG and CG.

- There were statistically significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to their post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV scores.

- Students in the SCLG had higher self-efficacy for learning and performance as compared to students in the CG. Therefore, it can be concluded that students who were instructed by CLCC had higher expectancies for success and were more confident in their own skills to learn concepts of chemistry, as compared to students taught by TI.

- Students in the SCLG had higher task value than students in the UCLG and CG, and students in the UCLG had higher task value than students in the CG. Correspondingly, it can be concluded that students instructed by CLCC viewed the concepts of chemistry as more useful, important, and valuable than students exposed to CLCC(-) and TI. Moreover, students taught by CLCC(-) viewed the concepts of chemistry as more useful, important, and valuable than students exposed to TI.

- Students in the SCLG had higher control of learning beliefs as compared to students in the UCLG and CG. Accordingly, it can be concluded that students exposed to CLCC felt greater control over their own learning and showed greater commitment to learn the concepts of chemistry, as compared to students instructed by CLCC(-) and TI.

- Students in the UCLG and CG had higher test anxiety as compared to students in the SCLG. Therefore, it can be concluded that students instructed by CLCC(-) and TI possessed more negative thoughts while they were taking chemistry tests, as compared to students exposed to CLCC.

- Students in the SCLG oriented mastery approach goals more than students in the UCLG and CG, and students in the UCLG oriented mastery approach goals more than students in the CG. Correspondingly, it can be concluded that students instructed by CLCC focused more on meaningful learning to understand the concepts of chemistry deeply, as compared to students exposed to CLCC(-) and TI. Moreover, students taught by CLCC(-) focused more on meaningful learning to understand the concepts of chemistry deeply than students instructed by TI.

- Students in the CG adopted mastery avoidance goals more than students in the SCLG and UCLG. Therefore, it can be concluded that students exposed to TI focused on avoiding any misunderstanding of the concepts of chemistry more than students taught by CLCC and CLCC(-).

- Students in the UCLG adopted performance approach goals more than students in the SCLG and CG. Accordingly, it can be concluded that students instructed by CLCC(-) focused more on trying to be the best performer in chemistry lessons in comparison to others, as compared to students taught by CLCC and TI.

- Students in the CG oriented performance avoidance goals more than students in the SCLG and UCLG, and students in the UCLG oriented performance avoidance goals more than students in the SCLG. Therefore, it can be concluded that students who instructed by TI focused more on trying not to perform worse in chemistry than others, as compared to students instructed by CLCC and CLCC(-). Moreover, students taught by CLCC(-) focused more on trying not to perform worse in chemistry than others, as compared to students instructed by CLCC.

- Analyses of responses of interview questions revealed that students in the SCLG had fewer alternative conceptions about the concepts of mixtures as compared to students in the UCLG and CG. In other words, alternative conceptions about the concepts of mixtures were overcome most effectively when the basics of cooperative learning are well-structured. Otherwise, cooperative learning based on conceptual change practices could not result in higher mastery and lower alternative conceptions than traditional instruction, even could cause lower understanding and higher alternative conceptions.

- Eventhough much lower than students performed in the UCLG and CG, students in the SCLG hold alternative conceptions related to the concepts of mixtures, which can be interpreted as an evidence of persistent nature of alternative conceptions as claimed by the relevant literature (Osborne & Cosgrove, 1983).

- Results drawn upon interviews verified results of percentages of students' correct responses on the post-MCT.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

This chapter presents discussion of the results, implications of the study, and recommendations for future studies.

5.1. Discussion

The purpose of this study is to investigate the effect of structuring cooperative learning based on conceptual change approach on grade nine students' understanding the concepts of mixtures and their motivation (Self-Efficacy for Learning and Performance, Task Value, Control of Learning Beliefs, Test Anxiety, Mastery Approach Goals, Mastery Avoidance Goals, Performance Approach Goals, Performance Avoidance Goals). Six classes of an Anatolian high school in Isparta participated in the study in the spring semester of 2011-2012 over eight weeks. Two of the participating classes were randomly assigned to SCLG where students were instructed by CLCC, the other two classes were randomly assigned to UCLG where students were instructed by CLCC(-), and the remaining two classes were randomly assigned to CG where students were instructed by TI.

All treatment groups were administered MCT, MSLQ, and AGQ as pretests to determine whether there were significant mean differences among the groups with respect to students' understanding the concepts of mixtures (pre-MCT), and their motivation (pre-SELP, pre-TV, pre-CLB, pre-TA, pre-MAP, pre-MAV, pre-PAP, pre-PAV). Students' pretest scores were analyzed by MANOVA which revealed that there were not statistically significant mean differences among SCLG, UCLG, and CG with respect to students' understanding the concepts of mixtures and their motivation, with a .05 effect size and .65 observed power.

After treatments were completed, MCT, MSLQ, and AGQ were administered to SCLG, UCLG, and CG as posttests to determine whether there were significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures (post-MCT), and their motivation (post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, post-PAV). Students' posttest scores were analyzed by MANOVA which assured that there were statistically significant mean differences among the groups exposed to variations of cooperative learning based on conceptual change and traditional instruction with respect to students' understanding the concepts of mixtures and their motivation, with a .90 effect size and 1.00 observed power. According to Cohen's guidelines, the effect size was such a large value that 90 % of the total variance of post-MCT, post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV could be attributed to the type of instruction (as cited in Pallant, 2001).

Cooperative learning is one of the greatest success of educational history (Slavin, 1996; Johnson & Johnson, 1999) since it has positive effects on multiple outcomes including conceptual understanding, motivation, higher-level reasoning, retention, attitudes, self-esteem, and social skills (Johnson & Johnson, 1979; Madden & Slavin, 1983; Webb, 1997; Johnson, Johnson, & Smith, 1998; Hancock, 2004; Bilgin & Geban, 2006; Acar & Tarhan, 2007). Whereas numerous research studies have documented the benefits of cooperative learning on student outcomes, few studies have improved our understanding of under which conditions cooperative learning results in such diverse outcomes (Cohen, 1994; Slavin, 1996; Ashman & Gillies, 1997; Johnson & Johnson, 1999; Gillies, 2003; 2004). It is a well-known fact that "having a number of people work together does not make them a cooperative group...Groups do not become cooperative groups simply because that is what someone labels them" (Johnson & Johnson, 1999, p. 70-71), it is only when positive interdependence, individual and group accountability, face-to-face promotive interaction, interpersonal and small group skills, and group processing are well-structured. Otherwise, learning groups can be labeled as "traditional learning group" (Johnson & Johnson, 1999), "unstructured cooperative learning group"

(Gillies & Ashman, 1996; 1998; Gillies, 2004), "group work-only group" (Gillies, 2006), "loosely structured cooperative learning group" (Ahmad & Mahmood, 2010), or "informal cooperative group" (Gillies, 2008; Slavin, 2009). Eventhough rare, research studies having been examined the effect of structuring certain elements of cooperative learning consistently concluded that cooperative learning has positive impacts if and only if students interdepend each other positively, are accountable to achieve the mutual goal, interact with each other in a manner to promote each other's learning, operate interpersonal and small group skills, and reflect on the process of learning to increase group members' commitment to reach the mutual goal of the group (Johnson & Johnson, 1989; 1999; 2008; Battistich, Solomon, & Delucchi, 1993; Ashman & Gillies, 1997; Gillies, 2003; 2004; 2008). Johnson and Johnson (1999), for instance, suggested a learning group performance curve which indicates performance of students in cooperative learning groups as higher than performance of students working in traditional learning groups, while performance of students in traditional learning groups as equally well as individuals working alone (see Figure 2.1). According to Gillies (2004), unstructured cooperative learning groups have the same frame with what Johnson and Johnson (1999) labeled as traditional learning groups, and structured cooperative learning groups have the same discourse with that of cooperative learning groups, proposed by Johnson and Johnson (1999). In the present study, analyses of post-MCT results revealed that there was a statistically significant mean difference among the SCLG, UCLG, and CG, favoring students in the SCLG ($SCLG_{mean}$ = 21.91, $UCLG_{mean}$ = 14.52, CG_{mean} = 15.41). Although post-MCT mean scores of students in the CG were higher than those of students in the UCLG, the mean difference was not statistically significant. Moreover, students having different achievement levels according to their post-MCT scores were selected for individual interviews to gain insight into students' conceptions about the concepts of mixtures after they have received instruction with CLCC, CLCC(-), or TI. Results drawn upon students' responses to interview questions verified results of post-MCT, that is, analyses of responses of interview questions revealed that students in the SCLG had fewer alternative conceptions about the concepts of mixtures as compared to students in the UCLG and CG. Although they had higher alternative conceptions than students in the SCLG, students working in groups in the UCLG and students working alone in the CG had nearly equal amounts of alternative conceptions about the concepts of mixtures. These results were consistent with what Johnson and Johnson (1999) suggested in the learning group performance curve as students in the SCLG had the best understanding with the lowest alternative conceptions, whereas students in the UCLG did not differ from students in the CG with regard to their understanding the concepts of mixtures.

Student Teams-Achievement Divisions (STAD), one of the methods of cooperative learning attributing achievement outcomes to group goals or group rewards based on individual learning of every group members (Slavin, 1996), was put into practice while CLCC and CLCC(-) treatments were implemented. The cooperative learning lessons (i.e. CLCC and CLCC(-)) were designed by taking conceptual change conditions into account, a popular approach in explaining how learners change their alternative conceptions with that of scientifically correct ones through introducing disagreement with the intelligible, plausible, and fruitful information (Posner et al., 1982). The teaching activities were prepared primarily to dissatisfy students with their current cognitive structures through incorporating alternative conceptions about the concepts of mixtures, the first and the fundamental condition for conceptual change to occur. A group of students, who were dissatisfied by the questions at the beginning of the teaching activities, required to deepen the state of disequilibrium by challenging each other's viewpoints while they were studying within their teams. The specified alternative conceptions were tested by asking conceptual questions at the end of the activities to provide intelligibility and plausibility, and by asking examples related to daily life to ensure fruitfulness. Apart from questions asked in the teaching activities, the teacher required students to explain learned concepts in their own words, assessed if students understood the concepts and made necassary connections with previous concepts, and tested whether students were able to internalize learned concepts to be used in different contexts to make the scientific concepts intelligible, plausible, and fruitful. In brief, the teacher presented discourse of lessons in the CLCC(-) as in the CLCC, students studied the same teaching activities within groups and they individually took the same quizzes following team study as in the CLCC, and the students' individual improvement scores were determined in the UCLG as in the SCLG. In contrast to CLCC, however, the basics of cooperative learning were not well-structured in the CLCC(-) treatment, which was the unique difference between two types of instruction. Whereas students in both of the SCLG and UCLG were instructed by the same method of cooperative learning (i.e. STAD) and the same procedures for conceptual change to happen were followed, there was statistically significant mean difference between students in the SCLG and UCLG with respect to their post-MCT scores, in the favor of students in the SCLG. Therefore, it can be concluded that cooperative learning strategy promotes conceptual change if and only if learning groups are well-structured as to be truly cooperative learning groups, as suggested by Johnson and Johnson (1999). Johnson and Johnson (1997) proposed several reasons that prevent learning groups to be an effective cooperative learning group (as cited in Johnson & Johnson, 1999). Among those reasons, four of them might be related to the present study, namely uncritically giving one's dominant response, groupthink, lack of sufficient heterogeneity, and lack of teamwork skills. Uncritically giving one's dominant response occurs when members of a group approve the response of students who have certain characteristics influencing other group members (e.g. achievement, leadership properties, physical appearance), instead of trying to reach a consensus among various ideas and disagreements which is the way of promoting conceptual change. It was observed during classroom observations that students in the SCLG proposed various ideas related to solutions of questions in the activity, discussed on disagreements and gave a group decision to complete tasks, and promoted each other's understanding by giving help to members who have not grasped the content well. On the contrary, students in the UCLG did not frequently share information but tried to complete the activity by their own with little commitment to each other's learning, did not challenge each other's thoughts in order not to hurt their friendship, and did not explain content of the activity to groupmates who need help. The main reason of not challenging each other's thoughts might be not structuring positive goal interdependence and other types of positive interdependence in groups in the UCLG since "the greater the positive interdependence within a learning group, the greater the likelihood of intellectual disagreement and conflict among group members" (Johnson & Johnson, 1999, p. 87). The second reason of non-cooperation suggested by Johnson and Johnson (1997) is the groupthink, which is actually a group pressure that cause members to perceive any disagreement or conflict as a threat to group cohesiveness. Viewing any disagreement as a threat to their friendship might cause students in the UCLG to accept beliefs of certain students readily, which formed an obstacle for conceptual change to happen. Another reason of groupthink might be having been assigned permanent leaders within groups who were coordinating and directing other members' point of views. As a result of not structuring positive role interdependence, members other than leaders might feel themselves unnecessary. Further reason of groupthink might be related to lack of sufficient group heterogeneity, which is also the third reason of not being a truly committed cooperative learning group. The composition of groups in the UCLG was homogeneous in nature since students selected generally their close friends to study with and student-made groups do not generally discuss on necessary tasks adequately which causes little benefit from cooperative learning. The final reason of non-cooperation related to the scope of this study is lack of teamwork skills. Johnson and Johnson (1999) supposed that taskwork cannot be attainable unless students are trained on teamwork skills since individuals are not born with qualified skills on how to study as a group. To sum up, students within groups in the UCLG were not able to overcome majority of common alternative conceptions about the concepts of mixtures as well as groups in the SCLG because they were not trained on teamwork skills necessary for effective cooperation, they were not assigned complementary roles, they tried to learn the concepts individually with little commitment to others' learning, and they were not heterogeneous enough to challenge each other's point of views. As a result of not well-structuring basics of cooperative learning, students in the UCLG viewed being in a group as a compulsory activity to be performed and completed tasks individually in groups.

Although the researcher did not encounter an experimental study investigating the effect of structuring all of the basics of cooperative learning on students' understanding and their motivation, the following research studies can be reported as sample to show consistency between the results found in the present study and the results drawn upon studies examplified. Ashman and Gillies (1997), for instance, investigated cooperative behaviors, small group interactions, and achievement of elementary school-age children who were either trained or untrained in cooperative learning skills. The researchers found that students in the trained groups achieved significantly better on the learning outcomes questionnaire, as compared to those in the untrained groups. Apart from better achievement outcomes, results of the study revealed that behaviors of students in the trained groups were more cooperative and helpful, and the language they used were more inclusive. The study concluded that cooperative behaviors of students maintained over time and students become more responsive to each others' learning needs as time passes when they have trained in cooperative learning skills. In their study, Yager et al. (1986, as cited in Johnson & Johnson, 2008) examined the effect of group processing on three measures of achievement namely, daily achievement, post-instructional achievement, and retention by assigning students to groups with group processing, groups without any group processing, and individualistic condition. The results of the study revealed that students in both of the two cooperative groups outperform students who worked alone. Of cooperative groups, furthermore, students within group processing condition performed better on three of the achievement measures as compared to students in without group processing condition.

In addition to the treatments of cooperative learning based on conceptual change, students in two classes of the participating school were exposed to TI which can be summarized as an instruction favoring environments based on rote learning where the teacher explains scientific knowledge through lecturing and asking factual questions mostly to successful students without taking possible alternative conceptions about the concepts of mixtures into account when individual students silently listen and take notes. Students in the CG neither worked on the teaching activities within groups nor took individual quizzes at school, but the activities and quizzes were assigned as homeworks to be completed at home. Post-MCT mean scores of students instructed by CLCC and TI were statistically significant, favoring students in the SCLG. Finding CLCC treatment superior than TI treatment in terms of students' conceptual understanding was in accord with the findings of previous research studies. For example, Bilgin and Geban (2006) examined the effect of cooperative learning on 10^{th} grade students' conceptual understanding and achievement in the concepts of chemical equilibrium. Students in the experimental group were instructed by cooperative learning accompanied with conceptual change conditions, and students in the control group were exposed to traditional instruction. Compared to those taught by traditional instruction, students instructed by cooperative learning accompanied with conceptual change conditions were found to had better understanding and higher achievement in the concepts of chemical equilibrium. In their study, Taştan-Kırık and Boz (2012) analyzed the effectiveness of cooperative learning on 11^{th} grade students' understanding of chemical kinetics and their motivation. While students in the experimental group instructed by cooperative learning based on conceptual change through STAD method of cooperative learning, students in the control group were exposed to traditionally designed chemistry instruction. The results of the study indicated that experimental group students understood the concepts of chemical kinetics better and possessed greater motivation to study chemistry than control group students, when students' science process skill scores were assigned as covariate. According to results drawn upon the present study, eventhough non-significant, post-MCT mean score of students exposed to TI was higher than post-MCT mean score of students instructed by CLCC(-). Actually, it was interesting to find lower post-MCT mean score in the UCLG than that of CG as numerous research studies reported benefits of cooperative learning over traditionally designed instruction. The reason of lower mean score might be explained by taking various intragroup conflicts into consideration. According to Behfar et al. (2010), members of a group may experience logistical conflict when they do not know how to manage and use resources, which diminishes students' performance on task. Logistical conflict might have occured in groups of UCLG since there were not any efforts to structure types of positive interdependence (especially, resource and task interdependence) and students were not trained on management skills before studying in groups. In addition to logistical conflict, groups in the UCLG might be faced with affective conflicts (i.e. contribution and relationship conflict) that might negatively affect psychosocial aspects of teamwork. Performance of groups in the UCLG might be lowered as a result of lessened motivational beliefs, which were proposed by Pintrich et al. (1993) as the mediators of conceptual change. More specifically, members might feel lessened enthusiasm for and commitment to the group goal as a result of members who were not contributing to the group's task, members who dominate other members' thoughts and disagreements, or members who act as detrimental to group cohesion.

Although lower than students exposed to CLCC(-) and TI, students possessed alternative conceptions about the concepts of mixtures even after CLCC treatment, which can be interpreted as an evidence of persistent nature of alternative conceptions as claimed by the relevant literature (Osborne & Cosgrove, 1983). Analyses of post-MCT and students' responses of interview questions categorized under the PUAC and AC levels of all of the six themes of the concepts of mixtures (i.e. nature of mixtures, dissolution process, properties of solutions, types of solutions, factors affecting solubility, and separation of mixtures) revealed that a few students in the SCLG and many students in the UCLG and CG were not aware of the difference between dissolution and melting, physical and chemical change, saturated and super saturated solutions, saturated and concentrated solutions, and super saturated and concentrated solutions. The most common source of alternative conceptions about the concepts of mixtures was found as alternative conceptions related to previous contents of mixtures and chemistry, which can be interpreted as students' prior knowledge may impede their future learning when they were scientifically incorrect (Hewson & Hewson, 1983). The following statements were sample alternative conceptions hold by students about the properties of solutions, both of which were anticipated as a result of low understanding of the nature of matter and nature of mixtures: "boiling point of the sugar-water solution is higher than boiling point of pure water because water boils first and then sugar boils" and "mass of the sugar-water solution is lower than total masses of sugar and water since sugar disappeared when dissolution takes place". Other alternative conceptions about the concepts of mixtures identified frequently while conducting interviews which were in harmony with the findings of previous research studies (Prieto et al., 1989; Abraham et al., 1994; Ebenezer & Erickson, 1996; Blanco & Prieto, 1997; Valanides, 2000a; 2000b; Sanger, 2000; Pınarbaşı & Canpolat, 2003; Çalık, 2003; 2005; Uzuntiryaki & Geban, 2005; Stains & Talanquer, 2007; Coştu et al., 2007) are presented as follows:

- Homogeneous mixtures are pure substances.
- Mixtures and compounds are the same.
- Sugar dissolved in water is a new substance.
- Sugar disappears when mixed with water since it is absorbed by water.
- Sugar melts and turns into liquid sugar when it is mixed with water.
- Sugar precipitates at the bottom when it is mixed with water since sugar is denser than water.
- Boiling points of the sugar-water solution and water are the same.
- Mass of the sugar-water solution equals to mass of water since dissolved sugar has no mass.
- Undissolved sugar is a component of the sugar-water solution.
- Super saturated solutions involve undissolved solute at the bottom.
- Undissolved sugar is an evidence for classifying sugar-water as a heterogeneous mixture.
- Sugar precipitated at the bottom dissolves if one continues to stir the sugar-water solution.
- Solubility of sugar increases as temperature increases because solids can dissolve in liquids when the liquid is hot.
- The amount of dissolved sugar increases when the amount of water is decreased because there are same amount of sugar in lower amount of water.
- Filtration is a method to separate solids from liquid solutions.
- Sugar and water can be separated from each other by filtration in which sugar stays on the filter paper and water goes on to the beaker.

Since researchers have generally omitted the concepts related to the separation of mixtures, alternative conceptions about that concept are rare in the related literature (e.g. Valanides, 2000b; Tüysüz, 2009). As a result of scarce alternative conceptions about the separation of mixtures, the researcher tried to analyze students' responses to the related questions, profoundly. The following alternative conceptions were found in the present study while conducting interviews with individual students, which were related to the concepts of mixtures, especially to the separation of mixtures:

- Mixtures containing water are homogeneous mixtures.
- Particles are mixed randomly in heterogeneous mixtures.
- Unsaturated solutions contain undissolved solute at the bottom.
- Solutions containing undissolved solute are diluted.
- The solution that is more concentrated than a saturated solution is a super saturated solution.
- Separating funnel is a general means to separate liquid-liquid mixtures.

- Sugar stays in separating funnel but water floats since sugar is denser than water.
- Distillation is a general method to separate liquid-liquid mixtures.
- Sugar stays in the distillation column since it has higher boiling point than water.

In addition to their understanding the concepts of mixtures, investigating the effect of CLCC, CLCC(-), and TI on grade nine students' motivational beliefs was within the scope of this study. Pintrich et al. (1993) supposed motivational beliefs as mediators of learning process and critized the conceptual change model proposed by Posner et al. (1982) by asking what about students who have necessary prior knowledge but do not activate that knowledge for learning tasks. Although this is not a correlational study examining correlations between motivational constructs and cognitive strategy use, students having higher scores in adaptive motivational beliefs (e.g. Self-Efficacy for Learning and Performance, Task Value, Control of Learning Beliefs, and Mastery Approach Goals) were expected to understand the concepts of mixtures better, as the relevant literature pointed out that conditions for conceptual change are promoted when deep processing strategies are mediated with adaptive motivational beliefs (Pintrich & De Groot, 1990; Strike & Posner, 1992; Pintrich et al., 1993; Kaplan & Midgley, 1997; Zusho, Pintrich, & Coppola, 2003; Sungur & Şenler, 2009). The linkage between motivational constructs and conceptual change process is supposed to be promoted by the moderating effects of learning contexts. Pintrich et al. (1993) claimed that students adopt mastery goals and have higher levels of self-efficacy when learning contexts promote vigorous interaction between students and the teacher and students take responsibility of their own learning, and when evaluation procedures promote cooperative goal structure rather than competitive and individualistic goal structures. Based on the claims of Pintrich et al. (1993), the treatments of cooperative learning based on conceptual change approach (i.e. CLCC and CLCC(-)) can be assumed to cause adaptive motivational beliefs and better understanding. The following paragraphs report on how motivational constructs are shaped by cooperative learning and traditional instruction settings by discussing on results drawn upon post-SELP, post-TV, post-CLB, post-TA, post-MAP, post-MAV, post-PAP, and post-PAV, respectively.

