EFFECTS OF 5E LEARNING CYCLE MODEL ON UNDERSTANDING OF STATE OF MATTER AND SOLUBILITY CONCEPTS

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ABSTRACT

EFFECTS OF 5E LEARNING CYCLE MODEL ON UNDERSTANDING OF STATE OF MATTER AND SOLUBILITY CONCEPTS

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The main purpose of the study was to compare the effectiveness of 5E learning cycle model based instruction and traditionally designed chemistry instruction on 10th grade students' understanding of state of matter and solubility concepts and attitudes towards chemistry as a school subject; and students' perceived motivation and perceived use of learning strategies.

In this study, 119 tenth grade students from chemistry courses instructed by same teacher from Atatürk Anatolian High School took part. The study was conducted during 2007-2008 spring semester.

This study included two groups which were randomly assigned as experimental and control groups. Control group students were taught by traditionally designed chemistry instruction, while the experimental group students were instructed by 5E learning cycle model based instruction. In the experimental group, students were taught with respect to the sequence of 5E learning cycle model which are engagement, exploration, explanation, elaboration, and evaluation through the use of activities such as demonstrations, video animations, laboratory ectivities, and discussions. In the control group, traditionally designed chemistry instruction was implemented through teacher explanations and use of textbook.

State of Matter and Solubility Concepts Test (SMSCT), Attitude Scale toward Chemistry (ASTC), and Motivated Strategies for Learning Questionnaire (MSLQ) were administered to both groups as a pre-test and post-test to assess the students understanding of state of matter and solubility concepts, students' attitudes toward chemistry, students' perceived motivations and students perceived use of learning strategies, respectively. Science Process Skills Test was given at the beginning of the study to determine students' science process skills.

The hypotheses were tested by using multivariate analysis of variance (MANOVAs). The results showed that instruction based on 5E learning cycle model caused significantly better acquisition of the scientific conceptions related to state of matter and solubility concepts than traditionally designed chemistry instruction. In addition, instruction based on 5E learning cycle model improved students' attitudes as a school subject, intrinsic goal orientation, extrinsic goal orientation, task value, elaboration strategy use, organization strategy use. A Science process skill was determined as a strong predictor in understanding the concepts related state of matter and solubility.

Keywords: Learning Cycle Model, 5E Learning Cycle Model, State of Matter and Solubility, Misconceptions, Attitude toward Chemistry, Motivation.

ÖZ

5E ÖĞRENME MODELİNİN MADDENİN YOĞUN FAZLARI VE ÇÖZÜNÜRLÜK KONUSUNU ANLAMAYA ETKİSİ

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Bu çalışmanın başlıca amacı, 5E öğrenme modeline dayalı öğretim yönteminin 10. sınıf öğrencilerinin maddenin yoğun fazları ve çözünürlük konularındaki kavramları anlamalarına, kimyaya karşı tutumlarına, kimya dersindeki motivasyonlarına, ve öğrenme stratejilerine etkisini geleneksel kimya öğretim yöntemi ile karşılaştırarak incelemektir.

Bu çalışma, Atatürk Anadolu Lisesinde, aynı öğretmenin kimya derslerinde bulunan 119 onuncu sınıf öğrencilerinin katılımı ile gerçekleşmiştir. Bu çalışma, 2007-2008 bahar döneminde yapılmıştır.

Bu çalışmada, deney grubu ve kontrol grubu olarak rastgele seçilen iki grup bulunmaktadır. Kontrol grubundaki öğrencilere geleneksel kimya öğretim yöntemi uygulanırken, deney grubundaki öğrencilere 5E öğrenme modeline dayalı öğretim yöntemi uygulanmıştır. Deney grubunda öğrenciler 5E öğrenme modelinin içerdiği sıralamayı gösteriler, video animasyonları, laboratuvar aktiviteleri ve tartışma yoluyla uygulamışlardır. Kontrol grubunda dersler öğretmen açıklamaları ve ders kitaplarına dayalı olarak işlenmiştir.