Pajares and Miller (1994) stated that students with high self-efficacy beliefs have a sense of serenity, in contrast to students with low self-efficacy beliefs who have a sense of worry and anxiety while approaching a task. In the present study, the results of post-SELP scores revealed that students had higher self-efficacy for learning and performance when basics of cooperative learning are well-structured. Although mean post-SELP scores were higher than mean pre-SELP scores in all of the three treatment groups ($SCLG_{gain\ score}$ = 4.35, $UCLG_{gain\ score}$ = 2.10, $CG_{gain\ score}$ = 1.70), the sole significant mean diference was detected between SCLG and CG. In other words, students who were instructed by CLCC had higher expectancies for success and were more confident in their own skills to learn concepts of chemistry, as compared to students taught by TI. As theorized by Bandura (1977), mastery experiences, vicarious experiences, verbal or social persuasions, and physiological states or emotional arousal are the four sources of self-efficacy beliefs. Finding mean post-SELP scores of students instructed by CLCC and CLCC(-) as higher than mean post-SELP scores of students instructed by TI ($SCLG_{mean}$ = 42.00, $UCLG_{mean}$ = 39.25, CG_{mean} = 36.79) is actually an expected result since students in both of the SCLG and UCLG were exposed to cooperative learning applications where they gained vicarious experiences through observing success of similar others (Schunk, 2000), and took appraisal of others by being within a group of similar others (Usher & Pajares, 2006). Finding mean post-SELP scores of students instructed by CLCC as higher than mean post-SELP scores of students instructed by CLCC(-), on the other hand, can be attributed to structuring basics of cooperative learning in the CLCC. Since there is not any study investigating particularly the effect of structuring cooperative learning on students' self-efficacy beliefs, this study contributed to the related literature by finding that students feel greater sense of serenity and confidence in their own skills to do a work when basics of cooperative learning are well-structured. Training students on teamwork skills and structuring positive goal interdependence are at the center of cooperative learning efforts, therefore the main reasons of higher levels of self-efficacy of students instructed by CLCC than those of students taught by CLCC(-) might be attributed to the specified basics. In addition, students might feel themselves important as a result of assigning each member a complementary role, they might perceive being a group as novel since they contributed each other's academic and personal well-being, and they might feel improvement in their higher-order thinking skills as a result of reflecting on group processing.

Students engage in academic tasks more readily when they view that task as the one which addresses their self-worth, interesting to do, useful for achieving immediate or long-term goals, or worth to try (Pintrich et al., 1993; Eccles & Wigfield, 2002), on the basis of norms of society and core psychological needs of individuals (Feather, 1988, as cited in Eccles & Wigfield, 2002). In brief, students perceive tasks as valuable when tasks are important, interesting, useful, or cost-effective for them, that results in higher cognitive engagement in turn (Pintrich & De Groot, 1990; Pintrich et al., 1991). The results of the present study indicated that students in the SCLG had higher task value than students in the UCLG and CG, and students in the UCLG had higher task value than students in the CG. More specifically, students instructed by CLCC viewed the concepts of chemistry as more useful, important, and valuable than students exposed to CLCC(-) and TI. Moreover, students taught by CLCC(-) viewed the concepts of chemistry as more useful, important, and valuable than students exposed to TI. According to the results of this study, it was apparent that studying in a group order and interacting with groupmates result viewing the task more valuable. The statistically significant mean difference between SCLG and UCLG in the favor of SCLG might be explained by positive goal, identity and environmental interdependence. Specifically, students instructed by CLCC might view chemistry concepts more valuable since they promote others' learning to achieve group's goal, since they feel greater group cohesion when they give their group a name, and since they had a chance to interact with their teammates face-to-face.

Students show greatest effort to learn academic tasks conceptually, that is, they become intentional learners, when they feel a sense of internal control over their own learning and when they perceive the outcome of their performance as a result of their own efforts instead of some external factors (Bereiter, 1990; Pintrich et al., 1993; Duncan & McKeachie, 2005). Accordingly, students instructed by CLCC and CLCC(-) can be expected to have higher control of learning beliefs as compared to students exposed to TI, since cooperative learning is one of the student-centered strategies giving responsibility to students on their own learning. However, the results of the current study revealed that students exposed to CLCC felt greater control over their own learning and showed greater commitment to learn the concepts of chemistry, as compared to students instructed by CLCC(-) and TI. Finding statistically significant mean differences between students in the SCLG and CG in terms of their post-CLB scores favoring students in the SCLG was an expected result according to the relevant literature (Bereiter, 1990; Pintrich et al., 1993; Duncan & McKeachie, 2005). Finding a statistically significant mean difference between students in the SCLG and UCLG in terms of their post-CLB scores in the favor of students in the SCLG, on the other hand, can be explained as a result of structuring positive interdependence, promotive interaction, group processing, and training students in the SCLG on small group skills. The primary reason of finding higher post-CLB mean score in the SCLG than those of in the UCLG might be explained by positive reward interdependence and team recognition. By the means of individual improvement score of STAD method of cooperative learning, each individual competed solely with their own past scores and not only high-performing students but also low- and medium-performing students had an equal chance of contributing to team score when they have studied hard enough. In brief, getting common grades based on each individual's improvement score might make students in the SCLG to feel a sense of control over their own learning.

As noted above, students with low self-efficacy beliefs tend to have a sense of worry and anxiety while approaching a task (Pajares & Miller, 1994) since emotionality component of test anxiety is closely related to students' physiological states which is one of the major sources of self-efficacy as suggested by Bandura (1977), therefore students in the SCLG can be anticipated as to have low levels of anxiety while taking chemistry exams. As literature points out, the results of the present study indicated that students in the SCLG had lower test anxiety as compared to students in the UCLG and CG. In other words, students instructed by CLCC(-) and TI possessed more negative thoughts while they were taking chemistry tests, as compared to students exposed to CLCC. In contrast to studies finding test anxiety as an obstacle to performance and self-efficacy, Sungur (2004) concluded that although non-significant, students who were instructed by problem based learning had higher level of test anxiety, as compared to students taught with traditionally designed biology instruction. Similar to Sungur (2004), Taştan (2009) concluded that students in the cooperative learning group had higher levels of test anxiety than that of control group students who were instructed by traditional instruction, though it was not statistically significant. Finally, it is worth to mention that the greatest mean difference between post-TA and pre-TA scores belonged to students in the UCLG ($SCLG_{gain\ score}$ = -5.83, $UCLG_{gain\ score}$ = 6.61, $CG_{gain\ score}$ = 5.40), which can be interpreted as cooperative learning contexts might cause students to feel greater worry and anxiety while taking chemistry exams if basics are not well-structured. Specifically, positive interdependence and promotive interaction might be thought as the reason of having higher levels of test anxiety since both of the two basics of cooperative learning regulate psychological adjustment (Johnson & Johnson, 1999). When cooperative learning settings do not make students to contribute to each other's learning, being exposed to numerous chemistry tests might cause them to feel greater worry and anxiety.

Up to here, the effect of structuring cooperative learning based on conceptual change approach on grade nine students' understanding the concepts of mixtures and their motivational beliefs (i.e. SELP, TV, CLB, and TA) were discussed. The effect of structuring cooperative learning based on conceptual change approach on grade nine students' reasons of being involved in various achievement behaviors was also investigated under their motivation by using all of the four sub-scales of AGQ, mastery approach goals (MAP), mastery avoidance goals (MAV), performance approach goals (PAP), and performance avoidance goals (PAV). Specifically, students adopting mastery goals (i.e. MAP and MAV) perceive their competence as intra-personal (own past performance) or absolute standards (the necessities of the task itself), as opposed to students orienting performance goals (i.e. PAP and PAV) who define their competence as normative standards (Elliot & McGregor, 2001) (see Table 2.3). The distinction between approach and avoidance dimensions, furthermore, was done on the basis of whether competence is valenced positively or negatively (Elliot & McGregor, 2001). In particular, positively valenced competence was anticipated to encourage emergence of approach dimensions (i.e. MAP and PAP), while negatively valenced competence promotes avoidance aspects (i.e. MAV and PAV). Regarding intercorrelations among these achievement goals, Elliot and McGregor (2001) claimed that goals having common dimensions associate with each other. For example, MAP are hypothesized to be correlated with MAV and PAP, since they share same standards of competence with MAV and same valence of competence with PAP. Sungur and Şenler (2009), on the other hand, suggested that all of the four achievement goals are significantly associated with each other. Research studies consistently point out adaptive achievement behaviors (e.g. deep processing strategies required for conceptual change to take place, high levels of self-efficacy) as a result of adopting MAP, whereas maladaptive achievement behaviors (e.g. sense of worry and emotionality, surface processing strategies and disorganized study strategies) as a result of orienting PAV (Ames, 1992; Pintrich et al., 1993; Kaplan & Midgley, 1997; Elliot & McGregor, 2001; Sungur, 2007). Pintrich (2000) proposed that students may have multiple motivational beliefs and decide on which orientation to activate with regard to the information available to them in the environment. For example, a student may activate a mastery goal orientation when they have a chance to interact with peers and the teacher while learning a challenging task, whereas the same student may activate a performance goal orientation when they have to compete with each other to get an external reward (e.g. to be accepted as successful). In brief, cooperative learning contexts (i.e. CLCC and CLCC(-)) were expected to favor adoption of mastery goals which are found as to promote necessary conditions for conceptual change to take place (Pintrich et al., 1993; Kaplan & Midgley, 1997). In contrast, traditional learning contexts were anticipated to favor adoption of performance goals which are found as to promote maladaptive achievement behaviors. As pointed out by the related literature, the results of this study revealed that students instructed by cooperative learning treatments (i.e. CLCC and CLCC(-)) oriented MAP more than students instructed by TI. As predicted, furthermore, students instructed by TI adopted PAV more than students instructed by cooperative learning treatments. More specifically, students focused on meaningful understanding of the chemistry concepts under examination for their self-improvement when they were exposed to variations of cooperative learning, whereas students tried not to be the owner of worst grade when they were exposed to traditional instruction. Meanwhile, the results drawn upon post-MAP and post-PAV confirm the theory related to correlation of these goals with achievement gains. Particularly, students instructed by cooperative learning treatments adopted MAP which might cause them to understand the concepts of mixtures better than students instructed by traditional instruction who oriented PAV which might cause lower understanding of the concepts of mixtures. Although the noted differences were in the same line with what literature reports, statistically significant mean differences between CLCC and CLCC(-) in terms of students' achievement goal orientations are hoped to advance the related literature by introducing the effect of structuring basics of cooperative learning. It was found that students instructed by CLCC focused more on meaningful learning to understand the concepts of chemistry deeply, as compared to students exposed to CLCC(-). Moreover, students taught by CLCC(-) focused more on trying not to perform worse in chemistry than others, as compared to students instructed by CLCC. Post-MAP and post-PAV mean differences between students instructed by CLCC and CLCC(-) can be expressed in terms of basics of cooperative learning since the unique difference between two treatments was well-structuring positive interdependence, individual accountability, promotive interaction, small group skills, and group processing in the CLCC, but solely limited individual accountability in the CLCC(-). Moreover, students instructed by TI were found to focus on avoiding any misunderstanding with a perfectionist manner, as compared to students instructed by CLCC and CLCC(-). When the results of post-MCT, interviews, and post-MAV were compared for students in the CG, it can be stated that students' alternative conceptions about the concepts of mixtures do not decrease as they avoid making mistakes. Accordingly, traditional learning environments cause students to be afraid of giving incorrect response during lessons which might result in lower understanding and higher alternative conceptions. Students exposed to CLCC(-), on the other hand, focused more on trying to be the best performer in chemistry lessons in comparison to others, as compared to students taught by CLCC and TI. Actually, the reason of lower understanding of the concepts of mixture by students in the UCLG can be explained through their post-PAP scores since they spended part of their energy to follow the performance of others instead of focusing solely on their self-improvement, as suggested by Pintrich and Schunk (2002).

To conclude, results drawn upon motivational constructs revealed that structuring basic elements of cooperative learning is crucial not only for achievement gains but also for motivational yields. Groups exposed to CLCC treatment achieved to form a warm climate where individuals feel less anxiety but a sense of autonomy to contribute to the group's goal by interacting frequently with each other on task-related concerns, caring and liking each other on the personal level, and supporting each other on the academic level, as cohesive groups proposed by Dörnyei (1997). Whereas all of the three treatment groups showed improvement in their post-MCT scores as compared to their pre-MCT scores ($SCLG_{gain\ score}$ = 10.59, $UCLG_{gain\ score}$ = 3.16, $CG_{gain\ score}$ = 4.82), SCLG gained the maximum score. Therefore, it is apparent that putting students in a group order is not adequate to make them to understand the concepts in chemistry better and to adopt more adaptive motivational beliefs, basics of cooperative learning should be well-structured through training students on social skills, forming heterogeneous groups, making students responsible from their own and each other's learning, giving chance to students to interact with each other to promote each other's learning, structuring numerous types of positive interdependence to make students to feel being a group is worth to try, encouraging students to challenge each other's conclusions by giving and receiving help and resolve conflicts constructively, motivating students to listen to each other and draw decisions as a group democratically, advocating time to students to revise what they have experienced while they were working in groups, enabling groups to celebrate joint efforts, and providing an atmosphere where members trust each other both personally and academically. CLCC treatment was found to be an exceptional way of higher conceptual understanding and motivation since cooperation among students was established by structuring basics of cooperative learning firmly, which caused the whole to be more than sum of its parts.

5.2. Implications

The implications drawn from the results of this study are presented below.

- The most common source of alternative conceptions about the concepts of mixtures was found as alternative conceptions related to previous contents of mixtures (e.g. the nature of mixtures) and chemistry (e.g. the nature of matters), which can be interpreted as students' prior knowledge may impede their future learning when they were scientifically incorrect, as suggested by Hewson and Hewson (1983). Therefore, teachers should identify students' pre-knowledge and try to overcome alternative conceptions about previous contents if students have, before presenting discourse of future concepts.

- As noted above, students may have scientifically incorrect pre-knowledge when they entered in classes (Hewson & Hewson, 1983). Taber (2001) further stated that students may have alternative conceptions not only at the beginning of a topic but also after the instruction is completed, which can be interpreted as it is not an easy task to overcome alternative conceptions. The results of the current study confirmed the theory that there was significant mean difference between students instructed by CLCC and students instructed by CLCC(-) in terms of their post-MCT scores, favoring students instructed by CLCC. Therefore, teachers should realize that preparing teaching activities on the basis of common alternative conceptions or putting students in a group order may not guarante that students overcome most of the alternative conceptions they hold before the lesson is started. To decrease the amount of alternative conceptions, teachers should promote conceptual change with cooperative learning by well-structuring positive interdependence firmly, which increases the likelihood of intellectual disagreements that is the first and the fundamental condition for conceptual change to happen (Johnson & Johnson, 1999).

- Although both of the CLCC and CLCC(-) treatments designed according to cooperative learning based on conceptual change conditions, students instructed by CLCC(-) had significantly lower mean scores on the post-MCT and had higher alternative conceptions about the concepts of mixtures as identified while conducting interviews. Even more, whereas not significant, mean post-MCT scores of students instructed by CLCC(-) were lower than those of students instructed by TI. Without well-structuring basics of cooperative learning, therefore, cooperative learning based on conceptual change practices could not result in higher mastery and lower alternative conceptions than traditional instruction, even could cause lower understanding. Based on the specified results, prospective science teachers should be well-educated on basics of cooperative learning, methods of cooperative learning, conditions of conceptual change, and the roles teachers have while implementing a lesson according to cooperative learning based on conceptual change approach.

- Results of this study revealed that students exposed to CLCC had better understanding of the concepts of mixtures, perceived contents related to chemistry more valuable, felt greater control over their own learning, and adopted mastery approach goals more than students instructed by CLCC(-) and TI. Whereas designed according to cooperative learning based on conceptual change conditions, CLCC(-) did not result in better understanding or greater adaptive motivational beliefs, as compared to students taught by CLCC. Accordingly, making individuals accountable for their own learning is not adequate for better understanding or greater adaptive motivational beliefs, positive interdependence, promotive interaction, small group skills, and group processing should also be well-structured besides individual accountability. More specifically, students should be trained on teamwork skills by the teacher before performing a cooperative learning practice since taskwork cannot be achieved unless students know how to manage cognitive conflicts and listen to each other. Moreover, teachers should make members to share resources and information with each other by establishing positive resource interdependence, perceive being a group as worth to try by structuring positive identity interdependence, perceive each member's contribution as necessary for achieving joint goals by structuring positive role interdependence, promote each others' learning by giving and receiving help by establishing positive goal interdependence, and reflect on how successful they were within their teams by allocating time for group processing.

- Teachers, who are inexperienced about cooperative learning applications, may fail to benefit from strength of cooperative learning unless they know the difference between studying in a group and studying as a group, as proposed by Chiriac and Granström (2012). Therefore, teachers should be informed on what cooperative learning is and is not through in-service training programs financed by the Ministry of National Education.

- Results drawn upon the present study revealed that students instructed by CLCC had better understanding of the concepts of mixtures and adaptive motivational beliefs, as compared to students exposed to CLCC(-) and TI. Correspondingly, curriculum developers should take the power of truly committed cooperative learning based on conceptual change into account through suggesting widespread applications of cooperative learning in science classes by introducing how to structure basics of cooperative learning, designing sample science lessons conducted by various methods of cooperative learning, and preparing teaching activities including common alternative conceptions on various science concepts to be completed during team studies.

5.3. Recommendations

The following recommendations are presented for future studies on cooperative learning and conceptual change.

- The results of this study can be generalized to grade nine students enrolling Anatolian high schools in Isparta. Therefore, this study should be replicated with students attending different grade levels, students attending different types of schools, and schools in different cities.

- Researchers can investigate the effect of structuring cooperative learning based on conceptual change approach on students' understanding the concepts of chemistry, other than mixtures.

- This study should be replicated with larger sample size and in different science domains.

- Cooperative base groups can be formed to investigate the effect of structuring cooperative learning based on conceptual change approach within a longer time period.

- The effect of structuring cooperative learning based on conceptual change approach on retention of concepts of mixtures can be examined.

- Students' ideas about cooperative learning based on conceptual change approach can be analyzed.

- Teachers' reflections on cooperative learning applications can be examined.

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APPENDIX A

KEYWORD LIST

- Science Education
- Chemistry Education
- Constructivism
- Alternative Conceptions
- Conceptual Change
- Cooperative Learning
- Motivation
- Heterogeneous Mixtures
- Homogeneous Mixtures
- Solute
- Solvent
- Dissolution
- Factors Affecting Solubility
- Colligative Properties of Solutions
- Filtration
- Separating Funnel
- Crystallization
- Distillation
- Fractional Distillation
- Paramagnetic Separation

APPENDIX B

INSTRUCTIONAL OBJECTIVES

Cognitive Domain

1. Heterojen ve homojen karışımları ayırt eder.
2. Çözücü, çözelti, çözünürlük kavramlarını ilişkilendirerek açıklar.
3. Çözünme ve erime arasındaki farkı kavrar.
4. Doymamış, doymuş, aşırı doymuş çözeltiler ile seyreltik ve derişik çözeltiler arasındaki farkı kavrar.
5. Çözünürlük ile çözünme hızı arasındaki farkı kavrar.
6. Sıcaklığın ve basıncın çözünürlüğe etkisini örneklerle açıklar.
7. Çözücü ve çözünen madde miktarlarındaki değişimin çözünürlüğü etkilemediğini kavrar.
8. Karıştırma ve temas yüzeyinin çözünürlük hızını etkilediğini fark eder.
9. Farklı maddelerin çözünürlüklerini karşılaştırarak çözünürlüğün maddenin kimlik özelliklerinden olduğunu fark eder.
10. Karışımların bileşimleri değiştikçe bazı fiziksel özelliklerinin değiştiğini deneyerek fark eder.
11. Karışımların fiziksel özellikleriyle ilgili günlük hayattan örnekler verir.
12. Tanecik boyutu farkından yararlanılarak geliştirilen ayırma yöntemlerini açıklar.
13. Maddelerin birbirinden ayrılmasında yoğunluk farkından yararlanan yöntemleri keşfeder.
14. Çözünürlük farklarının maddeleri ayırmada kullanılabildiğini fark eder.
15. Kaynama noktası farkından yararlanarak karışımların ayrılmasına örnekler verir.
16. Verilen karışımlar için uygun ayırma yöntemleri önerir.

Affective Domain

1. Kendisinin ve takım arkadaşlarının öğrenmesinde sorumluluk üstlenir.
2. Kendisinin ve diğerlerinin düşüncelerinin farklı olabileceğini kabul eder.
3. Yardım etmeyi ve gerektiğinde yardım istemeyi bilir.
4. Bilgi ve materyalleri paylaşır.
5. Farklı görüşe sahip bireylerle yapıcı tartışmalar yürüterek ortak bir karara ulaşmayı bilir.
6. Karşısındaki bireyleri saygı ve hoşgörüyle dinler.
7. Eleştirilere açıktır.
8. Herkesin farklı görevleri olduğunu bilir ve liderliği paylaşır.
9. Ortak bir amaca ulaşmak için üzerine düşen görevi yerine getirir.
10. Takım arkadaşlarını ortak amaç doğrultusunda cesaretlendirir.

APPENDIX C

DEMOGRAPHIC INFORMATION QUESTIONNAIRE

Sevgili Öğrenciler,
Uygulamakta olduğumuz araştırma kapsamında size ait bazı özelliklerin yer aldığı aşağıdaki sorulara cevap vermeniz gerekmektedir. Katkılarınız için teşekkür ederiz.

Cinsiyetiniz:

Doğum tarihiniz:

I. dönem kimya dersi karne notunuz:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Annenizin eğitim düzeyi:

☐ İlkokul ☐ Ortaokul ☐ Lise ☐ Üniversite ☐ Lisansüstü

Babanızın eğitim düzeyi:

☐ İlkokul ☐ Ortaokul ☐ Lise ☐ Üniversite ☐ Lisansüstü

APPENDIX D

MIXTURES CONCEPT TEST

KARIŞIMLAR KAVRAM TESTİ

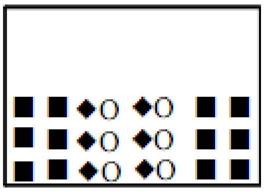
Sevgili Öğrenciler,

Bu çalışma, sizlerin karışımlar konusu ile ilgili sahip olduğunuz kavramları tespit etmek amacıyla hazırlanmıştır. **Soruları boş bırakmamanız ve tek bir seçeneği daire içine almanız gerekmektedir. İki bölümden oluşan sorularda cevabınızın doğru sayılabilmesi için her iki kısmında doğru olması beklenmektedir.** Bu sorulara vereceğiniz yanıtlar, araştırma amacıyla kullanılacak ve gizli tutulacaktır. Görüşleriniz bizler için çok önemlidir. Yardımlarınız için teşekkür ederiz.

Hatice BELGE CAN

Öğrenci Numaranız:

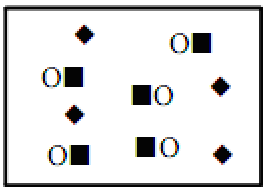
1) Yandaki çizimin temsil ettiği maddenin <u>fiziksel bileşimi</u>
(1) Saf maddedir
(2) Heterojen karışımdır*
(3) Homojen karışımdır



Çünkü

a. Karışımların tamamı heterojen görünümlüdür
b. Karışımlar saf maddedir
c. Farklı cins moleküller gelişigüzel dağılmamıştır*
d. Tüm karışımlar homojendir

2) Yandaki çizimin temsil ettiği karışımın <u>kimyasal bileşimi</u>
(1) Atomdur
(2) Moleküldür
(3) Hem atom hem de moleküldür*



Çünkü

a. Karışımlar en az iki çeşit maddeden oluşur*
b. Homojen karışımlar atomlardan oluşur
c. Karışımlar yapılarında her zaman molekül bulundurur
d. Karışımlar yapılarında her zaman iki cins atom bulundurur

3) Amalgam, civanın diğer metaller ile yaptığı bir <u>alaşımdır</u> ve kullanılan metale göre adlandırılır. Endüstri, sağlık, kimya gibi birçok sektörde kullanılan amalgamlar arasında gümüş amalgamı en yaygın olanıdır ve diş hekimliğinde dolgu maddesi olarak kullanılır. Bu bilgilere göre, amalgamlar ile ilgili olarak aşağıdaki ifadelerden hangisi <u>doğrudur</u>?

a. Amalgamı oluşturan maddeler özelliklerini kaybederler
b. Sıvı halde olmadıkları için çözelti değildirler
c. Fiziksel ayırma yöntemleri ile bileşenlerine ayrılamazlar
d. Saf madde değildirler*

4) Suyun içerisine sofra tuzu (NaCl) atılmasıyla oluşan tuzlu su çözeltisi ile ilgili aşağıdaki ifadelerden hangisi doğrudur?

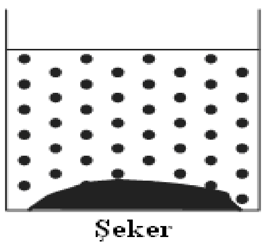
   a. Çözünme işlemi sırasında oluşan tuzlu su yeni bir maddedir
   b. Aynı basınçta, tuzlu su çözeltisinin kaynama noktası saf suyun kaynama noktasından daha yüksektir*
   c. Tuzlu su oluşumu kimyasal bir değişikliktir
   d. Çözünme işlemi sırasında tuz erir

5) Çözünme işlemi ile ilgili aşağıdaki ifadelerden hangisi doğrudur?
   a. Katı bir maddenin sıvının içerisinde kaybolmasıdır
   b. Çözünenin çözücü tarafından emilmesidir
   c. Çözünme işlemi sonucu yeni bir madde oluşmasıdır
   d. Çözünen ve çözücü parçacıklarının yoğun etkileşimi sonucu çözelti oluşturmasıdır*

6) 25 ^{o}C sıcaklıkta, içerisinde 100 gram su bulunan bir behere 18 gram şeker eklenir. Bir süre beklendikten sonra kabın tabanında bir miktar şekerin çöktüğü gözlemlenir. Bahsedilen şeker-su karışımıyla ilgili aşağıda verilen bilgilerden hangisi doğrudur?

   a. Derişik bir çözeltidir
   b. 25 ^{o}C sıcaklıkta, şekerin çözünürlüğü 0.18'den küçüktür*
   c. 25 ^{o}C sıcaklıkta, karışımın kütlesi 118 gramdır
   d. Çözünmeden kalan bir miktar şeker olduğu için aşırı doymuş bir çözeltidir

7) Oda sıcaklığında bulunan yandaki kabın içerisinde şekerli su çözeltisi bulunmaktadır. Kabın dibinde çözünmeden kalan şeker

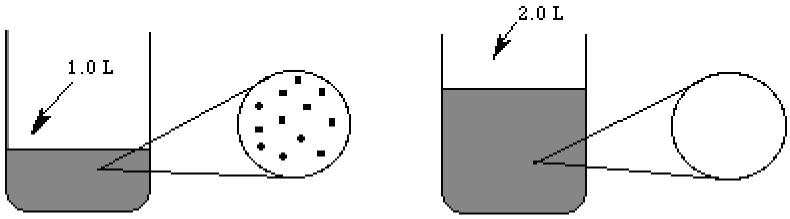


(1) Çözeltinin bileşenidir (2) Çözeltinin bileşeni değildir*

Çünkü

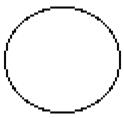
   a. Aşırı doymuş çözeltilerin dibinde çökelek oluşur
   b. Çözelti karıştırılmadığında çözünme olmaz
   c. Su çözebileceği en fazla maddeyi çözmüştür*
   d. Su sıcak olmadığı için şeker çözünmez

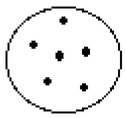
8) Şekil 1, 1 L şekerli su çözeltisini temsil etmektedir. Daire içine alınmış büyütülmüş alandaki noktalar şeker moleküllerini göstermektedir. Şekli basitleştirmek için, su molekülleri gösterilmemiştir.

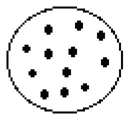


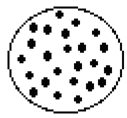
şekil 1 şekil 2

Şekil 1'deki şekerli su çözeltisine 1 L su eklenirse (Şekil 2), Şekil 1'de gösterilen büyütülmüş alanı <u>en iyi ifade eden</u> çizim aşağıdakilerden hangisi gibi olur?


a.


b.*


c.


d.

9) Çözeltilerin kaynama ve donma noktaları ile ilgili aşağıdaki ifadelerden hangisi <u>doğrudur</u>?
   a. Tuzlu su çözeltisinin kaynama ve donma sıcaklığı saf suyun kaynama ve donma sıcaklığından yüksektir
   b. Çözen ve çözünen maddeler farklı zamanlarda kaynadığı için çözeltiler ile saf sıvıların kaynama sıcaklıkları farklıdır
   c. Tuzlu su çözeltisine bir miktar daha tuz eklemek kaynama noktasını yükseltir*
   d. Çözeltiler ve saf sıvıların kaynama ve donma sıcaklıkları aynıdır

10) Alkol-su karışımı ile ilgili aşağıdaki ifadelerden hangisi <u>doğrudur</u>? (d_{su}: 1 g/cm^3, d_{alkol}: 0,79 g/cm^3)
   a. Hidrojen çözen madde, oksijen de çözünen maddedir çünkü suyun yapısında (H_2O) hidrojen miktarı daha fazladır
   b. Alkol-su çözeltisinde alkol temel bileşen, su ise pasif bileşendir
   c. Alkol ve su birbiri ile karıştırıldığında alkol kaybolur
   d. Alkol-su çözeltisinin özkütlesi alkolün özkütlesinden yüksektir*

11) İçerisinde bir miktar su bulunan kaba başka bir kapta bulunan bir miktar alkol ilave ediliyor. <u>Alkolün tamamı suyun içerisinde çözünüyor</u> ve kabın ağzı saat camıyla kapatılıyor. Kapta bulunan alkol-su çözeltisinin kütlesi eklenen su ve alkolün toplam <u>kütlesinden</u> azdır.

(1) Doğru (2) Yanlış*

Çünkü

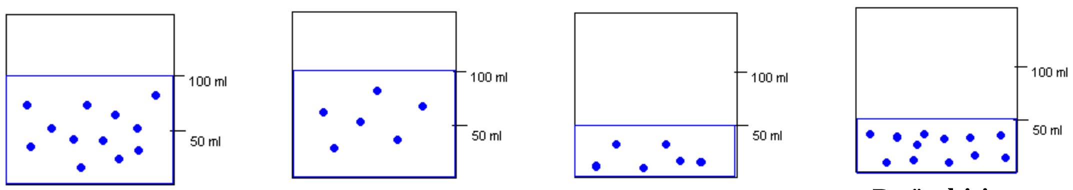
a. Alkolün kütlesi artar
b. Çözünme sırasında alkol kaybolur
c. Alkolün kütlesi yoktur
d. Alkolün tamamı suyun içerisinde çözünmüştür*

12) Aşağıdaki tablo K, L, M katı maddelerinin sudaki ve petroldeki çözünürlüğünü göstermektedir. Tablodaki bilgilere göre K maddesi aşağıdaki yöntemlerden hangisi ile elde edilebilir?

Maddeler	**Sudaki çözünürlüğü**	**Petroldeki çözünürlüğü**
K	Çözünmez	Çözünür
L	Çözünür	Çözünmez
M	Çözünür	Çözünmez

a. Önce petrol eklenir ve aktarılır sonra su eklenir
b. Petrol önce eklenir sonra aktarılır
c. Petrol eklenir ve oluşan karışım süzülür
d. Su eklenir ve oluşan karışım süzülür*

13) Aşağıdaki kaplarda gösterilen '•' simgeleri suda çözünen maddeyi temsil etmektedir. Buna göre aşağıdaki ifadelerden hangisi doğrudur?



A çözeltisi **B çözeltisi** **C çözeltisi** **D çözeltisi**

a. C çözeltisi en seyreltik çözeltidir
b. B çözeltisi doymamış çözeltidir
c. A ve C çözeltilerinin derişimleri eşittir*
d. D çözeltisi aşırı doymuş çözeltidir

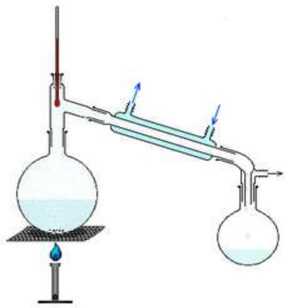
14) X, Y, Z, W, Q metallerinin mıknatısla çekilebilme özelliği tabloda verilmiştir.

Metal	X	Y	Z	W	Q
Mıknatısla çekilebilme özelliği	-	+	+	-	+

Buna göre, toz halinde bulunan metallerden oluşan aşağıdaki karışımların hangisindeki metaller mıknatıs yardımıyla birbirinden ayrılabilir?

a. Y ve Q
b. Y ve W*
c. Z ve Q
d. Y ve Z

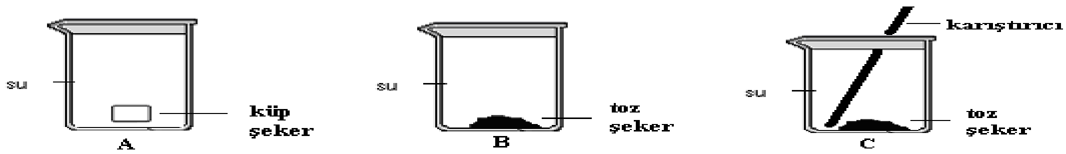
15) Yanda gösterilen düzenek kullanılarak bileşenlerine ayrılabilen bir karışım için aşağıda verilen seçeneklerden hangisi doğrudur?



a. Kaynama noktası farkından yararlanılarak bileşenlerine ayrılabilen sıvı-sıvı homojen bir karışımdır*
b. Damıtma kolonunda sadece kaynama noktası düşük olan bileşenin buharı bulunur
c. Damıtma kolonunun altında kaynama noktası düşük olan bileşenin buharı bulunur
d. Damıtma kolonunun üstüne yetişen buhar kaynama noktası yüksek olan bileşenindir

16. ve 17. soruları aşağıda verilen yönergeye ve şekle göre cevaplandırınız.

Sabit sıcaklıkta, 100 ml su bulunan A, B, C beherlerinin her birine 20 gram şeker ekleniyor. Ancak, A beherine küp şeker, B ve C beherlerine toz şeker ekleniyor. Ayrıca, C beherine şeker ilave edildikten sonra karıştırılıyor. Buna göre,



16) Beherlerdeki şekerlerin çözünme hızları

(1) Aynıdır (2) Farklıdır*

Çünkü

a. Şeker küp halinde iken toz haline göre daha fazla basınç uygular
b. Toz şekerin kütlesi küp şekerden daha azdır
c. Toz şekerin yüzey alanı küp şekerden fazladır*
d. Karıştırılmayan kapların dibinde bir miktar şeker çözünmeden kalır

17) Beherlerde bulunan sularda şekerin çözünürlükleri

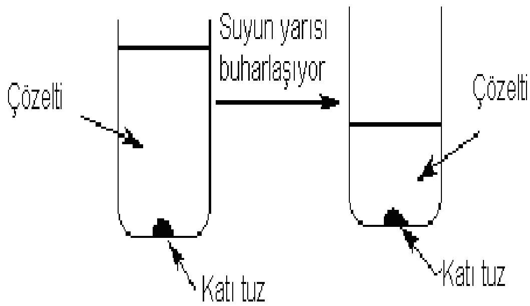
(1) Aynıdır* (2) Farklıdır

Çünkü

a. Şekerlerin yüzey alanları farklıdır
b. Sıcaklık sabittir*
c. Toz şeker erir
d. C beherindeki çözelti karıştırılmıştır

18) Sabit sıcaklıkta, suya bir miktar şeker eklenir ve daha fazla şeker çözünmez hale gelinceye kadar beklenilir, şekerin fazlası kabın tabanında çözünmeden kalır. Buna göre, aşağıdaki ifadelerden hangisi doğrudur?
   a. Şekerin bir kısmı çözünmeden kaldığına göre aşırı doymuş bir çözeltidir
   b. Daha fazla şeker çözemediğine göre derişik bir çözeltidir
   c. Aşırı doymuş bir çözeltidir ve dolayısıyla heterojendir
   d. Doymuş bir çözeltidir*

19) Suya tuz eklenir ve daha fazla tuz çözünmez hale gelinceye kadar karıştırılır. Çözünmeyen tuz çökmeye bekletilir. Çözeltinin hacmi ilk hacminin yarısı oluncaya kadar su buharlaşırsa, çözeltideki tuz derişimi ne olur? (Sıcaklığın sabit olduğunu farz edin).



(1) Artar (2) Azalır (3) Aynı kalır*

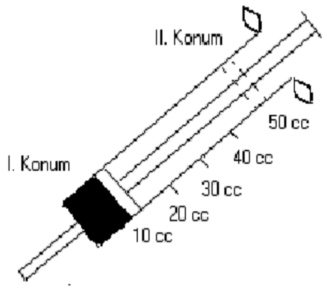
Çünkü
   a. Daha az suda aynı miktarda tuz vardır
   b. Tuz buharlaşmaz ve çözeltide kalır*
   c. Daha çok katı tuz oluşur
   d. Daha az su vardır

20) Alkol-su ve boya-tiner karışımları homojendir
(1) Doğru* (2) Yanlış

Çünkü

   a. Alkol suda, boya da tinerde çözünür*
   b. Çözeltilerin tümünde çözücü sudur
   c. Boyanın yoğunluğu yüksek olduğu için çözünemez
   d. Alkol ve boya erimez

21) Şekildeki şırıngada 10 cc gazlı içecek bulunmaktadır. Şırınga I konumundan II konumuna getirilirse içeceğin gaz çözünürlüğü (Basınç ve hacim arasında ters orantı olduğu bilgisini hatırlayınız)



(1) Değişmez (2) Azalır* (3) Artar

Çünkü

a. Gaz parçaları basıncın etkisiyle sıvı hale geçer
b. Basınç uygulandığında farklı gaz parçacıkları oluşur
c. Gaz parçacıkları sıkıştırılamaz
d. Basınç azaldıkça gazların çözünürlüğü de azalır*

22) Çamurlu suyu bileşenlerine ayırmak için kullanılan yöntem ile ilgili aşağıda verilen ifadelerden hangisi <u>doğrudur</u>?
a. Sadece katı-sıvı heterojen karışımları bileşenlerine ayırmada kullanılabilir
b. Şeker-su karışımı da aynı yöntemle bileşenlerine ayrılabilir
c. Homojen karışımlar aynı yöntemle bileşenlerine ayrılamaz*
d. Sulu çözeltiler süzüldüğünde katı madde her zaman filtre kâğıdında kalır

23) X maddesinin sudaki çözünürlüğü ile sıcaklık arasında doğru orantı vardır. Bu maddenin doymuş çözeltisinde <u>kristalleşme sağlamak için</u> çözeltinin sıcaklığı

(1) Düşürülmeli* (2) Yükseltilmeli

Çünkü

a. Sıcaklık azaldıkça katı ve sıvı maddelerin sudaki çözünürlüğü de azalır*
b. Çözeltinin sıcaklığı azaltılsa da çözünürlüğü değişmez
c. X maddesinin kristalleşmesi için suyun sıcak olması gerekir
d. Gazların çözünürlük katsayısı tüm gazlar için sabittir

24) Şekildeki tabloda aseton ve suyun bazı fiziksel özellikleri verilmiştir.

Maddeler	**Yoğunluk (g/cm^3)**	**Kaynama Noktası (^oC)**	**Donma Noktası (^oC)**	**Molekül Ağırlığı (g/mol)**	**Polarite**
Aseton	0,79	56	-95,4	58	Polar
Su	1	100	0	18	Polar

Karışım halinde bulunan aseton ve suyu ayrı ayrı elde etmek için aşağıdaki yöntemlerden hangisi uygulanabilir?
a. Buharlaştırma
b. Ayrımsal damıtma*
c. Kristallendirme
d. Aktarma

25) Q gezegeninde bulunan iki sıvı karıştırıldığında iki farklı tabaka oluşmaktadır. Bu sıvıların birbirinden ayrılmasıyla ilgili aşağıda verilen bilgilerden hangisi doğrudur?
a. Tanecik boyutu farkına göre birbirinden ayrılabilirler
b. Toplama kabına aktarılan maddenin yoğunluğu diğerinden daha küçüktür
c. Ayırma hunisi yardımıyla birbirinden ayrılabilir*
d. Yoğunluğu diğerinden küçük olan sıvı distilattır

APPENDIX E

MOTIVATED STRATEGIES FOR LEARNING QUESTIONNAIRE

ÖĞRENMEDE GÜDÜSEL STRATEJİLER ANKETİ

Değerli öğrenciler,

Öğrenmede Güdüsel Stratejiler Anketi'nde kimya dersine karşı motivasyonunuzu belirlemeye yönelik ifadeler yer almaktadır. Ankette yer alan soruların genel bir doğru cevabı yoktur, sizi en iyi ifade eden seçenek doğru cevaptır. Anketi derecelendirirken aşağıda verilen ölçeği kullanınız. **Verilen ifade sizin için kesinlikle doğruysa, 7'yi yuvarlak içine alınız. Verilen ifade sizin için kesinlikle yanlışsa, 1'i yuvarlak içine alınız. Bu iki durum dışında ise 1 ve 7 arasında sizi en iyi yansıttığını düşündüğünüz rakamı yuvarlak içine alınız.**

Benim için Kesinlikle YANLIŞ 1 2 3 4 5 6 7 Benim için Kesinlikle DOĞRU

Öğrenci Numaranız:

1. Kimya dersinden çok iyi bir not alacağımı düşünüyorum.	(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 dersinde öğrendiklerimi başka derslerde de kullanabileceğimi düşünüyorum.	(1) (2) (3) (4) (5) (6) (7)
4. Kimya dersinde öğretilen becerileri iyice öğrenebileceğimden eminim.	(1) (2) (3) (4) (5) (6) (7)
5. Kimya dersinde bir konuyu anlayamazsam bu yeterince sıkı çalışmadığım içindir.	(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. Kimya dersindeki konulardan hoşlanıyorum.	(1) (2) (3) (4) (5) (6) (7)
8. Kimya sınavları sırasında, diğer arkadaşlarıma göre soruları ne kadar iyi yanıtlayıp yanıtlayamadığımı düşünürüm.	(1) (2) (3) (4) (5) (6) (7)
9. Kimya dersinde çok başarılı olacağımı umuyorum.	(1) (2) (3) (4) (5) (6) (7)
10. Kimya sınavlarında kalbimin hızla attığını hissederim.	(1) (2) (3) (4) (5) (6) (7)
11. Kimya dersindeki konuları anlamak benim için önemlidir.	(1) (2) (3) (4) (5) (6) (7)
12. Kimya dersinde öğretilen temel kavramları öğrenebileceğimden eminim.	(1) (2) (3) (4) (5) (6) (7)
13. Kimya dersinde öğrendiklerimin benim için faydalı olduğunu düşünüyorum.	(1) (2) (3) (4) (5) (6) (7)
14. Kimya dersindeki konuları öğrenemezsem bu benim hatamdır.	(1) (2) (3) (4) (5) (6) (7)
15. Kimya sınavları sırasında bir soru üzerinde uğraşırken, aklım sınavın diğer kısımlarında yer alan cevaplayamadığım sorularda olur.	(1) (2) (3) (4) (5) (6) (7)
16. Kimya dersinde, öğretmenin anlattığı en karmaşık konuyu anlayabileceğimden eminim.	(1) (2) (3) (4) (5) (6) (7)
17. Yeterince sıkı çalışırsam kimya dersinde başarılı olurum.	(1) (2) (3) (4) (5) (6) (7)

18. Kimya dersinin kapsamında yer alan konular çok ilgimi çekiyor.	(1) (2) (3) (4) (5) (6) (7)
19. Kimya dersinde verilen sınav ve ödevleri en iyi şekilde yapabileceğimden eminim.	(1) (2) (3) (4) (5) (6) (7)
20. Kimya sınavları sırasında bu dersten başarısız olmanın sonuçlarını aklımdan geçiririm.	(1) (2) (3) (4) (5) (6) (7)
21. Kimya dersindeki konuları öğrenmek benim için önemlidir.	(1) (2) (3) (4) (5) (6) (7)
22. Kimya sınavlarında kendimi mutsuz ve huzursuz hissederim.	(1) (2) (3) (4) (5) (6) (7)
23. Dersin zorluğu, öğretmen ve benim becerilerim göz önüne alındığında, kimya dersinde başarılı olacağımı düşünüyorum.	(1) (2) (3) (4) (5) (6) (7)

APPENDIX F

ACHIEVEMENT GOAL QUESTIONNAIRE

HEDEF YÖNELİMİ ANKETİ

Değerli öğrenciler,

Hedef Yönelimi Anketi, kimya dersindeki hedeflerinizi belirlemek amacıyla hazırlanmıştır. Ankette yer alan soruların genel bir doğru cevabı yoktur, sizi en iyi ifade eden seçenek doğru cevaptır. **Verilen ifadeye kesinlikle katılıyorsanız, 5'i yuvarlak içine alınız. Verilen ifadeye kesinlikle katılmıyorsanız, 1'i yuvarlak içine alınız. Bu iki durum dışında ise 1 ve 5 arasında sizi en iyi yansıttığını düşündüğünüz rakamı yuvarlak içine alınız.**

Öğrenci Numaranız:

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Kimya derslerinin içeriğini mümkün olduğunca iyi anlamak benim için önemlidir.	1	2	3	4	5
2. Kimya derslerinde amacım sınıftaki diğer öğrencilerden daha kötü performans sergilemekten kaçınmaktır.	1	2	3	4	5
3. Diğer öğrencilerden daha iyisini yapmak benim için önemlidir.	1	2	3	4	5
4. Kimya derslerinden mümkün olduğunca çok şey öğrenmek istiyorum.	1	2	3	4	5
5. Kimya derslerinde beni sıklıkla motive eden şey, diğerlerinden daha kötü performans sergileme korkusudur.	1	2	3	4	5
6. Kimya derslerinde verilen her şeyi tam olarak öğrenmek arzusundayım.	1	2	3	4	5
7. Kimya derslerinde amacım, diğer pek çok öğrenciden daha iyi bir not almaktır.	1	2	3	4	5
8. Kimya derslerinde öğrenebileceğimden daha azını öğrenmekten korkuyorum.	1	2	3	4	5
9. Kimya derslerindeki tek amacım diğerlerinden daha başarısız olmanın önüne geçmektir.	1	2	3	4	5
10. Kimya derslerinde öğrenilecek her şeyi öğrenemeyebileceğimden sıklıkla endişe duyuyorum.	1	2	3	4	5
11. Kimya derslerinde diğerlerine göre daha başarılı olmak benim için önemlidir.	1	2	3	4	5
12. Bazen kimya derslerinin içeriğini istediğim kadar iyi anlayamayacağımdan korkuyorum.	1	2	3	4	5
13. Kimya derslerinde amacım başarısız olmaktan kaçınmaktır.	1	2	3	4	5
14. Kimya derslerinde beni sıklıkla motive eden şey başarısız olma korkusudur.	1	2	3	4	5
15. Kimya derslerinde sadece başarısız olmaktan kaçınmak istiyorum.	1	2	3	4	5

APPENDIX G

SEMI-STRUCTURED INTERVIEW QUESTIONS

MÜLAKAT SORULARI

Oda sıcaklığında bulunan 100 gram suya her biri üç gram olan altı adet kesme şeker eklenir.