Maddenin yoğun fazları ve çözünürlük testi, kimya tutum ölçeği, öğrenmede güdüsel stratejiler anketi öğrencilere ön-test ve son-test olarak dağıtılarak öğrencilerin maddenin yoğun fazları ve çözünürlük konularını anlamaları, kimyaya karşı olan tutumları, kimya derslerindeki motivasyonları ve öğrenme stratejileri değerlendirilmiştir. Öğrencilerin bilimsel işlem becerilerini belirlemek üzere bilimsel işlem beceri testi çalışmanın başında öğrencilere uygulanmıştır.

Bu çalışmanın hipotezleri çok değişkenli varyans analizi (MANOVA) kullanılarak test edilmiştir. Analiz sonuçlarından, 5E öğrenme modeli kullanılan öğrencilerin, maddenin yoğun fazları ve çözünürlük kavramlarını, geleneksel kimya anlatımı kullanılan gruba göre daha iyi anladıkları tespit edilmiştir. Buna ek olarak, sonuçlar, 5E öğrenme modeline dayalı öğretimin öğrencilerin kimyaya karşı tutumlarına, içsel ve dışsal mtivasyon bileşenlerine, işleme ve organizasyon becerilerine etkisi olduğunu göstermiştir. Öğrencilerin bilimsel işlem becerileri, öğrencilerin maddenin yoğun fazları ve çözünürlük kavramlarını anlamasında belirleyici bir unsur olduğu tespit edilmiştir.

Anahtar Kelimeler: Öğrenme Halkası, 5E Öğrenme Modeli, Maddenin Yoğun Fazları ve Çözünürlük , Kimyaya Karşı Tutum, Motivasyon .

To my mother and father…

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SMSCT: State of Matter and Solubility Concept Test

MSLQ: Motivated Strategies for Learning Questionnaire

ASTC: Attitude Scale toward Chemistry

SPST: Science Process Skill Test

5EIM: Instruction based on 5E Learning Cycle Model

TM: Instruction based on Traditional Methods

CU: Concept Understanding

AC: Attitude toward Chemistry

CG: Control Group

EG: Experimental Group

N: Nunber of Students

f: Effect Size

df: Degrees of Freedom

SS: Sum of Squares

MS: Mean Square

X: Mean of the Sample

p: Significance Level

F: F Statistics

t: t Statistics

CHAPTER 1

INTRODUCTION

Global changes in the world affect people's lives in ways unfamiliar to previous generations. Today, societies affect each others by their cultures, languages, art, technologies, music and literature. When the advancement of technology is taken into consideration, the vital role of knowledge and experience of peoples, in other words the importance of knowledge base society is recognized in all around the world. Education plays an important role to recognize young people's responsibilities in this globalize world and to equip them with the skills to make true decisions. With the effect of globalization, developed countries redesign their education system with respect to relationships between local and global issues. The main of purpose of these countries is to provide their young generations knowledge, skills and understanding that enable them to make appropriate decisions and develop their competencies to work anywhere in the world. Moreover, developed countries try to find some ways to provide their students with a strong foundation for lifelong learning. The notions of "lifelong learning" and "learning to learn" are the common words when the developed countries' aims of curriculum reforms are examined.

The responsibilities of today's science education include helping students to understand the natural world, to use appropriate skills and scientific process for developing their competencies, to promote lifelong learning and learning how to learn, to improve their attitudes toward science and promote their motivation.