1. Maddenin sınıflandırılmasını düşünürsen, ne tür bir madde oluşur? Neden?
   Karışımların hangi parçacıklardan oluştuğunu düşünüyorsun?
   Karışımlar saf madde midir?

2. Karışımların sınıflandırılmasını düşünürsen, ne tür bir karışım oluşur? Neden?
   Tüm karışımlar homojen karışım mıdır?
   Homojen karışımların tamamında çözücü su mudur?

3. Şeker suya eklendiği zaman ne olur? Bahsettiğin olay nasıl gerçekleşir?
   Şeker ve su tekrar elde edilebilir mi? Neden?

Oda sıcaklığında bulunan 100 gram suya her biri üç gram olan altı adet kesme şeker eklenir ve daha fazla şeker çözünmez hale gelinceye kadar karıştırılır. Bir süre bekledikten sonra beherin tabanında üç gram şekerin çöktüğü gözlemlenir.

4. Çözeltinin kaynama noktası saf suyun kaynama noktası ile karşılaştırıldığında ne olmasını beklersin? Neden?

5. Çözeltinin kütlesi kaçtır? Neden?

6. Çözeltiyi çözünen madde miktarına göre sınıflandırabilir misin? Neden?

7. Bahsedilen çözeltiyi A, oda sıcaklığında 100 gram su içerisine her biri üç gram olan sekiz adet kesme şeker eklenerek oluşturulan çözeltiyi de B olarak tanımlarsak, bu iki çözeltiyi eklenen çözünen miktarına göre sınıflandırabilir misin? Neden?
   Belirli sıcaklıkta doymuş bir çözelti seyreltik olabilir mi? Neden?

8. Aşağıdaki faktörlerden hangisi/hangileri şekerli su çözeltisinin çözünürlüğünü etkiler? Neden?
   a. Oda sıcaklığında bulunan 100 gram suya şekerler eklendikten sonra çözeltiyi karıştırmak.
   b. Oda sıcaklığında bulunan 100 gram suya her biri 3 gram 6 adet kesme şeker yerine 18 gram toz şeker eklemek.
   c. Çözeltinin sıcaklığını 50 ^{o}C’ye yükseltmek.
   d. Oda sıcaklığında bulunan çözeltideki suyun 50 gramını buharlaştırmak.

9. Çözeltiden hem şekeri hem de suyu elde etmek için aşağıdaki ayırma yöntemlerinden hangisi/hangileri kullanılabilir? Neden?
   a. Buharlaştırma
   b. Süzme
   c. Ayırma hunisi
   d. Damıtma

APPENDIX H

CLASSROOM OBSERVATION CHECKLIST

Sınıf:
Konu:

	YES	NO
1. The teacher trained students on social skills before the first lesson commenced and encourages them for frequent use of those skills.		
2. Lesson starts with the teacher's presentation which has the same discourse with teaching activity and individual quiz.		
3. Groups include four or five students with mixed-ability and gender.		
4. Students' physical positions are appropriate for ensuring face-to-face promotive interaction.		
5. The teacher assigns complementary roles to each student within a group.		
6. The teacher changes assigned roles for each activity.		
7. The teacher administers individual quizzes after groups completed the group activity.		
8. Students are not allowed to help each other during individual quizzes.		
9. Individual quizzes are scored and distributed to groups to be analyzed each member's challenges.		
10. Members get a common score according to each member's improvement score.		
11. Individual quizzes are scored and distributed to individuals.		
12. Each member is graded according to individual improvement score.		
13. The team showed the greatest improvement is announced in the bulletin board.		
14. An individual who showed the greatest improvement is announced in the bulletin board.		
15. Students give a name to their group.		
16. The students ensure that all members of the group mastered the assigned material.		

17. The teacher shares the records of the group observation checklist.		
18. Students dissatisfied with the questions included in teaching activities and directed by the teacher.		
19. Students use social skills during team studies.		
20. Students reflect on what they have experienced in groups.		
21. The teacher randomly selects students to share their group's answers to the activities.		
22. The teacher tries to make the knowledge more intelligible, plausible, and fruitful.		
23. The teacher asked questions to voluntary and successful students.		
24. The teacher explains the scientific knowledge without taking common alternative conceptions into account.		
25. The students selected the groups to be involved.		

APPENDIX I

LESSON PLANS

Table I.1 Lesson plan 1

Dersin Adı	Kimya
Sınıf	9. Sınıf
Ünitenin Adı	Karışımlar
Konu	Karışımların Sınıflandırılması/ Karışımların Yapısı ve Özellikleri
Önerilen Süre	2 ders saati
Kazanımlar	• Karışımları ve bileşikleri tanecik boyutunda ayırt eder • Karışımların saf madde olmadığını kavrar • Heterojen ve homojen karışımları tanecik boyutunda ayırt eder • Karışımların kimyasal bileşimlerini kavrar • Karışımların ve bileşiklerin özelliklerini ayırt eder • Karışımların çeşitli fiziksel yöntemlerle birbirlerinden ayrılabildiğini kavrar • Karışımı oluşturan maddelerin özelliklerini koruduğunu keşfeder
İçerik	Saf madde, homojen karışım, heterojen karışım
Kullanılan Araç- Gereçler	Çalışma yaprağı I ve II, oyun hamuru, deney tüpü, demir tozu, kükürt tozu, mıknatıs, ısıtıcı
Öğrenme-Öğretme Süreci Sınıf sunumu (I. Aşama)	İşbirlikli öğrenme metotlarından Öğrenci Takımları- Başarı Bölümleri (ÖTBB) Grup çalışmasına geçilmeden önce, “Karışımlar saf madde midir?” ve “Tüm karışımlar homojen midir?” soruları öğrencilere yöneltilir ve ön bilgileri alınır. Günlük hayatta karşılaşılan karışım örnekleri verilerek tüm karışımların aynı özellikte olmadığı vurgulanır. Karışımların sınıflandırılması, maddenin tanecikli yapısı boyutunda ele alınır ve karışımların yapılarında bulunan parçacıklardan (atom, molekül) bahsedilerek homojen ve heterojen karışımlar açıklanır. Karışımların sadece iki veya daha fazla elementten ya da saf olmayan maddelerden oluşacağı yanılgısı kontrol edilir ve karışımların tanımı yapılır. **[Çalışma yaprağı I burada dağıtılır].** “Demir ve Kükürt tozları karıştırıldığı zaman demir mıknatıslanma özelliğini kaybeder mi?” ve “tuzlu suyun içerisinde bulunan tuz tekrar elde edilebilir mi?” soruları öğrencilere yöneltilir ve fikirleri alınır. **[Çalışma yaprağı II burada dağıtılır].**

Table I.1 (continued)

Grup çalışması (II. Aşama) Grup içi işleyiş değerlendirmesi (III. Aşama) Bireysel test (IV. Aşama)	**Çalışma yaprağı I ve II** dağıtılarak öğrencilerin grupları ile birlikte çalışması sağlanır. Öğretmen grupların arasında dolaşarak grupların çalışmalarını kontrol eder, çelişki yaratıcı sorular sorarak öğrencilerin üst düzey düşünme becerilerini geliştirir, yapıcı tartışma ortamları sağlar, geri bildirimlerde bulunur. Grupların tartışarak verdikleri ortak cevaplar öğretmenin belirleyeceği bir grup üyesi tarafından tüm sınıfa açıklanır. Tüm gruplar cevaplarını duyurduktan sonra anlaşılamayan kısımlar varsa öğretmen tarafından açıklığa kavuşturulur. Grup çalışması sırasında üyelerin nasıl çalıştığıyla ilgili öğrencilerin algılamalarını anlamak ve aksayan ya da güçlü özelliklerin farkına varmak amacıyla öğrencilerin **"Grupta Ne Oldu"** adlı anketi doldurması sağlanır. Öğretmenin grup çalışması sırasında yaptığı gözlemlere göre doldurduğu **"Grup Gözlem Formu"** sonuçlarından öğrenciler haberdar edilir ve hem bireysel hem de grup olarak ilerlemeleri değerlendirilir. **Quiz 1** dağıtılarak öğrencilerin bireysel olarak cevaplamaları istenir. Bu aşamada grup üyelerinin birbirlerine yardımcı olmaması beklenir.
Ölçme-Değerlendirme	• Çalışma yaprağı I ve II' de bulunan sorular • Quiz 1

Table I.2 Lesson plan 2

Dersin Adı	Kimya
Sınıf	9. Sınıf
Ünitenin Adı	Karışımlar
Konu	Karışımların Sınıflandırılması/ Çözünme ve Çözelti Bileşenleri
Önerilen Süre	2 ders saati
Kazanımlar	• Çözünme kavramını açıklar • Çözünme ve erime arasındaki farkı kavrar • Çözünme olayının fiziksel değişme olduğunu kavrar • Verilen karışım örneklerinde "benzer benzeri çözer" ilkesini uygular • Çözünen, çözücü ve çözelti kavramlarını ilişkilendirerek açıklar • Verilen çözeltileri bileşenlerine ayırır • Çözeltilerin farklı hallerde (katı, sıvı, gaz) olabileceğini fark eder • Çözelti ile heterojen karışım örneklerini ayırt eder • Çözeltilere günlük hayattan örnekler verir
İçerik	Çözünme, erime, fiziksel değişme, kimyasal değişme, çözünen, çözücü, çözelti, alaşım
Kullanılan Araç-Gereçler	Çalışma yaprağı III ve IV
Öğrenme-Öğretme Süreci Sınıf sunumu (I. Aşama)	İşbirlikli öğrenme metotlarından Öğrenci Takımları- Başarı Bölümleri (ÖTBB) "Çözünme esnasında yeni bir madde mi oluşur, çözünen madde erir veya kaybolur mu?" gibi yaygın alternatif kavramlar öğrencilere sorulur ve ön fikirleri alınır. Bu sorular öğrencilerin çelişkiler yaşamasına ve dikkatlerini derse yönlendirmesine sebep olur. Günlük hayatta karşılaşılan çözelti örnekleri verilerek derste öğrenilenlerin hayatta işe yarar olduğu vurgulanır. Tuzlu su çözeltisinde tuzu ve suyu oluşturan taneciklerin etkileşimlerinden bahsedilir ve çizilerek somutlaştırılır. Böylece, çözünme olayının nasıl gerçekleştiğiyle ilgili temel oluşturulmuş olur. Bazı maddelerin birbirleri içerisinde çözünmesine (örneğin; oje-aseton) rağmen bazılarının çözünmemesinin (örneğin; zeytinyağı-su) sebebi sorulur ve "benzer benzeri çözer" ilkesi açıklanır. **[Çalışma yaprağı III burada dağıtılır].** "Çözünen, çözücü ve çözelti deyince aklınıza neler geliyor?" sorusu öğrencilere yöneltilir ve günlük hayattan çözelti örnekleri vermeleri istenir. "Tüm çözeltilerin sıvı olduğu" yanılgısına karşı tedbir almak amacıyla katı (alaşımlar) ve gaz çözelti örnekleri üzerinde durulur. **[Çalışma yaprağı IV burada dağıtılır].**

Table I.2 (continued)

Grup çalışması (II. Aşama)	**Çalışma yaprağı III ve IV** dağıtılarak öğrencilerin grupları ile birlikte çalışması sağlanır. Öğretmen grupların arasında dolaşarak grupların çalışmalarını kontrol eder, çelişki yaratıcı sorular sorarak öğrencilerin üst düzey düşünme becerilerini geliştirir, yapıcı tartışma ortamları sağlar, geri bildirimlerde bulunur. Grupların tartışarak verdikleri ortak cevaplar öğretmenin belirleyeceği bir grup üyesi tarafından tüm sınıfa açıklanır. Tüm gruplar cevaplarını duyurduktan sonra anlaşılamayan kısımlar varsa öğretmen tarafından açıklığa kavuşturulur.
Grup içi işleyiş değerlendirmesi (III. Aşama)	Grup çalışması sırasında üyelerin nasıl çalıştığıyla ilgili öğrencilerin algılamalarını anlamak ve aksayan ya da güçlü özelliklerin farkına varmak amacıyla öğrencilerin **"Grupta Ne Oldu"** adlı anketi doldurması sağlanır. Öğretmenin grup çalışması sırasında yaptığı gözlemlere göre doldurduğu **"Grup Gözlem Formu"** sonuçlarından öğrenciler haberdar edilir ve hem bireysel hem de grup olarak ilerlemeleri değerlendirilir.
Bireysel test (IV. Aşama)	**Quiz 1** dağıtılarak öğrencilerin bireysel olarak cevaplamaları istenir. Bu aşamada grup üyelerinin birbirlerine yardımcı olmaması beklenir.
Ölçme-Değerlendirme	• Çalışma yaprağı III ve IV' de bulunan sorular • Quiz 1

Table I.3 Lesson plan 3

Dersin Adı	Kimya
Sınıf	9. Sınıf
Ünitenin Adı	Karışımlar
Konu	Karışımların Sınıflandırılması/ Çözelti Türleri ve Çözünürlüğe Etki Eden Faktörler (Basıncın Gazların Çözünürlüğüne Etkisi)
Önerilen Süre	2 ders saati
Kazanımlar	• Çözeltileri doymuşluk seviyelerine göre ayırt eder • Çözünen maddenin çözücü içerisinde belirli bir çözünme kapasitesi olduğunu kavrar • Çözünürlük kavramını tanımlar • Sabit sıcaklık ve basınçta çözünürlüğün maddenin kimlik özelliklerinden olduğunu fark eder • Çözeltileri çözünen madde miktarına göre ayırt eder • Doymamış, doymuş, aşırı doymuş çözeltiler ile seyreltik ve derişik çözeltiler arasındaki farkı kavrar • Çözelti türleriyle ilgili problemleri çözer • Gazların çözünürlüğünün basınçla nasıl değiştiğini kavrar • Gazların farklı basınç değerlerindeki çözünürlüğünü tanecik boyutunda çizer • Basıncın gazların çözünürlüğüne etkisiyle ilgili günlük hayattan örnekler verir
İçerik	Doymamış- doymuş- aşırı doymuş çözelti, çözünürlük, seyreltik-derişik çözelti, basıncın gaz çözünürlüğüne etkisi
Kullanılan Araç- Gereçler	Çalışma yaprağı V ve VI
Öğrenme-Öğretme Süreci Sınıf sunumu (I. Aşama)	İşbirlikli öğrenme metotlarından Öğrenci Takımları- Başarı Bölümleri (ÖTBB) "Çözünen bir madde çözücü içerisinde sonsuza kadar mı çözünür?" sorusu sorularak öğrencilerin ön fikirleri alınır. Bir çözeltinin doymuşluk seviyesini belirlemek için kıyaslama değerinin çözünürlük olarak tanımlanan "belirli sıcaklık ve basınçta 100 ml çözücüde çözünen madde miktarı" olduğu vurgulanır. Yani çözünürlüğün doymuş çözelti için söz konusu olduğu belirtilir. Belirli sıcaklık ve basınçta, çözünürlüğün maddenin kimlik özelliklerinden olduğu özellikle vurgulanır. Seyreltik ve derişik çözeltinin eşit miktarda çözücüde çözünen madde miktarına göre bağıl olarak belirlendiği, her madde için standart bir değeri olmadığı belirtilir. **[Çalışma yaprağı V burada dağıtılır].** "Çözünürlük değeri neden <u>belirli sıcaklık ve basınçta</u> belirlenir?" sorusu sorularak öğrencilerin sıcaklık ve basıncın çözünürlüğü etkileyen faktörlerden olduğunu fark etmeleri sağlanır.

Table I.3 (continued)

Sınıf sunumu (I. Aşama)	Sabit sıcaklıkta, basıncın artmasıyla gaz ve çözücü taneciklerinin etkileşiminin arttığı ve buna bağlı olarak gazların çözünürlüğünün arttığından bahsedilir. Azot ve oksijen gazlarının 25 ^{o}C sıcaklıktaki çözünürlüklerinin basınçla değişim (doğru orantılı) grafiği çizilir ve öğrencilerle birlikte yorumlanır. **[Çalışma yaprağı VI burada dağıtılır].**
Grup çalışması (II. Aşama)	**Çalışma yaprağı V ve VI** dağıtılarak öğrencilerin grupları ile birlikte çalışması sağlanır. Öğretmen grupların arasında dolaşarak grupların çalışmalarını kontrol eder, çelişki yaratıcı sorular sorarak öğrencilerin üst düzey düşünme becerilerini geliştirir, yapıcı tartışma ortamları sağlar, geri bildirimlerde bulunur. Grupların tartışarak verdikleri ortak cevaplar öğretmenin belirleyeceği bir grup üyesi tarafından tüm sınıfa açıklanır. Tüm gruplar cevaplarını duyurduktan sonra anlaşılamayan kısımlar varsa öğretmen tarafından açıklığa kavuşturulur.
Grup içi işleyiş değerlendirmesi (III. Aşama)	Grup çalışması sırasında üyelerin nasıl çalıştığıyla ilgili öğrencilerin algılamalarını anlamak ve aksayan ya da güçlü özelliklerin farkına varmak amacıyla öğrencilerin **“Grupta Ne Oldu”** adlı anketi doldurması sağlanır. Öğretmenin grup çalışması sırasında yaptığı gözlemlere göre doldurduğu **“Grup Gözlem Formu”** sonuçlarından öğrenciler haberdar edilir ve hem bireysel hem de grup olarak ilerlemeleri değerlendirilir.
Bireysel test (IV. Aşama)	**Quiz 2** dağıtılarak öğrencilerin bireysel olarak cevaplamaları istenir. Bu aşamada grup üyelerinin birbirlerine yardımcı olmaması beklenir.
Ölçme-Değerlendirme	• Çalışma yaprağı V ve VI’da bulunan sorular • Quiz 2

Table I.4 Lesson plan 4

Dersin Adı	Kimya
Sınıf	9. Sınıf
Ünitenin Adı	Karışımlar
Konu	Karışımların Sınıflandırılması/ Çözünürlüğe Etki Eden Faktörler (Sıcaklık- Karıştırma- Temas Yüzeyi)
Önerilen Süre	2 ders saati
Kazanımlar	• Katıların ve gazların çözünürlüğünün sıcaklıkla nasıl değiştiğini kavrar • Çözünürlük-Sıcaklık tablo ve grafiklerini yorumlar • Gazların farklı sıcaklıklardaki çözünürlüğünü tanecik boyutunda çizer • Sıcaklığın katıların ve gazların çözünürlüğüne etkisiyle ilgili günlük hayattan örnekler verir • Karıştırma ve temas yüzeyinin çözünürlüğe etkisini kavrar • Sabit sıcaklık ve basınçta, çözünürlüğün maddenin kimlik özelliklerinden olduğunu fark eder
İçerik	Çözünürlük, sıcaklığın katı ve gazların çözünürlüğüne etkisi, karıştırma, temas yüzeyi
Kullanılan Araç- Gereçler	Çalışma yaprağı VII ve VIII
Öğrenme-Öğretme Süreci Sınıf sunumu (I. Aşama)	İşbirlikli öğrenme metotlarından Öğrenci Takımları- Başarı Bölümleri (ÖTBB) Çözünürlüğün, belirli sıcaklık ve basınçta 100 ml çözücüde çözünen madde miktarı olduğu hatırlatılarak öğrencilerin geçmiş öğrenmeleriyle yeni öğrenecekleri kavramlar arasında bağ kurulur. Çözünürlük tanımında geçen “belirli sıcaklık” şartına dikkat çekilerek sıcaklığın çözünürlüğü etkileyen faktörlerden olduğu vurgulanır. Sıcaklık artırıldığında katı ve gaz çözünen madde taneciklerinin çözücü tanecikleriyle aralarındaki etkileşimin farklı olduğu ve buna bağlı olarak çözünürlüklerinin de sıcaklıktan farklı etkilendiği açıklanır. Yapılan açıklamayı desteklemek amacıyla bazı katı ve gaz maddelerin sabit basınç ve farklı sıcaklıklardaki çözünürlük değerleri verilir ve öğrencilerin, sıcaklığın çözünürlüğe etkisinin maddenin fiziksel hallerine ve cinsine göre değiştiğini fark etmeleri sağlanır. **[Çalışma yaprağı VII burada dağıtılır].** “Sabit sıcaklık ve basınçtaki bir maddeyi karıştırmak veya temas yüzeyini değiştirmek o maddenin çözünürlüğünü etkiler mi?” sorusu sorularak öğrencilerin ön fikirleri alınır. Matematik ve Fizik derslerinin de konusu olan “hız, yol, zaman” kavramlarından kısaca bahsedilerek öğrencilerin çözünme hızı ve çözünürlük arasındaki farkı kavraması sağlanır. **[Çalışma yaprağı VIII burada dağıtılır].**

Table I.4 (continued)

Grup çalışması (II. Aşama)	Çalışma yaprağı VII ve VIII dağıtılarak öğrencilerin grupları ile birlikte çalışması sağlanır. Öğretmen grupların arasında dolaşarak grupların çalışmalarını kontrol eder, çelişki yaratıcı sorular sorarak öğrencilerin üst düzey düşünme becerilerini geliştirir, yapıcı tartışma ortamları sağlar, geri bildirimlerde bulunur. Grupların tartışarak verdikleri ortak cevaplar öğretmenin belirleyeceği bir grup üyesi tarafından tüm sınıfa açıklanır. Tüm gruplar cevaplarını duyurduktan sonra anlaşılamayan kısımlar varsa öğretmen tarafından açıklığa kavuşturulur.
Grup içi işleyiş değerlendirmesi (III. Aşama)	Grup çalışması sırasında üyelerin nasıl çalıştığıyla ilgili öğrencilerin algılamalarını anlamak ve aksayan ya da güçlü özelliklerin farkına varmak amacıyla öğrencilerin "Grupta Ne Oldu" adlı anketi doldurması sağlanır. Öğretmenin grup çalışması sırasında yaptığı gözlemlere göre doldurduğu "Grup Gözlem Formu" sonuçlarından öğrenciler haberdar edilir ve hem bireysel hem de grup olarak ilerlemeleri değerlendirilir.
Bireysel test (IV. Aşama)	Quiz 2 dağıtılarak öğrencilerin bireysel olarak cevaplamaları istenir. Bu aşamada grup üyelerinin birbirlerine yardımcı olmaması beklenir.
Ölçme-Değerlendirme	• Çalışma yaprağı VII ve VIII'de bulunan sorular • Quiz 2

Table I.5 Lesson plan 5

Dersin Adı	Kimya
Sınıf	9. Sınıf
Ünitenin Adı	Karışımlar
Konu	Karışımların Sınıflandırılması ve Ayrılması/ Karışımların Fiziksel Özellikleri ve Tanecik Boyutu Farkından Yararlanılarak Geliştirilen Ayırma Yöntemleri
Önerilen Süre	2 ders saati
Kazanımlar	• Karışımların fiziksel özelliklerinin madde miktarına göre değiştiğini fark eder • Karışımı oluşturan bileşenlerin karışımın kaynama ve donma noktasına etkisini kavrar • Çözünme sırasında kütlenin korunduğunu kavrar • Karışımların fiziksel özellikleriyle ilgili günlük hayattan örnekler verir • Tanecik boyutu farkından yararlanılarak geliştirilen ayırma yöntemlerini açıklar • Tanecik boyutu farkı ile ayrılan maddelerin tamamının heterojen karışımlar olduğunu fark eder • Süzme ve diyaliz yöntemleri arasındaki farkı kavrar • Katı-katı heterojen karışımların yanı sıra katı-sıvı ve katı-gaz heterojen karışımların da tanecik boyutu farkıyla ayrılabildiğini fark eder • Farklı ayırma yöntemlerinde farklı ayırma araçlarının kullanıldığını kavrar • Tanecik boyutu farkından yararlanılarak geliştirilen ayırma yöntemlerinin günlük hayat uygulamalarına örnekler verir
İçerik	Kaynama noktası, donma noktası, kütle, yoğunluk, ayıklama, eleme, süzme, diyaliz, mıknatısla ayırma
Kullanılan Araç- Gereçler	Çalışma yaprağı IX ve X
Öğrenme-Öğretme Süreci Sınıf sunumu (I. Aşama)	İşbirlikli öğrenme metotlarından Öğrenci Takımları- Başarı Bölümleri (ÖTBB) “1 atmosfer basınçta tuzlu suyun kaynama noktası kaç ^{o}C’dir?” sorusu yöneltilerek öğrencilerin sahip olması muhtemel olan “karışımların saf maddeler gibi belirli bir kaynama noktası vardır” kavram yanılgısı kontrol edilir. Suyun içerisine değişik miktarlarda etil alkol eklenerek oluşturulan çözeltilerin kaynama noktalarını gösteren bir tablo sunulur ve öğrencilerle birlikte yorumlanır. Karışımı meydana getiren bileşenlerin birleşme oranına göre kaynama noktasının değiştiğini fark eden öğrencilere, donma noktası ve yoğunluk için de madde miktarının önemi vurgulanır

Table I.5 (continued)

Sınıf sunumu (I. Aşama)	Karışımı meydana getiren bileşenlerin birleşme oranına göre kaynama noktasının değiştiğini fark eden öğrencilere, donma noktası ve yoğunluk için de madde miktarının önemi vurgulanır. Kaynama noktası yükselmesi ve donma noktası alçalması ile ilgili günlük hayattan örnekler verilir ve bu örneklerin nedenleri hakkında öğrencilerin yorumları alınır. "Çözünme esnasında çözünen maddeye ne olur", "Çözünen maddenin kütlesi var mıdır?" soruları yöneltilir ve madde miktarı değişmediği sürece çözünme sırasında çözeltinin toplam kütlesinin korunacağı açıklanır. **[Çalışma yaprağı IX burada dağıtılır].** Karışımlar ünitesinin ikinci konusu olan karışımların ayrılmasına geçilmeden önce karışımların sınıflandırılması konusunda önemli olan noktalar üzerinde durulur. Karışımları ayırmak için maddelerin farklı özelliklerinden yararlanıldığını ve bu özelliklere göre ayırma yöntemleri geliştirildiği açıklanır. Karışımları ayırma yöntemlerinin genelinden bahsedildikten sonra "Homojen karışımlar tanecik boyutu farkıyla bileşenlerine ayrılabilir mi?" sorusu sorularak öğrencilerin ön fikirleri alınır ve tanecik boyutu farkıyla ayırma yöntemlerine geçiş yapılır. Ayıklama, eleme, süzme, diyaliz ve mıknatısla ayırma yöntemlerinin prensipleri açıklanır ve bu yöntemlerin ortak noktaları ile farklı noktaları üzerinde durularak öğrencilerde olması muhtemel kavram yanılgıları kontrol edilir. Tanecik boyutu farkıyla ayrılabilen karışımların heterojen olduğunu öğrenen öğrencilere "Alaşımlar ve gaz karışımları tanecik boyutu farkıyla bileşenlerine ayrılabilir mi?" sorusu sorularak geçmiş öğrenmeleriyle yeni öğrenecekleri kavramlar arasında bağ kurmaları sağlanır (heterojen karışımlar, alaşımlar, gaz karışımları gibi kavramlar önceki derslerin konuları içerisinde yer almaktadır). Sadece katı-katı değil katı-sıvı ve katı-gaz heterojen karışımların da tanecik boyutu farkıyla ayrılabildiğini keşfetmeleri için günlük hayatta karşılaşılan örnekler verilir ve öğrencilerden de örnekleri çeşitlendirmesi beklenir. Süzme ve diyaliz yöntemleri arasındaki tek farkın, karışımın içerisindeki katı maddenin moleküllerinin büyüklüğü olduğu vurgulanır ve "kum ve su karışımı da katı-sıvı heterojen karışım olduğuna göre diyaliz yöntemiyle bileşenlerine ayrılabilir mi?" sorusu sorularak öğrencilerin anlamlı öğrenmesi sağlanır. Mıknatıslanma özelliğine sahip olan tek maddenin demir olmadığı, nikel ve kobalt elementlerinin de mıknatıstan etkilendiği açıklanır ve iki maddeden oluşan bir karışımın mıknatısla ayrılabilmesi için maddelerden birinin mıknatıslanma özelliğine sahip, diğerinin ise mıknatıslanma özelliğine sahip olmaması gerektiği vurgulanır. **[Çalışma yaprağı X burada dağıtılır].**
Grup çalışması (II. Aşama)	Çalışma yaprağı IX ve X dağıtılarak öğrencilerin grupları ile birlikte çalışması sağlanır. Öğretmen grupların arasında dolaşarak grupların çalışmalarını kontrol eder, çelişki yaratıcı sorular sorarak öğrencilerin üst düzey düşünme becerilerini geliştirir, yapıcı tartışma ortamları sağlar, geri bildirimlerde bulunur. Grupların tartışarak verdikleri ortak cevaplar öğretmenin belirleyeceği bir grup üyesi tarafından tüm sınıfa açıklanır. Tüm gruplar cevaplarını duyurduktan sonra anlaşılamayan kısımlar varsa öğretmen tarafından açıklığa kavuşturulur.

Table I.5 (continued)

Grup içi işleyiş değerlendirmesi (III. Aşama) Bireysel test (IV. Aşama)	Grup çalışması sırasında üyelerin nasıl çalıştığıyla ilgili öğrencilerin algılamalarını anlamak ve aksayan ya da güçlü özelliklerin farkına varmak amacıyla öğrencilerin "Grupta Ne Oldu" adlı anketi doldurması sağlanır. Öğretmenin grup çalışması sırasında yaptığı gözlemlere göre doldurduğu "Grup Gözlem Formu" sonuçlarından öğrenciler haberdar edilir ve hem bireysel hem de grup olarak ilerlemeleri değerlendirilir. Quiz 3 dağıtılarak öğrencilerin bireysel olarak cevaplamaları istenir. Bu aşamada grup üyelerinin birbirlerine yardımcı olmaması beklenir
Ölçme-Değerlendirme	• Çalışma yaprağı IX ve X'da bulunan sorular • Quiz 3

Table I.6 Lesson plan 6

Dersin Adı	Kimya
Sınıf	9. Sınıf
Ünitenin Adı	Karışımlar
Konu	Karışımların Ayrılması/ Yoğunluk, Çözünürlük ve Kaynama Noktası Farkından Yararlanılarak Geliştirilen Ayırma Yöntemleri
Önerilen Süre	2 ders saati
Kazanımlar	• Karışımı oluşturan maddelerin yoğunluk farklarına göre birbirinden ayrılabildiğini fark eder • Katı-katı ve sıvı-sıvı heterojen karışımların yoğunluk farkına göre bileşenlerine ayrılabildiğini fark eder • Katı-katı heterojen karışımların yoğunluk farkıyla ayrılabilmesi için eklenen çözücünün sahip olması gereken özellikleri kavrar • Karışımı oluşturan maddelerin yoğunluk sıralamasını kavrar • Karışımı oluşturan maddelerin çözünürlük farkına göre birbirinden ayrılabildiğini fark eder • Kristallendirme ile ayrımsal kristallendirme yöntemleri arasındaki farkı keşfeder • Kaynama noktası farkından yararlanılarak geliştirilen ayırma yöntemlerini açıklar • Buharlaştırma ile basit damıtma yöntemleri arasındaki farkı kavrar • Basit damıtma ile ayrımsal damıtma yöntemleri arasındaki farkı keşfeder • Basit damıtma ve ayrımsal damıtma düzeneklerini kurar • Sıcaklık-zaman grafiği verilen karışımların ayrılma yöntemleri ile ilgili yorum yapar • Verilen karışımlar için uygun ayırma yöntemleri önerir • Karışımları ayırma yöntemlerine günlük hayattan örnekler verir
İçerik	Ayırma hunisi ile ayırma, çöktürme, aktarma, yüzdürme, kristallendirme, ayrımsal kristallendirme, özütleme, buharlaştırma, basit damıtma, ayrımsal damıtma
Kullanılan Araç- Gereçler	Çalışma yaprağı XI ve XII
Öğrenme-Öğretme Süreci	İşbirlikli öğrenme metotlarından Öğrenci Takımları- Başarı Bölümleri (ÖTBB)

Table I.6 (continued)

Sınıf sunumu (I. Aşama)	Yoğunluk farkı deyince öğrencilerin öncelikle aklına gelen zeytinyağı-su karışımından bahsedilerek, sıvı-sıvı heterojen karışımların yoğunluk farklarına göre ayırma hunisiyle ayrılabileceği açıklanır. "Sadece sıvı-sıvı heterojen karışımlar mı yoğunluk farkına göre ayrılabilir?" sorusu yöneltilerek öğrencilerin fikirleri alınır ve olası kavram yanılgıları kontrol edilir. Katı-katı heterojen karışımların da yoğunluk farkına göre ayrılabileceği açıklığa kavuşturulur ve böyle bir karışımı (kum-talaş gibi) ayırmak için maddelerin üzerine eklenecek çözücünün özelliklerinden bahsedilir. Yoğunluk farkına göre ayrılacak karışımlarda maddelerin yoğunluk sıralaması ile ilgili örnek sorular çözülerek öğrencilerin, en altta toplanan maddenin yoğunluğunun en büyük ve en üstte toplanan maddenin yoğunluğunun en küçük olduğunu kavramaları sağlanır. Katı-katı heterojen karışımların yoğunluk farkıyla ayrılabildiğini öğrenen öğrencilere "Naftalin-tuz karışımı da katı-katı heterojen karışım olduğuna göre maddelerin yoğunluk farklarına göre ayrılabilir mi?" sorusu sorularak yoğunluk ve çözünürlük farkı ile ayırma yöntemleri arasındaki farka vurgu yapılır. Böyle bir karışımın çözünürlük farkına göre ayrılabileceği açıklandıktan sonra "Karışımda birden fazla çözünen madde olursa nasıl ayırabiliriz?" sorusu yönlendirilir ve öğrencilerin fikirleri alınır. Katıların çözünürlüğünün sıcaklıkla artmasından yararlanarak geliştirilen kristallendirme yöntemi açıklandıktan sonra ayrımsal kristallendirme ile olan farkı vurgulanır. **[Çalışma yaprağı XI burada dağıtılır].** Şimdiye kadar bahsedilen ayırma yöntemlerinin tamamının heterojen karışımları ayırmak için uygun yöntemler olduğu hatırlatılarak "Homojen karışımlar bileşenlerine nasıl ayrılabilir?" sorusu yöneltilir. Saf maddeler ile çözeltilerin farklı olan bazı fiziksel özellikleri (kaynama süresince sıcaklık değişimi ve kaynama noktası yükselmesi) ile ilgili önbilgiler kontrol edilir. Katı-sıvı çözeltileri bileşenlerine ayırmak için buharlaştırma ve basit damıtma yöntemlerini kullanabileceklerini açıklayarak, bu iki yöntem arasındaki önemli fark üzerinde durulur. Diğer bir ifadeyle, sadece katı maddeyi elde etmek istiyorsak buharlaştırma yöntemini, hem katı hem de sıvı maddeyi geri elde etmek istiyorsak basit damıtma yöntemini kullanacaklarını öğrencilerin kavraması sağlanır. "Birden fazla sıvı birbiri içerisinde çözünüyorsa yine basit damıtma yöntemiyle bileşenlerine ayrılabilir mi?" sorusu yöneltilir ve öğrencilerden, bu duruma uygun örnekler vererek cevaba ulaşmaları istenir. Sıvı-sıvı homojen karışımların basit damıtma yerine ayrımsal damıtma yöntemiyle bileşenlerine ayrılabileceği açıklanır ve basit damıtma ile ayrımsal damıtma düzenekleri arasındaki tek fark olan fraksiyon kolonundan bahsedilir. Öğrencilerin öğrendikleri bilgileri uygulamalarına olanak tanımak amacıyla ayrımsal damıtma düzeneğini kurmaları sağlanır. Ham petrolün rafinerilerde çeşitli ürünlere ayrılmasının, endüstride ayrımsal damıtma yönteminin kullanım alanlarından birisi olduğu açıklanarak öğrencilerin sınıfta işlenilen konularla günlük hayat uygulamaları arasındaki bağlantıyı kurması sağlanır. **[Çalışma yaprağı XII burada dağıtılır].**

Table I.6 (continued)

Grup çalışması (II. Aşama)	Çalışma yaprağı XI ve XII dağıtılarak öğrencilerin grupları ile birlikte çalışması sağlanır. Öğretmen grupların arasında dolaşarak grupların çalışmalarını kontrol eder, çelişki yaratıcı sorular sorarak öğrencilerin üst düzey düşünme becerilerini geliştirir, yapıcı tartışma ortamları sağlar, geri bildirimlerde bulunur. Grupların tartışarak verdikleri ortak cevaplar öğretmenin belirleyeceği bir grup üyesi tarafından tüm sınıfa açıklanır. Tüm gruplar cevaplarını duyurduktan sonra anlaşılamayan kısımlar varsa öğretmen tarafından açıklığa kavuşturulur.
Grup içi işleyiş değerlendirmesi (III. Aşama)	Grup çalışması sırasında üyelerin nasıl çalıştığıyla ilgili öğrencilerin algılamalarını anlamak ve aksayan ya da güçlü özelliklerin farkına varmak amacıyla öğrencilerin "Grupta Ne Oldu" adlı anketi doldurması sağlanır. Öğretmenin grup çalışması sırasında yaptığı gözlemlere göre doldurduğu "Grup Gözlem Formu" sonuçlarından öğrenciler haberdar edilir ve hem bireysel hem de grup olarak ilerlemeleri değerlendirilir.
Bireysel test (IV. Aşama)	Quiz 3 dağıtılarak öğrencilerin bireysel olarak cevaplamaları istenir. Bu aşamada grup üyelerinin birbirlerine yardımcı olmaması beklenir.
Ölçme-Değerlendirme	• Çalışma yaprağı XI ve XII'de bulunan sorular • Quiz 3

APPENDIX J

TEACHING ACTIVITIES

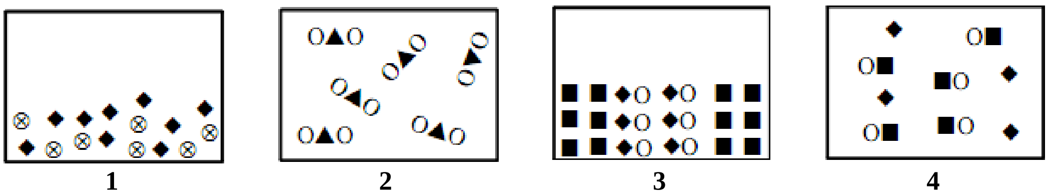
Karışımların Fiziksel ve Kimyasal Bileşimleriyle İlgili Çalışma Yaprağı

Doğada bulunan tüm maddeler saf madde midir

Karışımlar ve bileşikler aynı özelliklere mi sahiptirler

Karışımlar mı saf maddedir? Homojen karışımlar mı saf maddedir

Aşağıda gösterilen etkinliği tamamladıktan sonra bu sorulara cevap bulacaksınız.



İrem, yukarıda gösterilen maddeleri bileşik veya karışım olacak şekilde sınıflandırmaya çalışmaktadır. Gösterilen şekillerin tamamı farklı cins taneciklerden oluştuğu için maddelerin hepsinin karışım olduğuna karar verir. Fakat 2. şekilde gösterilen maddenin taneciklerinin her yerde aynı göründüğünü fark ederek onun homojen karışım olduğunu düşünür.

Cevabının doğru olup olmadığını kontrol etmek amacıyla arkadaşı Öykü'ye düşüncelerini sorar.

Öykü, 2. maddenin bileşik, diğerlerinin karışım olduğunu ve doğadaki tüm karışımların heterojen karışım olduğunu ileri sürer. İrem ve Öykü'nün verdikleri cevapları tartışarak;

a) Yukarıda gösterilen 4 maddeyi sınıflandırmalarında ve nedenlerini açıklamalarında onlara yardımcı olunuz (Saf madde olup olmadığını ve bileşik veya karışım olduğunu belirtiniz)

ÖRNEK: 1. madde ……………. Çünkü ……………………..

b) Yukarıda gösterilen 4 maddenin kimyasal bileşimlerini belirtiniz (atom, molekül, hem atom hem de molekül).

ÖRNEK: 1. madde ………… içermektedir.

c) Yukarıdaki kısımlarda verdiğiniz cevaplardan (a ve b soruları) yola çıkarak homojen karışım ve heterojen karışımın tanımını yapınız (Yaptığınız tanımlarda, bu karışımların içerdikleri taneciklerden de bahsetmeyi unutmayınız).

d) Homojen ve heterojen karışımlara günlük hayattan 2'şer tane örnek veriniz.

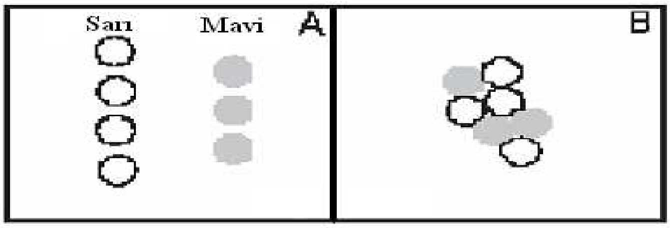
Karışımların Özellikleriyle İlgili Çalışma Yaprağı

Gerekli Malzemeler
-Oyun hamurları
-Deney tüpü
-Demir tozu
-Kükürt tozu
-Mıknatıs

Aslı: Turşu suyu nasıl hazırlanır anne?
Annesi: Tuz ve suyu karıştırman yeterli kızım.
Aslı: Her ikisinden de eşit miktarda mı eklemeliyiz?
Annesi: Eşit miktar olmak zorunda değil. Tadını nasıl istiyorsan ona göre ayarlama yapabilirsin.
Aslı: Peki, turşu suyunun içindeki tuz ve su özelliklerini kaybeder mi?
Annesi: Bilmiyorum.
Aslı: Bence kaybeder çünkü tuz artık katı değil sıvı halde bulunuyor yani eriyor. Peki, tuz ve suyu ilk hallerine döndürebilir miyiz?
Annesi: Emin değilim ama döndürebiliriz sanırım.
Aslı: Peki, nasıl? Tuzu ve suyu fiziksel yollarla elde edebilir miyiz?
Annesi: Mmm…

Yapacağınız etkinlikler sonunda Aslı ve annesinin arasında geçen konuşmalarda Aslı'nın sorduğu sorulara cevap bulacaksınız. Bunun için öncelikle aşağıda verilen yönergeleri takip ediniz ve sorulan sorulara cevap bulmaya çalışınız.

I. KISIM

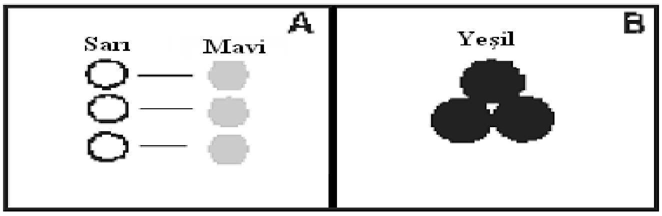


Figür 1

Elinizde bulunan sarı ve mavi hamurlardan 4 tane sarı ve 3 tane mavi top yapınız ve Figür 1'deki gibi rastgele sıralayınız.

- Sıraladığınız sarı ve mavi toplar fiziksel yollarla birbirlerinden ayrılabilir mi?
- Sıraladığınız sarı ve mavi toplar özelliklerini (renk) korudu mu?

II. KISIM

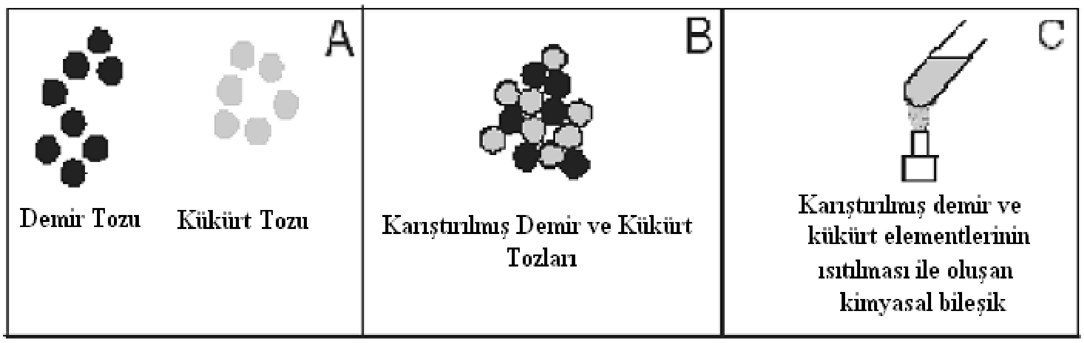


Figür 2

Elinizde bulunan sarı ve mavi hamurlardan 3 tane sarı ve 3 tane mavi top yapınız ve 1'e 1 oranında karıştırınız. Bu 2 rengin karışımıyla oluşan yeşil renkli 3 büyük top elde ediniz. Yeşil renkli topları Figür 2'deki gibi sıralayınız.

- Sıraladığınız yeşil toplar fiziksel yollarla ilk baştaki toplara (sarı ve mavi) dönüştürülebilir mi?
- Bu sıralamada ilk baştaki toplar (sarı ve mavi) özelliklerini korudu mu?

Şimdi kendi deneyimizi yapalım.



I. Kısım: Demir (Fe) ve Kükürt (S) tozunu karıştırınız ve karışıma mıknatıs yaklaştırınız. Demir ve kükürt tozları özelliklerini kaybetti mi? Tekrar eski hallerine dönüştürülebilir mi? Açıklayınız.

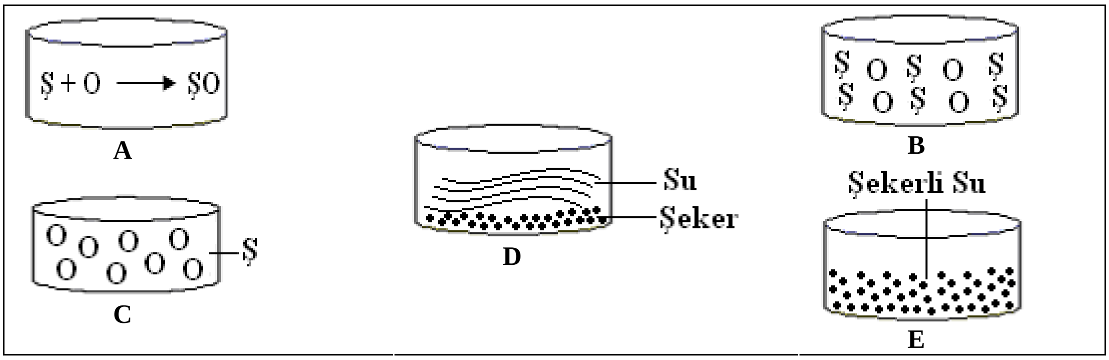
II. Kısım: Deney tüpüne Demir ve Kükürt tozu koyup, ısıtınız ve karışıma mıknatıs yaklaştırınız. Demir ve kükürt tozları özelliklerini kaybetti mi? Tekrar eski hallerine dönüştürülebilir mi? Açıklayınız.

I. ve II. Kısımlarda yapmış olduğunuz etkinliklere göre Aslı ve annesi arasında geçen diyalogda yer alan boşlukları doldurunuz.

Aslı: Turşu suyu nasıl hazırlanır anne?
Annesi: Tuz ve suyu karıştırman yeterli kızım.
Aslı: Her ikisinden de eşit miktarda mı eklemeliyiz?
Annesi: Eşit miktar olmak zorunda değil. Tadını nasıl istiyorsan ona göre ayarlama yapabilirsin.
Aslı: Peki, turşu suyunun içindeki tuz ve su özelliklerini kaybeder mi?
Annesi:…………………………………………….
Aslı: Peki, tuz ve suyu ilk hallerine döndürebilir miyiz?
Annesi:…………………………………………….
Aslı: Peki, nasıl? Tuzu ve suyu fiziksel yollarla elde edebilir miyiz?
Annesi:…………………………………………….

Çözünme Kavramıyla İlgili Çalışma Yaprağı

Elif öğretmen; **"Şekeri suyun içerisine attığımızda, şekerin kap içerisindeki dağılımı nasıl olur?"** sorusunu yöneltir ve öğrencilerden beşinin çizimleri aşağıdaki gibidir. Sizce bu gösterimlerden hangisi veya hangileri doğrudur? Neden doğru ya da neden yanlış olduklarını tartışınız. (Ş: Şekeri, O: Suyu temsil etmektedir).



- **A kabındaki gösterim:**
- **B kabındaki gösterim:**
- **C kabındaki gösterim:**
- **D kabındaki gösterim:**
- **E kabındaki gösterim:**

Tartışmalardan elde ettiğiniz bilgileri kullanarak aşağıda yer alan soruları cevaplayınız.

- Çözünme nasıl gerçekleşir?
- Erime nedir?
- Şekerli suyu kimyasal bir formülle ifade edebilir miyiz? Neden?
- Şekerli su kendini oluşturan şeker ve sudan farklı bir madde midir? Neden?
- Çaya şeker attığımızda homojen bir karışım mı, heterojen bir karışım mı elde ederiz?
- Çay bardağının tabanında şeker bulunmasını nasıl açıklarsınız?

Çözelti ve Bileşenleriyle İlgili Çalışma Yaprağı

- Çözeltiler her zaman sıvı halde midir
- Tüm çözeltilerde çözücü su mudur
- Çözeltiyi oluşturan bileşenler farklı fiziksel hallerde (katı, sıvı, gaz) olabilir mi

Öğrencilerin çoğunluğu yukarıdaki soruların cevaplarına ilişkin doğru olmayan fikirlere sahiptir. Etkinlikte verilen sistemlerle ilgili soruları tartışarak cevapladığınızda yukarıdaki soruların doğru cevaplarına da ulaşmış olacaksınız.

Sistem A: Tuzlu su

Sistem B: Ayran

Sistem C: Aseton ve su

Sistem D: Oje ve su

Sistem E: Deodorant

Sistem F: Hava

Sistem G: Tunç

Sistem H: Su

1. KISIM

- Sistem A ve Sistem B'yi; çözücü ve çözünenin cinsi, çözücü ve çözünenin fiziksel halleri, çözünenin çözücü içerisinde dağılma durumu (çözelti veya heterojen karışım), çözeltinin fiziksel hali ölçütlerine göre sırayla karşılaştırınız.

- Sistem C ve Sistem D'yi; çözücü ve çözünenin cinsi, çözücü ve çözünenin fiziksel halleri, çözünenin çözücü içerisinde dağılma durumu (çözelti veya heterojen karışım), çözeltinin fiziksel hali ölçütlerine göre sırayla karşılaştırınız.

2. KISIM

- Sistem E'de belirtilen deodorantta çözücü olarak, oda sıcaklığında kolaylıkla buharlaşan etanol kullanılmaktadır. Deodorantta çözücü olarak etanol yerine su kullanılsaydı ne gibi farklılıklar olurdu?

- Sistem F'de belirtilen hava hangi karışım sınıfına girer? Havayı oluşturan madde(leri)n fiziksel hallerini belirtiniz.

- Sistem G'de belirtilen tunç, % 85 bakır ve % 15 kalaydan meydana gelen bir alaşımdır. Bu alaşımı oluşturan maddeler özelliklerini korur mu?

- Sistem H'de belirtilen su hangi madde sınıfına girer? Suyu oluşturan maddeleri ve varsa çözünen, çözücü maddelerin isimlerini yazınız.

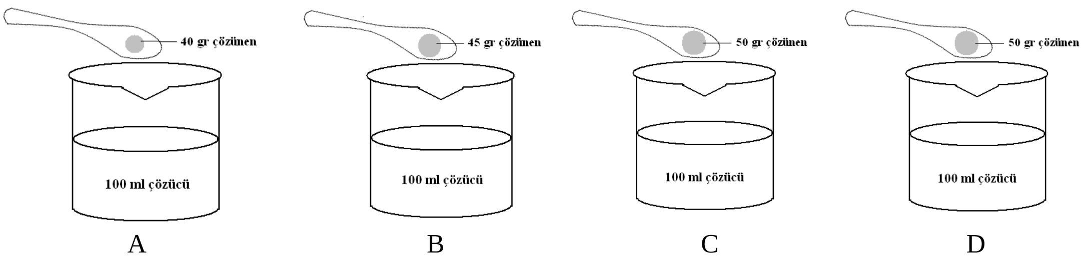
Tartışmalardan elde ettiğiniz deneyimlerden faydalanarak çözünen, çözücü ve çözelti kavramlarını açıklayınız ve çalışma yaprağının başında sorulan soruları günlük hayattan örnekler vererek cevaplayınız.

- Çözünen
- Çözücü
- Çözelti
- Çözeltiler her zaman sıvı halde midir?
- Tüm çözeltilerde çözücü su mudur?
- Çözeltiyi oluşturan bileşenler farklı fiziksel hallerde (katı, sıvı, gaz) olabilir mi?

Çözelti Türleriyle İlgili Çalışma Yaprağı

- Derişik çözeltiyle doymuş çözelti, seyreltik çözeltiyle doymamış çözelti aynı anlamda mıdır?
- Dibinde çözünmemiş madde olan çözelti aşırı doymuş çözelti midir?
- Kabın tabanındaki çözünmeyen madde çözeltinin bileşeni midir?

Bu sorulara cevap bulmak için öncelikle etkinlikte verilen yönergeleri takip ediniz ve sorulan soruları cevaplayınız.



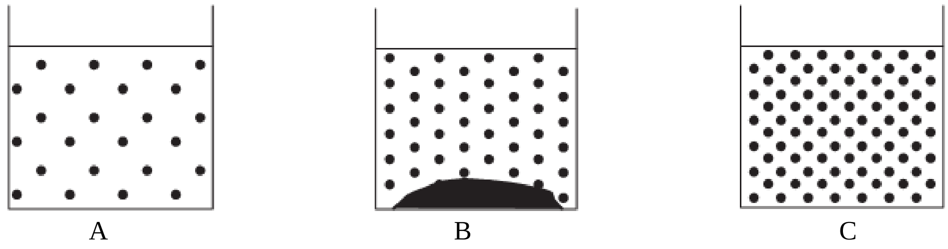
1. Yukarıdaki A, B, C ve D beherlerinde **eşit miktarda (100 ml)** çözücü bulunmaktadır ve 100 ml çözücü 25 ^{o}C'de 50 gram madde çözmektedir. A beherine 40 gram, B'ye 45 gram, C ve D'ye 50 gram çözünen ekleniyor ve karıştırılıyor. Daha sonra, D beherine 5 gram daha çözünen ilave edilip, 50 ^{o}C'ye kadar ısıtılıyor ve tekrar soğutuluyor.

- Beherlerde bulunan çözeltilerin doymuşluk seviyelerine göre türlerini belirtiniz.

- Aşağıdaki cümlelerde yer alan boşlukları doldurunuz.

  1) B kabındaki çözelti …………………. çözeltidir ve A kabındaki çözeltiye göre ……………………….. çözeltidir.

  2) C kabındaki çözelti …………………. çözeltidir ve D kabındaki çözeltiye göre ……………………….. çözeltidir.



2. Yukarıdaki A, B ve C beherlerinde farklı yoğunluklarda şekerli su çözeltileri bulunmaktadır. Kapların içerisinde gösterilen noktalar çözünen şeker moleküllerini ve noktaların yoğunluğu da çözeltilerin yoğunluğunu temsil etmektedir. B beherinin altında bulunan koyu alan, çözünmeden kalan şekeri göstermektedir.

   - Beherlerde bulunan çözeltilerin doymuşluk seviyelerine göre türlerini belirtiniz ve nedenlerini tartışınız.

   - B beherinin dibindeki çözünmeden kalan şeker çözeltinin bileşeni midir? Nedenini açıklayınız.

3. Derişik çözeltiyle doymuş çözelti, seyreltik çözeltiyle doymamış çözelti aynı anlamda mıdır? Neden?

4. Çay bardağına çayın çözebileceğinden fazla şeker atarsak fazla olan şeker bardağın tabanında birikir. Sizce dipte kalan şeker de çaya tat verir mi? Neden?

Basıncın Gazların Çözünürlüğüne Etkisiyle İlgili Çalışma Yaprağı

Gaz parçacıkları arasındaki mesafe azalacağı için mi basınç arttıkça gazların çözünürlüğü artar

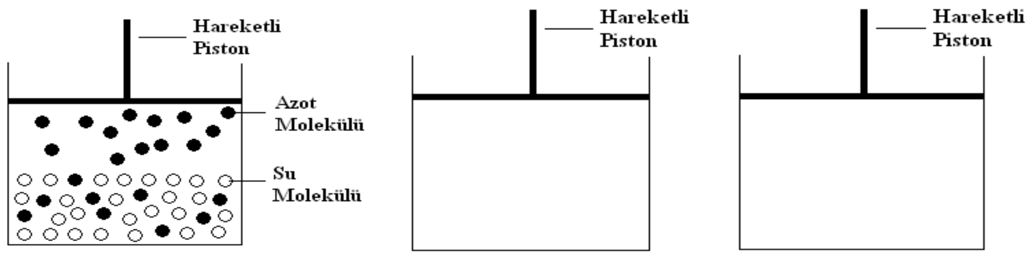
Gaz parçacıkları kabın şeklini alacağı için mi basınç arttıkça gazların çözünürlüğü artar

Gaz parçacıkları sıvı hale geleceği için mi basınç arttıkça gazların çözünürlüğü azalır

Basınç altında farklı gaz parçacıkları üreyeceği için mi basınç arttıkça gazların çözünürlüğü azalır

1. Denizin derinliklerinden su yüzeyine süratle çıkılması durumunda azot gazının kandaki çözünürlüğü azalır ve dekompresyon ya da vurgun adıyla bildiğimiz sağlığı tehdit edici bir olay yaşanır. Yukarıda yer alan soruları tartışarak vurgun olayının sebebini açıklayınız.

2. Aşağıdaki pistonlu kap deniz seviyesinde ve 25 °C'de azot gazının sudaki çözünürlüğünü göstermektedir. Deniz seviyesinden 15 metre ve 30 metre derinliğe inildiğinde **aynı sıcaklıkta** azot gazı moleküllerinin tahmini dağılımını çiziniz ve nedenini kısaca açıklayınız. (İpucu: Derinlik arttıkça basınç artar)



Deniz Seviyesi **15 metre** **30 metre**

3. Gazlı bir içecek şişesinin kapağı açıldığında kabarcıklarının yükseldiği gözlemlenir. Bu olayı, basıncın gazların çözünürlüğüne etkisini ele alarak açıklayınız.

Sıcaklığın Katıların ve Gazların Çözünürlüğüne Etkisiyle İlgili Çalışma Yaprağı

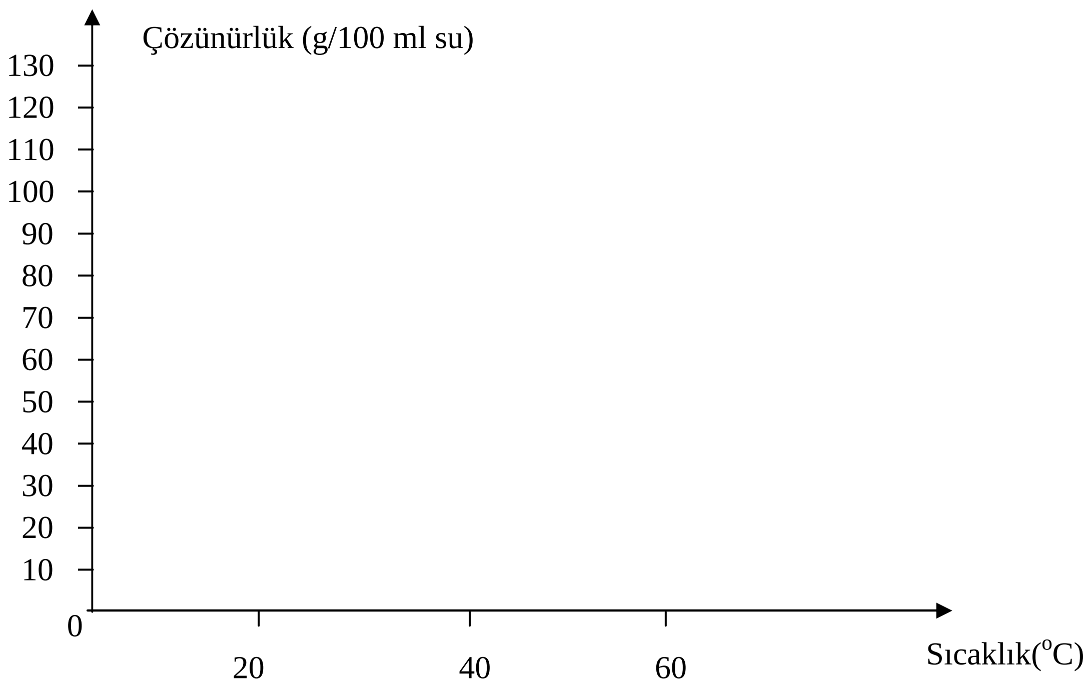
- Katı maddelerin çözünebilmesi için çözücünün sıcak olması mı gerekir?
- Çözücü sıcak olmazsa katı madde çöker mi?

Yapacağınız etkinlikler sonunda bu sorulara cevap bulacaksınız. Bunun için öncelikle aşağıda verilen yönergeleri takip ediniz ve sorulan sorulara cevap bulmaya çalışınız.

1. Aşağıdaki tabloda bazı maddelerin sabit basınçta ve farklı sıcaklıklarda 100 ml sudaki çözünürlükleri verilmiştir.

Sıcaklık (°C) / **Madde**	**0**	**20**	**40**	**60**
NaCl	35,7	36,0	36,5	37,2
KNO_3	13,3	31,6	63,9	110,0
$NaNO_3$	73,0	88,0	104,0	124,0
KCl	27,6	34,0	40,0	45,5

a. Tablodaki bilgileri kullanarak, maddelerin çözünürlüklerinin sıcaklıkla değişimi grafiğini çiziniz.



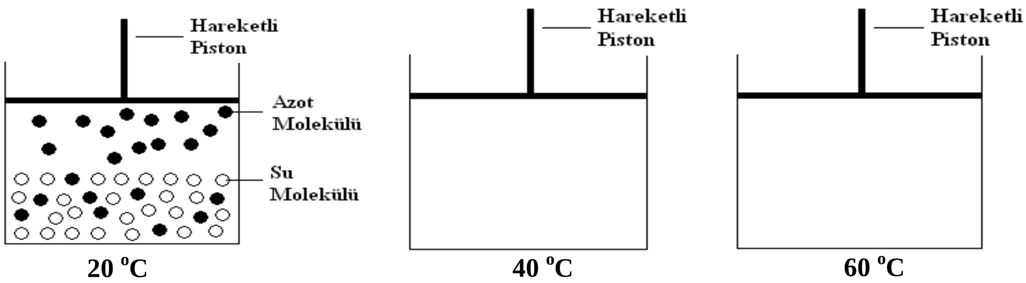
b. Grafiğe göre, su sıcak olmasa da içerisinde katı madde çözünebilir mi? Açıklayınız.

c. Tabloda belirtilen maddelerin katı halde olduğu bilindiğine göre, sabit basınçta sıcaklık ve katıların çözünürlüğü arasında nasıl bir ilişki vardır? (Değişkenlerden her ikisinin de arttığı veya azaldığı ilişkiler doğru orantı, değişkenlerden birisi artarken diğerinin azaldığı ilişkiler ters orantı olarak tanımlanır)

d. Tabloda belirtilen maddelerin tümü katı olduğu halde çözünürlüklerinin farklı olması ne anlama gelir?

e. Tabloda belirtilen maddelerden, 20 ^oC'de 100 ml suda çözünen madde miktarı aynı olan var mı? Nedenini açıklayınız.

2. Aşağıdaki pistonlu kap 1 atm basınç ve 20 ^oC'de azot gazının sudaki çözünürlüğünü göstermektedir. 40 ^oC ve 60 ^oC'de azot gazı moleküllerinin tahmini dağılımını çiziniz ve nedenini kısaca açıklayınız.



3. Yaz aylarında balıklar suların derinliklerinde yaşar. Bu durumun sebebi ne olabilir? Açıklayınız.

Karıştırma ve Temas Yüzeyinin Çözünürlüğe Etkisiyle İlgili Çalışma Yaprağı

> Sabit sıcaklık ve basınçtaki bir maddeyi karıştırmak veya temas yüzeyini değiştirmek o maddenin çözünürlüğünü etkiler mi?

Bu soruya cevap bulmak için öncelikle İrem ve annesi arasında geçen diyalogu okuyunuz ve sorulan soruları cevaplayınız.

İrem: Reçel yaparken sana yardım edebilir miyim, anne?
Annesi: Elbette. Şekeri bana vermekle başlayabilirsin.
(İrem, şekeri annesine uzatır)
Annesi: İlahi İremcim! Toz şekeri uzatmanı bekliyordum fakat sen bana küp şeker verdin.
İrem: Fark etmez diye düşünmüştüm. Neden toz şeker kullanmalıyız?
Annesi: Mmm…
(Annesi toz şekeri çileklerin üzerine döker ve tencereyi ocağın üzerine koyar)
Annesi: Reçeli karıştırabilir misin, kızım?
İrem: Karıştırmazsam reçel olmaz mı yani?
Annesi: Mmm…

1. İrem'in sorduğu sorular karşısında zor durumda kalan annesine, aşağıdaki soruları cevaplayarak yardımcı olunuz.

    - Reçel yaparken küp şeker yerine toz şeker kullanılmasının sebebini açıklayınız.

    - Reçelin karıştırılması neden gereklidir? Açıklayınız.

2. 1 kg şeker ve 1 kg çilekle yapılan reçeli: Deniz, toz şeker kullanarak yapmış ve karıştırmamıştır; Ceyda, pudra şekeri kullanarak yapmış ve karıştırmamış, Merve ise pudra şekeri kullanarak ve karıştırarak yapmıştır. Deniz, Ceyda ve Merve'nin yaptığı reçellere göre;

    - Reçellerin tadı (şeker bakımından) AYNIDIR/ FARKLIDIR. Çünkü,

    - Reçellerin olma süresi AYNIDIR/ FARKLIDIR. Çünkü,

    - Yukarıdaki soruya "FARKLIDIR" yanıtını verdiyseniz, reçellerin olma süresini kısadan uzuna doğru sıralayınız.

Karışımların Fiziksel Özellikleriyle İlgili Çalışma Yaprağı (Koligatif Özellikler)

Esra, İpek, Sevda, Harun ve Ahmet karışımların fiziksel özellikleriyle ilgili bilgiler vermektedirler. Bu 5 arkadaşın verdiği bilgileri tartışınız ve doğru mu yanlış mı olduklarını sebepleriyle birlikte açıklayınız.

Esra: “Yemek pişirirken tuz başta eklenirse yemek daha çabuk pişer”

İpek: “100 gram şeker ve 200 gram suyla yapılan şerbetin kütlesi 200 gramdır”

Sevda: “Belirli sıcaklık ve basınçta aseton-su çözeltisinin yoğunluğu bellidir”

Harun: “Antifriz katkılı suyun 1 atmosfer basınçta kaynama noktası 100 ^{o}C’dir”

Ahmet: “Kışın yollara atılan tuz karların erimesini sağlar”

Tanecik Boyutu Farkından Yararlanılarak Geliştirilen Ayırma Yöntemleri

Kimya dersinde verilen "diyaliz" konulu performans ödevini yapmak için araştırmalar yapan Ahmet, Dünya böbrek günü kapsamında düzenlenen etkinlikleri incelemiş ve "diyaliz makinesine bağlı hastaları ziyaret" adlı etkinliğe katılmaya karar vermiştir. Bu ziyaret sırasında, diyalizin ne olduğunu ve nasıl yapıldığını yetkililerden öğrenme fırsatı yakalamıştır.
Ahmet: Diyaliz nedir?
Yetkili: Vücutta oluşan atık maddeleri vücuttan uzaklaştırmakla görevli böbreğin çeşitli sebeplerle görevini yapamaz hale gelmesi sonucu oluşacak sorunları önlemek amacıyla dışarıdan müdahale edilmesine olanak tanıyan yönteme diyaliz denir.
Ahmet: Vücutta oluşan atık maddeler diyaliz yöntemiyle kandan nasıl uzaklaştırılır?
Yetkili: Kan, yararlı ve zararlı maddelerden oluşan heterojen katı-sıvı karışımıdır. Tanecik boyutları farklı olan maddeleri yapısında bulunduran kan, yarı geçirgen zar (membran) yardımıyla temizlenir. Şöyle ki, proteinler büyük moleküllü olduğu için zardan geçemezken, üre ve ürik asit gibi zararlı ve küçük moleküllü bazı maddeler zardan dışarı atılır. Böylelikle, kan temizlenmiş olur.
Ahmet: Öyleyse diyaliz bir çeşit süzme yöntemi midir?
Yetkili: Evet. Diyaliz, koloit karışımların gözenekli zarlardan geçebilmesi temeline dayanan çözümleme ve arıtma işlemidir.

1. Diyalizin ne olduğunu ve çalışma prensibini anlayan Ahmet'in aklına bir soru takılmıştır. Kum ve su da heterojen bir karışım olduğuna göre, kumlu suyu bileşenlerine ayırmak için kullanılacak en uygun yöntem diyaliz midir? Nedenini açıklayınız.

2. Homojen karışımları bileşenlerine ayırmak için tanecik boyutu farkı kullanılabilir mi? Nedenini açıklayınız.

3. Katı-gaz karışımları (örneğin; zehirli gazın salındığı hava) ayırmak için süzme yöntemi kullanılabilir mi? Cevabınız evet ise, süzme yöntemiyle bileşenlerine ayrılabilen katı-gaz karışımına günlük hayattan bir örnek veriniz.

4. Tanecik boyutu farkından yararlanılarak geliştirilen ayırma yöntemlerinin (ayıklama, eleme, süzme, diyaliz) ortak özelliği nedir? (İpucu: karışımların sınıflandırılmasını düşününüz)

5. Çamurlu suyu süzme yöntemiyle bileşenlerine ayırırsak,
   a. Süzgeç kâğıdının üzerinde kalan madde hangisidir? Nedenini açıklayınız.

   b. Süzgeç kâğıdından geçen madde hangisidir? Nedenini açıklayınız.

Yoğunluk ve Çözünürlük Farkından Yararlanılarak Geliştirilen Ayırma Yöntemleri

1. Su, zeytinyağı ve civadan oluşan bir karışım ayırma hunisine koyulduğunda yanda gösterilen şekildeki gibi görünmektedir.

   a. Bu karışımı bileşenlerine ayırmak için karışımı oluşturan maddelerin hangi özelliklerinin farklı olmasından yararlanılır?

   b. Şekilde görülen tabakaların aşağıdan yukarıya doğru 1, 2 ve 3 numaralarıyla temsil edildiği bilindiğine göre, 2 ile gösterilen tabakadaki madde hangisidir?

   c. Toplama kabında en son toplanan madde hangisidir? Nedenini açıklayınız.

   d. Ayırma hunisi yardımıyla hangi tür karışımlar bileşenlerine ayrılabilir? (İpucu: maddelerin fazını ve karışımların sınıflandırılmasını düşününüz)

2. Doğada saf halde bulunan altın madenlerinden altın elde etmek için altın, toprak ve suyun yoğunluk farkından yararlanılarak geliştirilen aktarma yöntemi kullanılır. Süspansiyon karışımlara örnek olan tebeşirli su da aktarma yöntemiyle bileşenlerine ayrılabilir mi? Nedenini açıklayınız.

3. Aşağıdaki tablo K, L, M ve N katı maddelerinin sudaki çözünürlüklerinin sıcaklıkla değişimini göstermektedir. Tablodaki bilgileri kullanarak aşağıdaki soruları cevaplayınız.

Maddeler	**Sudaki Çözünürlüğü (20°C)**	**Sudaki Çözünürlüğü (50°C)**
K	36,0	37,0
L	Çözünmez	Çözünmez
M	88,0	113,0
N	22,0	15,0

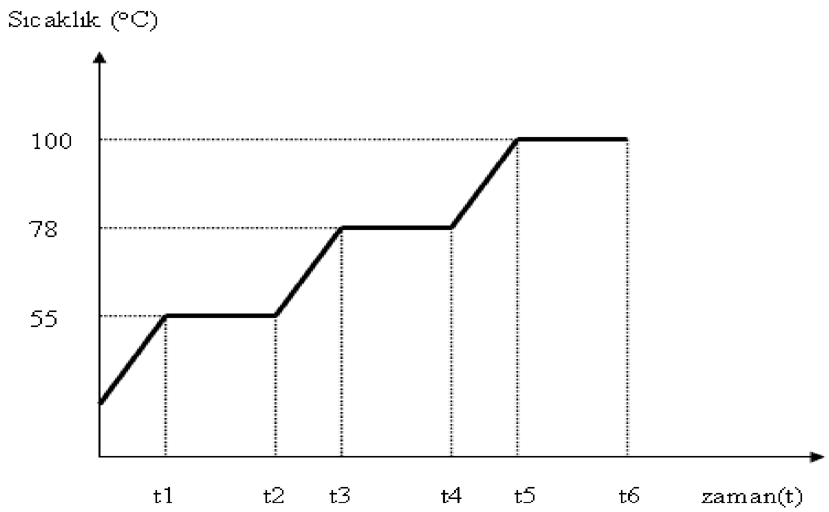
   a. K ve L maddelerinden oluşan karışımı bileşenlerine ayırırken hangi ayırma yöntemini kullanırsınız? Nedenini açıklayınız.

   b. M ve N maddelerinden oluşan karışımı bileşenlerine ayırırken hangi ayırma yöntemini kullanırsınız? Nedenini açıklayınız.

   c. K ve N maddelerinden oluşan karışım bileşenlerine ayrılırken hangi madde süzgeç kâğıdında kalır?

Kaynama Noktası Farkından Yararlanılarak Geliştirilen Ayırma Yöntemleri

Etil alkol, aseton ve sudan oluşan karışımın bileşenlerine ayrılmasına ilişkin bilgiler içeren aşağıdaki sıcaklık-zaman grafiğini kullanarak soruları cevaplandırınız. (İpucu: Asetonun kaynama noktası etil alkolün kaynama noktasından küçüktür).



a. Grafiğe göre 3 zaman diliminde (t_1-t_2, t_3-t_4, t_5-t_6) sıcaklık sabit kalmıştır. Bu durumun nedenini açıklayınız.

b. Grafiğe göre, 0-t_1, t_2-t_3 ve t_4-t_5 zaman aralıklarında sıcaklık nasıl değişmektedir? Bu durumun nedenini açıklayınız.

c. Etil alkol, aseton ve sudan oluşan bu karışımı bileşenlerine ayırmak için hangi yöntemi kullanırsınız? Nedenini açıklayınız.

d. t_2 anından itibaren karışımda hangi maddeler vardır? Nedenini açıklayınız.

e. t_4 anında karışımdan tamamen ayrılan madde hangisidir? Nedenini açıklayınız.

f. Metil alkol ve sudan oluşan bir karışımı da yukarıdaki karışım için önerdiğiniz yöntem ile bileşenlerine ayırabilir misiniz? Nedenini açıklayınız. (1 atmosfer basınçta metil alkolün kaynama noktası 65 ^{o}C ve suyun kaynama noktası 100 ^{o}C'dir).

g. Şekerli su karışımını bileşenlerine ayırırken hangi yöntemi kullanırsınız? Nedenini açıklayınız.

h. Şekerli su ve metil alkol-su karışımı arasındaki benzerlikler ve farklılıklar nelerdir? (Karışımların sınıflandırılması, karışımı meydana getiren bileşenlerin fiziksel halleri ve bileşenlere ayrılma yöntemlerine göre kıyaslama yapınız).

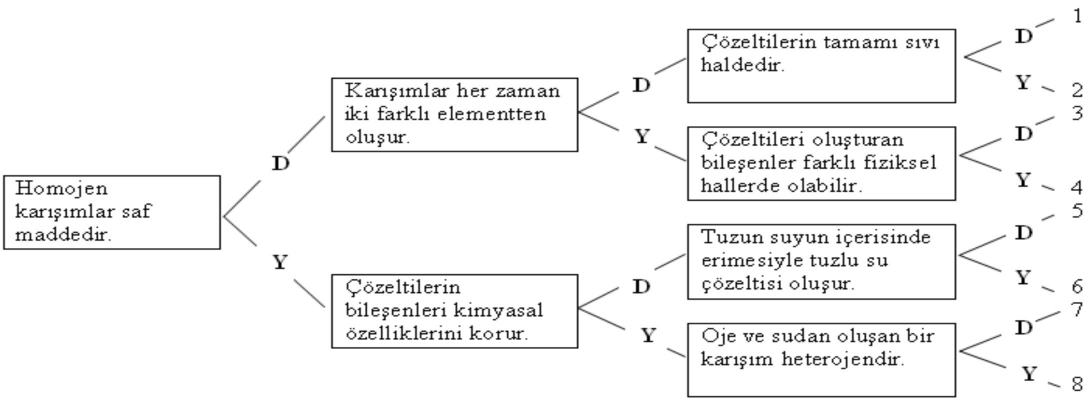
APPENDIX K

QUIZZES

QUIZ 1

1. **"D" nin doğru ifadeyi "Y" nin yanlış ifadeyi temsil ettiği aşağıdaki şekilde, kutuların içerisinde yer alan bilgilerin doğru veya yanlış olmasına göre devam ederek 8 tane çıkışın birini işaretleyiniz. Bu sorudan, seçtiğiniz her bir adıma göre puan alacaksınız; 3 doğru adım işaretleyerek doğru çıkışı seçenler 60 puan alacak, 2 doğru adım işaretleyenler 40 puan alacak, 1 doğru adım işaretleyenler 20 puan alacak, hiçbir adımı doğru işaretleyemeyenler ise puan alamayacaktır.**

   Örnek: 1. kutuda yer alan bilgi doğru ise üst taraftaki yanlış ise alt taraftaki kutuya geçin. Geçtiğiniz kutudaki bilgi doğru ise üst taraftaki yanlış ise alt taraftaki kutuya geçin. Böylelikle, sağ taraftaki 8 çıkıştan birini işaretleyin.



2. **Aşağıdaki ifadelerin doğru ya da yanlış olduğunu uygun yere çarpı işareti (X) koyarak gösteriniz. İfade yanlış ise doğrusunu kısaca açıklayınız. Her bir soru 2 puan değerindedir.**

		DOĞRU	YANLIŞ
a.	Şeker ve su karıştırıldığı zaman şekerli su adıyla yeni bir madde oluşur.	……..	……..
b.	Bir maddenin diğeri içinde çözünmesi fiziksel bir olaydır.	……..	……..
c.	Alkolün suyun içerisinde çözünmesi esnasında alkol molekülleri kaybolur.	……..	……..
d.	Alaşımları oluşturan maddeler kendi özelliklerini kaybetmezler.	……..	……..
e.	Çözeltiyi oluşturan bileşenler farklı fiziksel hallerde olabilir.	……..	……..
f.	Tuzlu su çözeltisinde tuz parçacıkları kabın dibinde toplanırken su molekülleri kabın üstünde toplanır.	……..	……..
g.	Şeker suyun içerisinde erir ve şekerli su çözeltisi oluşur.	……..	……..

3. Aşağıdaki ifadelerde verilen boşlukları doldurunuz. Her bir boşluk 2 puan değerindedir.

a. ………….. ve …………….. saf maddeler olarak gruplandırılırken, ………………… saf madde değildirler.

b. Kükürt ve demir tozunun karıştırılması ile …………….. karışım meydana gelir ve demirin mıknatıslanma özelliğinden faydalanarak bu iki madde birbirinden tekrar ayrılabilir. Kükürt ve demir tozu karışımını ısıtıp mıknatıs yaklaştırırsak, kükürt ve demir tozunu …………………….. Çünkü ………………………………………..

c. Çözeltilerin tamamı sıvı halde değildir. ……………… katı çözeltilere, ……………. gaz çözeltilere örnek olarak verilebilir.

4. Aşağıdaki kavramları kendi ifadelerinizle tanımlayınız. Her bir soru 2 puan değerindedir.

a. Heterojen karışım

b. Çözelti

c. Çözünen

d. Alaşım

e. Çözünme

QUIZ 2

1. Aşağıdaki ifadelerde verilen boşlukları doldurunuz. Her bir boşluk 2 puan değerindedir.

a. Belirli bir sıcaklıkta, belirli bir miktar çözücünün çözebileceği en fazla miktarda çözünen madde içeren çözeltiye …………………… çözelti denir.

b. Çözeltileri doymuşluk seviyelerine göre sınıflandırabilmek için …………………….. değerinin bilinmesi gerekir fakat ………………….. ve ………………………… çözeltiler, çözücü içerisinde çözünen madde miktarının az veya çok olmasına göre sınıflandırılır.

c. Yaz aylarında balıkların suların derinliklerinde yaşaması ………………………… çözünürlüğüne etkisiyle açıklanır.

d. Belirli sıcaklık ve basınçta farklı iki maddenin çözünürlüğü ……………………….

e. Sıcaklığın sabit tutulduğu hareketli pistonda bulunan O_2 gazının sudaki çözünürlüğü, piston indirildikçe ………………

f. Sabit basınçta, 20 ^{o}C ve 60 ^{o}C’de bulunan CO_2 gazının sudaki çözünürlükleri karşılaştırılırsa 20 ^{o}C’de bulunan CO_2 gazının sudaki çözünürlüğü daha ………….

g. 1 atmosfer basınçta, 20 ^{o}C ve 60 ^{o}C’de bulunan NaCl’ün sudaki çözünürlükleri karşılaştırılırsa 20 ^{o}C’de bulunan NaCl’ün sudaki çözünürlüğü daha ……………...

2. Aşağıdaki ifadelerin doğru ya da yanlış olduğunu uygun yere çarpı işareti (X) koyarak gösteriniz. İfade yanlış ise doğrusunu kısaca açıklayınız. Her bir soru 4 puan değerindedir.

		DOĞRU	**YANLIŞ**
a.	Aşırı doymuş çözeltiler, tabanında çözünmeden kalan madde içeren çözeltilerdir.	……..	……..
b.	Kabın tabanında çözünmeden kalan madde çözeltinin bileşenidir.	……..	……..
c.	Belirli sıcaklık ve basınçtaki çözünürlük değeri maddelerin kimliklerinin anlaşılmasında kullanılabilir.	……..	……..
d.	Derişik çözeltiler de doymuş çözeltiler gibi daha fazla madde çözemez.	……..	……..
e.	Belirli bir sıcaklıkta doymamış çözelti aynı zamanda derişik olabilir.	……..	……..
f.	Katı maddelerin çözünebilmesi için çözücünün sıcak olması gerekir.	……..	……..
g.	Katı bir maddenin belirli bir sıcaklıkta ve belirli bir çözücüdeki çözünme hızı karıştırılarak artırılabilir.	……..	……..

3. K, L, M maddelerinin farklı sıcaklıklarda bulunan çözücüdeki çözünürlükleri ile ilgili verilen grafiği kullanarak aşağıdaki soruları cevaplayınız. Her bir boşluk 4 puan değerindedir.

Maddeler	**0 ^oC**	**20 ^oC**	**40 ^oC**	**60 ^oC**
K	35,7	36,0	36,5	37,2
L	0,335	0,169	0,076	0,050
M	73,0	88,0	104,0	124,0

a. L maddesinin doymuş çözeltisinde kristalleşme sağlamak için çözeltinin sıcaklığı ……………….. Çünkü…………………………………………………………

b. K maddesinin doymuş çözeltisinde kristalleşme sağlamak için çözeltinin sıcaklığı ……………….. Çünkü …………………………………………………………

c. K, L, M maddelerinin fiziksel halleri (katı, sıvı, gaz) ne olabilir?

d. Tabloda verilen bilgileri ve yukarı verdiğiniz cevapları birlikte değerlendirerek maddelerin katı, sıvı ve gaz hallerinde çözünürlüğün sıcaklıkla nasıl değiştiğini açıklayınız.

4. Aşağıdaki kavramları kendi ifadelerinizle tanımlayınız. Her bir soru 5 puan değerindedir.

a. Çözünürlük

b. Doymuş çözelti

c. Derişik çözelti

d. Doymamış çözelti

e. Seyreltik çözelti

f. Aşırı doymuş çözelti

QUIZ 3

1. **Aşağıdaki ifadelerin doğru ya da yanlış olduğunu uygun yere çarpı işareti (X) koyarak gösteriniz. İfade yanlış ise doğrusunu kısaca açıklayınız. Her bir soru 4 puan değerindedir.**

		DOĞRU	**YANLIŞ**
a.	Katı-sıvı karışımların tamamı süzme yöntemiyle bileşenlerine ayrılabilir.	……..	……..
b.	Süzme yöntemi katı-gaz heterojen karışımları bileşenlerine ayırmak için kullanılabilir.	……..	……..
c.	Alaşımlar tanecik boyutu farkından yararlanılarak bileşenlerine ayrılabilirler.	……..	……..
d.	Katı-sıvı heterojen karışımlar süzüldüğü zaman katı olan madde filtre kâğıdında kalır.	……..	……..
e.	Otomobillerde polen filtresi ile havayı süzme işlemi katı-gaz heterojen karışımları ayırmaya bir örnektir.	……..	……..
f.	Diyaliz, büyük moleküllü maddelerin zardan dışarı atılması esasına dayanan bir çeşit süzme yöntemidir.	……..	……..
g.	Gaz karışımları yoğunluk farkı kullanılarak bileşenlerine ayrılabilir.	……..	……..
h.	Deniz suyundan tuz elde ederken çöktürme yöntemi kullanılır.	……..	……..

2. **Aşağıdaki ifadelerde verilen boşlukları doldurunuz. Her bir boşluk 2 puan değerindedir.**

   a. Tanecik boyutu farkından yararlanılarak geliştirilen yöntemler …….., …….., …….., ……… Bu dört yöntemin ortak özelliği ……………………………………..(İpucu: karışımların sınıflandırılmasını düşününüz).

   b. Diyaliz ve süzme yöntemleri katı-sıvı heterojen karışımları bileşenlerine ayırmak için kullanılır. Bu iki yöntem arasındaki fark ………………………………………………

   c. Sıvı-sıvı karışımların ayırma hunisi yardımıyla bileşenlerine ayrılabilmesi için ………………….. farklı olması ve birbiri içerisinde ………………… gerekir.

   d. Katı-katı heterojen karışımların yoğunluk farkına göre bileşenlerine ayrılabilmesi için eklenecek sıvının yoğunluğunun ………………………….. olması gerekir.

   e. Çözünürlüklerinin sıcaklıkla değişimi farklı olan iki katı maddeyi ayırmak için ……… yöntemi kullanılır.

   f. Karışımları meydana getiren maddelerin kaynama noktaları arasındaki farktan yararlanılarak geliştirilen ayırma yöntemleri ……………….., ……………………… ve …………………… Bu üç yöntemin ortak özelliği …………………… karışımları ayırmak için kullanılmalarıdır.

   g. Katı-sıvı homojen karışımlardan sadece katı olan maddeyi elde etmek için ……………., hem katı hem de sıvı maddeyi elde etmek için ise ………………….. yöntemi kullanılır.

h. Sıvı-sıvı homojen karışımları bileşenlerine ayırmak için ……………………... yöntemi kullanılır.

i. Gül çiçeğinden gül yağı elde etmek için kullanılan yöntem ……………………………

3. Aşağıdaki karışımları ayırmak için uygun ayırma yöntemleri öneriniz ve önerinizin gerekçesini kısaca açıklayınız. (Karışımların ayrılması için birden fazla yöntem önermeniz gerekebilir). Her bir soru 5 puan değerindedir.

a. Aseton-talaş-su

b. Nikel tozu-kum

c. Naftalin-şeker

d. NaCl-$CaCl_2$

4. Aşağıdaki tabloda karışımları ayırmak için kullanılan özellikler ve bu özelliklerden yararlanılarak geliştirilen yöntemlerde kullanılan araçlar verilmiştir. Maddelerin özelliklerini ve araçları eşleştiriniz. Her bir boşluk 3 puan değerindedir.

1. Tanecik boyutu farkı	a. Ayrımsal damıtma düzeneği
2. Yoğunluk farkı	b. Süzgeç kâğıdı
3. Kaynama noktası farkı	c. Filtre
4. Tanecik boyutu farkı	d. Ayırma hunisi

APPENDIX L

GROUP OBSERVATION FORM

GRUP GÖZLEM FORMU

Grup gözlem formu, işbirlikli öğrenme yönteminden verim elde edebilmek için gerekli olan temel ilkeleri kapsayan cümlelerden oluşmaktadır. Öğrencilerin takım çalışmaları sırasında sergiledikleri davranışların ne derece etkili olduğunu kontrol etmek ve geri dönüt vermek amacıyla, öğretmen tarafından her bir yapılandırılmış işbirlikli öğrenme grubu için doldurulacaktır. Verilen cümleleri dikkatle okuduktan sonra, "Hiçbir zaman", "Bazen" veya "Her zaman" derecelerinden birini işaretleyiniz.

Sınıf:

Konu:

Grup Adı:

	Hiçbir Zaman	**Bazen**	**Her Zaman**
1. Öğrenciler, bireysel olarak test edilmeden önce tüm grup üyelerinin konuyu öğrendiğinden emin oluyor.			
2. Etkinliklere tüm grup üyeleri katılıyor ve grup olduklarının bilinciyle takım çalışması yürütüyorlar.			
3. Öğrenciler, yardıma ihtiyacı olan grup üyelerini fark ediyor ve anlamalarına yardımcı oluyor.			
4. Öğrenciler, birbirlerinin söylediklerini dinliyor, düşüncelerine saygı duyuyor ve grup çalışması için gerekli olan kaynakları (çalışma kâğıdı, kitap, vb.) paylaşıyorlar.			
5. Öğrenciler, anlamakta zorlandıkları kısımları öğretmene sormadan önce, üst düzey düşünme becerileri kullanarak kendi aralarında çözmeye çalışıyor.			
6. Öğrenciler, fikir ayrılıklarına düştükleri konular üzerine yapıcı tartışmalar yürütüyor ve grup kararını demokratik şekilde alıyorlar.			
7. Öğrenciler etkinlikler sonunda grup işleyişini değerlendiriyorlar.			

APPENDIX M

WHAT HAPPENED IN THE GROUP QUESTIONNAIRE

“GRUPTA NE OLDU” ANKETİ

“Grupta Ne Oldu” anketi, grup çalışmalarınız sırasında yaşananları grubunuzla birlikte değerlendirmeniz amacıyla hazırlanmıştır. Verilen cümleleri dikkatlice okuduktan sonra “Hiçbir zaman”, “Nadiren”, “Bazen”, “Sıklıkla”, “Her zaman” seçeneklerinden birisini işaretleyiniz.

Sınıf:

Konu:

Grup Adı:

	Hiçbir Zaman	**Nadiren**	**Bazen**	**Sıklıkla**	**Her Zaman**
1. Grup üyelerinin konuşma özgürlüğü					
2. Grup üyelerinin birbirlerinin sözünü kesmesi					
3. Grup üyelerinin birbirlerini dinlemesi					
4. Grup üyelerinin anlamadıkları kısımları sorması					
5. Grup üyelerinin fikirlerini paylaşması					
6. Grup üyelerinden birisinin baskınlık kurması					
7. Grup üyelerinin diğerlerinin ihtiyaçlarına duyarlı olması					
8. Grup üyelerinin birbirlerinin düşüncelerini dikkate alması					
9. Grup üyelerinin alınan kararlarda hemfikir olması					
10. Grup üyelerinin grup olma bilincinde olması					
11. Grup üyelerinin yeni arkadaşlıklar kurması					
12. Grup üyelerinin ihtiyacı olan grup üyesine yardımcı olması					
13. Grup üyelerinin birlikte çalışması					
14. Grup üyelerinin grupla birlikte olduğunda kendini iyi hissetmesi					
15. Grup üyelerinin birbirlerine yardım etmesi					

APPENDIX N

HANDOUT FOR THE TEACHER

İşbirliğine dayalı öğrenme yöntemi, öğrencilerin hem kendi öğrenmelerinin hem de takım arkadaşlarının öğrenmelerinin sorumluluğunu alarak ortak bir amaç doğrultusunda, küçük gruplar halinde çalışması esasına dayanmaktadır. "Birimiz hepimiz, hepimiz birimiz" anlayışıyla takım olarak çalışabilme ve takım ruhunu sürdürebilme, modern hayata uyum sağlayabilmeleri için öğrencilerimizde kazandırmak istediğimiz en temel hayat becerilerindendir. İşbirlikli öğrenme ile her bir öğrencinin daha iyi öğrenmesi desteklenirken, aynı zamanda olumlu tutum geliştirme ve sağlıklı iletişim kurma özellikleri geliştirilir. İşbirliğine dayalı öğrenme yönteminin diğer faydaları aşağıda sıralanmıştır: (Saban, 2002, 204-205)

- İşbirliğine dayalı öğrenme, öğrencilerin motivasyonunu artırır.
- İşbirliğine dayalı öğrenme, bir gruptaki bireylerin birbirlerinden öğrenmelerine fırsat tanır.
- İşbirliğine dayalı öğrenme sürecinde öğrencilerin birbirleriyle olan etkileşimleri, zihinsel aktivitelerin yoğun olduğu bilişsel ve sosyal çatışma ortamlarını doğurur.
- İşbirliğine dayalı öğrenme, öğrencilerin öğrenme-öğretme sürecinde kendilerini yalnız ve soyutlanmış olarak hissetmelerini engeller.
- İşbirliğine dayalı öğrenme, öğrencilerin birbirlerine karşı olumlu hisler geliştirmelerini sağlar.
- İşbirliğine dayalı öğrenme, öğrencilerin kendilerine olan özgüvenlerini artırır.
- İşbirliğine dayalı öğrenme, öğrencilerin sosyal becerilerini geliştirir.
- İşbirliğine dayalı öğrenme, öğrencilerin kendi öğrenmelerinden sorumlu olmalarını sağlar.

Fakat küçük gruplar halinde yürütülen bütün çalışmalar işbirlikli öğrenme grubu değildir, geleneksel öğrenme grubu, yapılandırılmamış işbirlikli öğrenme grubu veya yalancı öğrenme grubu da (pseudo-learning group) olması mümkündür. Öğrencilerin grup oturma düzeninde oturarak sadece kendi öğrenmelerinden sorumlu olduğu, grup olarak tamamlanması gereken etkinliklerin birkaç öğrencinin çalışması ile tamamlandığı ve diğerlerinin çaba sarf etmeden aynı notu aldığı ve öngörülen iletişim ve işbirliğinin sağlanmadığı gruplar işbirlikli öğrenme grubu olarak nitelendirilemez. Nitelikli bir işbirlikli öğrenme grubunda yapılandırılması gereken ilkeler şöyledir: olumlu bağımlılık, bireysel sorumluluk, yüz yüze destekleyici etkileşim, sosyal beceriler ve grup işleyişinin değerlendirilmesi. İşbirlikli öğrenme gruplarında yapılandırılması gereken ilkeler ve ilkelerin tanımları için Tablo N.1'e bakınız.

Tablo N.1 İşbirliğine dayalı öğrenme yönteminin ilkeleri

İlke	Tanım
Olumlu Amaç Bağımlılığı	Grubun amacına ulaşabilmesi için bireysel başarıların yetersiz olacağını ve grup olarak başarılı olunması gerektiğini algılayarak grup üyelerinin birbirlerinin öğrenmesinde sorumluluk almasıdır.
Olumlu Ödül Bağımlılığı	Aynı grupta yer alan öğrencilerin tamamına aynı ödülün (notun) verilmesidir.
Olumlu Rol Bağımlılığı	Grubun amacına ulaşabilmesi için her bir üyeye, birbirlerinden bağımsız rollerin verilmesi ve bu rollerin her etkinlikte değiştirilmesidir.
Olumlu Kaynak Bağımlılığı	Gruba sınırlı sayıda materyal yada bilgi vererek üyelerin ortaklaşa kullanmasını sağlamaktır.

Tablo N.1 (devamı)

İlke	Tanım
Bireysel Sorumluluk	Grubun amacına ulaşabilmesi için her bir üyenin sorumluluğunu yerine getirmesidir. Grubu oluşturan öğrenci sayısının 5'i geçmemesi, her bir üyenin bireysel olarak test edilmesi, grubun ortak cevabını sunması için gruptan tesadüfi bir öğrenci seçilmesi, öğretmenin düzenli olarak grup çalışmalarını gözlemlemesi, her grupta kontrol edici rolüne sahip bir öğrencinin bulunması gibi yöntemlerle öğrencilerin bireysel sorumluluğu yapılandırılabilir.
Destekleyici Etkileşim	Üyelerin birbirlerini düşünmeye yönlendirmesi, anlaşılamayan yerleri açıklaması ve yardım istemesi, geri bildirim sağlaması, ortak amaç doğrultusunda ilerleyen üyelerin cesaretlendirilmesi, materyal ve bilginin paylaşılması ve güvenilir şekilde davranmasıdır.
Sosyal Beceriler	Üyelerin birbirlerine saygı duyması ve güvenmesi, demokratik biçimde ortak karar alması, bilişsel çatışmaları yapıcı biçimde çözüme ulaştırması, yardım etmesi ve gerektiğinde yardım istemesi, dinlemesidir. Öğrencilere grup çalışmasından önce sosyal beceri eğitimi sağlanmalıdır.
Grup İşleyişinin Değerlendirilmesi	Grup üyelerinin ortak amaca ulaşabilmek için nasıl daha verimli çalışabilecekleriyle ilgili tartışmasıdır. Grup çalışmaları bittikten sonra neyi doğru veya neyi yanlış yaptıklarını düşünüp tartışmaları için gruplara süre tanınmalıdır.

İşbirliğine dayalı öğrenme yöntemini sınıf içerisinde uygulamaya koymak amacıyla birçok strateji geliştirilmiştir. Öğrenci Takımları-Başarı Bölümleri (ÖTBB), işbirlikli öğrenme yöntemleri arasında kullanımı en kolay strateji olduğu ve birçok derse ve sınıf seviyesine uyarlanabildiği için ekonomik bir stratejidir. ÖTBB stratejisinde öğretmen sunumu, takım çalışması, bireysel test, bireysel ilerleme puanı ve takım takdiri basamakları sırasıyla birbirini takip eder. Dersler öğretmenin o derste işlenecek konuyla ilgili öğrencileri bilgilendirmesiyle başlar. Öğretmen sunumunun içeriği, grupların üzerinde çalışacağı çalışma yapraklarının ve öğrencilerin bireysel olarak girecekleri testlerin kapsamına uygun olacak şekilde planlanır. Kapsanacak konunun yoğunluğuna göre 15-30 dakika süren sunumdan sonra öğrencilere, öğretmenin önceden belirlediği gruplarla bir araya gelmeleri ve küme oturma düzenine geçmeleri söylenir. Gruplara çalışma yaprakları dağıtılır ve grup olarak tamamlamaları için 10-15 dakika süre verilir. Süre bitiminde öğrenciler bireysel olarak test edilirler ve bu aşamada takım arkadaşlarının birbirlerine yardım etmemesi beklenir. 10-15 dakika sürecek şekilde hazırlanan testler bitirildikten sonra toplanır ve bir sonraki derse kadar öğretmen tarafından puanlanır. Sürecin başında her bir öğrenci için hesaplanan başlangıç puanını, testten alınan puandan çıkarmak suretiyle bireysel ilerleme puanı saptanır. Grupta bulunan her bireyin ilerleme puanı toplanarak, takım ilerleme puanları hesaplanır. En fazla ilerleme gösteren takım ve birey ilan panosundan duyurulur. Öğretmen, en fazla ilerleme gösteren takım üyelerinin birbirlerinin başarılarını takdir etmesi yönünde bireyleri teşvik eder.

Bu çalışmada, dokuzuncu sınıf öğrencilerinin karışımlar konusunu anlamaları ve motivasyonu üzerine işbirlikli öğrenme varyasyonlarının, geleneksel öğretim yöntemine kıyasla etkisini incelemek amaçlanmıştır. Bu amaca ulaşmak için işbirliğine dayalı öğrenme yönteminin tüm ilkelerinin hassasiyetle sağlandığı yapılandırılmış işbirlikli öğrenme grupları (YİÖG), işbirliğine dayalı öğrenme yönteminin bazı ilkelerinin gelişi güzel sağlandığı yapılandırılmamış işbirlikli öğrenme grupları (YİÖG(-)) ve geleneksel öğretimin uygulandığı kontrol grupları (KG) oluşturulmuştur. KG'nda işbirliğine dayalı öğrenme yöntemi uygulamalarına değinilmezken, YİÖG ve YİÖG(-)'nda işbirliğine dayalı öğrenme yöntemi uygulamalarına yer verilecektir. YİÖG ve YİÖG(-)'nda dersler ÖTBB stratejisinin basamaklarına göre işlenecek ve her iki grupta da kavramsal değişim koşulları gözetilecektir. Kavramsal değişim koşullarının gözetilmesi ve derslerin ÖTBB metoduyla işlenmesi YİÖG ve YİÖG(-)'nın ortak özellikleriyken, bu iki grup işbirliğine dayalı öğrenme yöntemi ilkelerinin yapılandırılması açısından çok farklı uygulamalar içermektedir. Tablo N.2, YİÖG ve YİÖG(-)'nda ilkeler yapılandırılırken nasıl farklılık oluşturulduğunu karşılaştırmalı olarak sunmaktadır.

Tablo N.2 Yapılandırılmış ve yapılandırılmamış işbirlikli öğrenme gruplarının karşılaştırılması

Yapılandırılmış İşbirlikli Öğrenme Grubu	Yapılandırılmamış İşbirlikli Öğrenme Grubu
Öğrenciler sosyal beceri eğitimi alır.	Öğrenciler sosyal beceri eğitimi almaz.
4 kişiden oluşan heterojen (cinsiyet ve başarı düzeyine göre) gruplar öğretmen tarafından belirlenir.	4 kişiden oluşan homojen grupları öğrenciler kendileri seçerler.
Öğrenciler gruplarına isim verir.	Öğrenciler gruplarına isim vermez.
Takım çalışmaları sırasında grup oturma düzenine geçilir.	Takım çalışmaları sırasında grup oturma düzenine geçilir.
Her öğrenci için başlangıç puanı belirlenir.	Her öğrenci için başlangıç puanı belirlenir.
Dersler öğretmen sunumuyla başlar.	Dersler öğretmen sunumuyla başlar.
Öğrenciler çalışma yapraklarını tamamlamak için takım çalışması yürütür.	Öğrenciler çalışma yapraklarını tamamlamak için takım çalışması yürütür.
Takım çalışmaları sırasında, öğretilen sosyal becerilerin sıkça kullanılması için üyeler güdülenir.	Öğrenciler sosyal beceri eğitimi almaz.
Öğrenciler hem kendilerinin hem de takım arkadaşlarının öğrenmesinden sorumludur.	Öğrenciler sadece kendi öğrenmelerinin sorumluluğunu alır.
Takım arkadaşları birbirlerini düşünmeye sevkeder, yardım eder ve gerektiğinde yardım ister.	Öğrenciler arasında destekleyici etkileşim yoktur.
Grup üyelerinin her birine roller verilir ve her etkinlikte roller değiştirilir.	Sadece grup lideri belirlenir ve lider öğrenci sürecin sonuna kadar değiştirilmez.
Grubun ortak cevabını sunması için gruptan tesadüfi bir öğrenci seçilir.	Grubun cevabını sunmaya gönüllü olan, çalışkan öğrenciler seçilir.
Gruplara iki adet çalışma kağıdı verilir.	Gruplara dört adet çalışma kağıdı verilir.
Öğrenciler bireysel olarak test edilir.	Öğrenciler bireysel olarak test edilir.
Bireysel ilerleme puanları hesaplanır.	Bireysel ilerleme puanları hesaplanır.
Aynı grupta yer alan öğrencilerin tamamına aynı not verilir.	Aynı grupta yer alan öğrencilere aynı not verilmez, bireyler sadece kendi ilerleme puanına göre değerlendirilir.
En fazla ilerleme gösteren takım(lar) panoda ilan edilir.	En fazla ilerleme gösteren birey(ler) panoda ilan edilir.
En fazla ilerleme gösteren takımın üyeleri başarılarını birlikte kutlar.	En fazla ilerleme gösteren birey kendi başarısını kutlar.
Dersler grupların "Grupta Ne Oldu" adlı ölçeği doldurmasıyla biter.	"Grupta Ne Oldu" adlı ölçek doldurulmaz.
Öğretmen "Grup Gözlem Formu" adlı ölçeği doldurarak elde ettiği sonuçları öğrencilerle paylaşır.	"Grup Gözlem Formu" adlı ölçek doldurulmaz.

Öğretmen, YİÖG ve YİÖG(-)'nda rehber görevi üstlenir. Bilimsel bilgileri doğrudan öğrencilere aktarmak yerine bilimsel olayların nedenlerini düşünmelerini sağlayacak sorular sorarak öğrencilerin anlamlı öğrenmesini destekler. Grup çalışmaları sırasında etkinliklerdeki sorularla bilişsel karmaşa yaşayan öğrencilere ipuçları vererek doğru cevapların gruplar tarafından tartışılarak bulunmasını sağlar. Grup çalışması sırasında hangi grupların ve üyelerin neleri yaptıklarını ve neleri yapamadıklarını düzenli olarak gözlemler ve YİÖG'ndaki her bir grup için "Grup Gözlem Formu" doldurur. Ölçekte elde ettiği kayıtları dersin sonunda geri bildirim amacıyla öğrencilerle paylaşır. Sosyal becerilerin sıkça kullanımını teşvik eder. Dersi özetleyerek bitirir ve bu aşamada öğrencilerin o derste öğrendikleri bilgileri pekiştirmeyi, bilginin anlamlı hale gelmesini hedefler.

YİÖG'nda yer alan öğrencilerden ve YİÖG(-)'nda yer alan öğrencilerden beklenenler farklılık göstermektedir (bkz. Tablo N.2). Ancak her iki grupta da öğrencilerin anlamlı öğrenmesi desteklenmekte ve sahip oldukları kavram yanılgılarını gidermek hedeflenmektedir. Grup çalışmaları sırasında öğrencilerin üzerinde çalıştıkları çalışma yaprakları, kavramsal değişimin koşulları olan "memnuniyetsizlik" (dissatisfaction), "anlaşılırlık" (intelligibility), "akla yatkınlık" (plausibility) ve "verimlilik" (fruitfulness) sağlamayı amaçlamaktadır. Öğrencilerin sahip olması muhtemel kavram yanılgılarının yer aldığı etkinlikler ile öğrencilerde öncelikle memnuniyetsizlik yaratmak amaçlanmıştır. Memnuniyetsizlik yaşayan öğrencilerin ise takım arkadaşları ile görüş paylaşarak, birbirlerini düşünmeye ve daha çok bilgiye ulaşmaya sevk ederek, dinleyerek, tartışarak, demokratik bir şekilde ortak kararlar alarak, çatışmaları yapıcı bir şekilde çözerek, birbirlerine nitelikli yardımlar vererek ve gerektiğinde yardım isteyerek tekrar dengeye dönmelerini sağlamak amaçlanmaktadır. Diğer bir ifadeyle, ÖTBB stratejisinin takım çalışması aşamasında, kavramsal değişim koşullarını sağlamak hedeflenmektedir. Grup çalışması sırasında öğrenilen bilgilerin daha anlaşılır, akla yatkın ve verimli olması için öğretmen ders sonunda öğrencilere sorular sorar ve gerektiğinde kendisi açıklar.

APPENDIX O

Table O.1 The percentages of students' correct responses for each item on the post-Mixtures Concept Test

Item Number	Alternative	Response Percentage (%)		
		Structured Cooperative Learning Group	Unstructured Cooperative Learning Group	Control Group
1	1	0	1.7	0
	2*	100.0	71.2	80.0
	3	0	27.1	20.0
	A	0	0	5.1
	B	0	3.3	0
	C*	96.6	76.7	69.0
	D	3.4	20.0	25.9
	Total	96.6	48.3	51.7
2	1	0	0	0
	2	0	1.8	15.8
	3*	100.0	98.2	84.2
	A*	96.6	85.7	72.4
	B	0	0	0
	C	0	8.9	15.5
	D	3.4	5.4	12.1
	Total	96.6	71.7	69.0
3	A	0	12.2	2.0
	B	3.4	25.7	15.2
	C	0	13.8	6.9
	D*	96.6	48.3	75.9
4	A	0	8.3	0
	B*	100.0	61.7	67.2
	C	0	1.7	3.4
	D	0	28.3	29.4
5	A	6.9	6.8	5.2
	B	5.2	5.1	5.5
	C	0	23.1	23.8
	D*	87.9	65.0	65.5
6	A	0	0	2.0
	B*	94.8	70.0	70.7
	C	5.2	20.0	22.4
	D	0	10.0	4.9
7	1	10.3	32.1	26.3
	2*	89.7	67.9	73.7
	A	20.6	47.0	34.5
	B	0	3.0	0
	C*	79.4	50.0	65.5
	D	0	0	0
	Total	79.3	45.0	62.1
8	A	0	3.3	3.4
	B*	94.8	93.3	89.7
	C	5.2	3.4	3.4
	D	0	0	3.5
9	A	0	8.5	19.0
	B	12.1	24.8	22.4
	C*	87.9	65.0	58.6
	D	0	1.7	0

Table O.1 (continued)

Item Number	Alternative	Response Percentage (%)		
		Structured Cooperative Learning Group	**Unstructured Cooperative Learning Group**	**Control Group**
10	A	0	13.3	7.2
	B	0	1.7	7.1
	C	3.4	21.7	28.8
	D*	96.6	63.3	56.9
11	1	10.3	37.9	27.6
	2*	89.7	62.1	72.4
	A	0	0	0
	B	10.3	43.4	42.9
	C	0	0	0
	D*	89.7	56.6	57.1
	Total	89.7	46.7	55.2
12	A	0	5.3	8.7
	B	10.3	29.8	6.9
	C	12.1	10.5	3.4
	D*	77.6	51.7	81.0
13	A	3.4	0	5.1
	B	3.4	30.9	19.0
	C*	86.2	45.0	56.9
	D	7.0	22.1	19.0
14	A	0	5.0	6.9
	B*	100.0	95.0	82.8
	C	0	0	6.9
	D	0	0	3.4
15	A*	96.6	60.0	62.1
	B	0	10.1	10.3
	C	0	0	3.4
	D	3.4	29.9	24.2
16	1	6.9	3.5	0
	2*	93.1	96.5	100.0
	A	0	8.5	3.4
	B	0	0	0
	C*	96.6	89.8	96.6
	D	3.4	1.7	0
	Total	96.6	83.3	96.6
17	1*	84.5	57.4	70.7
	2	15.5	42.6	29.3
	A	0	11.6	19.0
	B*	82.8	55.0	65.5
	C	3.4	1.7	5.2
	D	13.8	31.7	10.3
	Total	81.0	50.0	65.5
18	A	0	0	11.1
	B	0	18.2	22.0
	C	0	8.5	4.8
	D*	100.0	73.3	62.1

Table O.1 (continued)

Item Number	Alternative	Response Percentage (%)		
		Structured Cooperative Learning Group	Unstructured Cooperative Learning Group	Control Group
19	1	31.0	57.9	78.6
	2	6.9	8.8	10.7
	3*	62.1	33.3	10.7
	A	44.8	54.1	68.0
	B*	44.9	32.7	20.4
	C	10.3	9.1	10.4
	D	0	4.1	1.2
	Total	44.8	23.3	6.9
20	1*	87.9	58.2	69.6
	2	12.1	41.8	30.4
	A*	56.9	18.3	22.4
	B	22.4	71.7	63.8
	C	20.7	6.7	12.1
	D	0	3.3	1.7
	Total	56.9	16.7	22.4
21	1	0	5.0	0
	2*	100.0	75.0	76.4
	3	0	20.0	23.6
	A	6.9	13.8	16.4
	B	0	5.2	3.6
	C	0	0	16.4
	D*	93.1	81.0	63.6
	Total	93.1	70.0	51.7
22	A	0	3.3	3.6
	B	0	8.3	1.8
	C*	100.0	80.0	86.2
	D	0	8.4	8.4
23	1*	82.8	61.7	64.3
	2	17.2	38.3	35.7
	A*	65.5	69.0	76.8
	B	0	0	1.8
	C	34.5	29.3	21.4
	D	0	1.7	0
	Total	48.3	28.3	39.7
24	A	1.4	5.0	1.8
	B*	89.7	40.0	63.8
	C	7.4	49.0	32.0
	D	1.5	6.0	2.4
25	A	0	20.9	24.7
	B	0	3.4	16.0
	C*	96.6	56.7	41.4
	D	3.4	19.0	17.9

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