Students do not come to science classes with blank slates. The ideas of the students are developed based on their previous experiences before coming to schools. Researches have indicated that students come to classrooms with well-established understandings about how and why everything behaves as they do (Posner, Strike, Hewson, & Gertzog, 1982; Resnik, 1983; Strike, 1983). In constructivism, it is believed that knowledge is actively constructed by learner on the basis of the knowledge that individual already held (Duit & Tregaust, 1998). Therefore, as Ausubel (1968) emphasized as "If I had to reduce all educational psychology to just one principle, I would say this: The most important factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly", the importance of prior knowledge of the learner should not be underestimated. However, the prior knowledge of an individual may be correct or incorrect. The ideas which are different from the commonly accepted scientific conceptions were defined as misconceptions or preconceptions (Nakhleh, 1992; Schmidt, 1997; Teichert & Stacy, 2002). Misconceptions are appeared by students as logical, sensible, and valuable. In addition, these beliefs are persuasive, stable, and resistant to change and can not be easily eliminated by traditional methods since they are not taken into consideration. Several contemporary instructional approaches based on constructivism were developed to overcome and remediate students' alternative conceptions. All the approaches accepted the common notion that meaningful learning occurs when the links between new information and prior knowledge is actively constructed. The main aim of these approaches is to facilitate conceptual change by removing students' misconceptions. Learning cycle model based instruction which is also based on constructivist epistemology is an instructional model in which conceptual change is facilitated (Boylan, 1988). The modification of learning cycle model produced 3E, 4E, 5E, and 7E learning cycle models. Instruction based on learning cycle model is found to improve students' understanding of science, improve students' attitudes toward chemistry, and overcome students' misconceptions (Cambell, 1977; Cumo, 1992; Davis,1978; Klindienst, 1993; Shadburn, 1990; Cumo, 1992; Davidson, 1989; Campbell, 1977; Kurey, 1991; Purser & Renner, 1983; Saunders & Shepardson, 1987; Schneider & Renner, 1980; Lawson & Thompson, 1988; Marek, Cowan, & Cavollo, 1994; Scharmann, 1991, Gang, 1995; Garcia, 2005; Akar, 2005; Boddy, Watson & Aubusson, 2003; Balcı, Çakıroğlu & Tekkaya, 2006; Lord, 1997; Mecit, 2006). Moreover; 5E learning cycle model consisted of an instructional sequence in which the activities are used to produce changes in students' knowledge, skills, attitudes and motivation. In addition, students are encouraged to develop their own learning strategies by using of activities carried out in the phases of 5E instructional model (Bybee et al., 2006).

It was indicated that understanding of chemistry is a hard thing for most of the students (Nieswandt, 2001; Chittleborough, Treagust & Mocerino, 2002). Therefore, designing instructions to improve chemistry learning is very important. Facilitating conceptual change and remediation of misconceptions about chemistry subjects should be the main aims to promote meaningful learning. One of the fundamental topics of chemistry is state of matter and solubility concepts. Although many researchers investigated students' misconceptions about chemistry topics such as electrochemistry (Garnett & Treagust, 1992), acid-base (Cakır, Uzuntiryaki & Geban, 2002), atom and molecules (Griffiths & Preston, 1992), chemical equilibrium (Chiu, Chou & Liu, 2002), chemical change (Hesse & Anderson, 1992), researches about state of matter and solubility topic are limited.

In the light of the evidence that was stated above, it is very crucial to eliminate students' misconceptions about chemistry. Students believed that one of difficult subject in chemistry is state of matter and solubility topic. Since state of matter and solubility constitute fundamentals of complex topics in chemistry, it is very important to find an instructional method that prevent students from the misconceptions and eliminate the misconceptions about this subject. For instance, the properties of gases and the fundementals of gased concepts can be understood more meaningfully when the phase changes concepts are learned appropriatelly. In addition, students realize the diffence of chemical change and physical change when the phase changes concept was understood meaningfully. Moreover, temperature changes during phase transition are related to thermodynamic concepts in chemistry. As it was indicated above 5E learning cycle model can be effective on removing students misconceptions related to chemistry concepts. Therefore, the main aim of the study is to investigate the effectiveness of instructions, one based on traditional methods and the other based on 5E learning cycle model, on tenth grade students' understanding of state of matter and solubility concepts, attitude toward chemistry, and students' perceived motivation strategies learning strategies.

1.1 Purpose

The aim of the study was to: (1) identify and examine students' misconceptions about state of matter and solubility concept; (2) compare the effectiveness of instruction based on 5E learning cycle model and instruction based on traditional method with respect to understanding of state and matter and solubility concepts; (3) compare the effectiveness of instruction based on 5E learning cycle model and instruction based on traditional method with respect to students' attitudes toward chemistry as a school subject; (4) compare the effectiveness of instruction based on 5E learning cycle model and instruction based on traditional method with respect to students' perceived motivation; (5) compare the effectiveness of instruction based on 5E learning cycle model and instruction based on traditional method with respect to students' perceived use of learning strategies.

1.2 Significance of the study

In constructivism, the assumption that the interaction between new and existing conceptions constitutes one side of learning has been accepted. In addition, prior knowledge of the students was expressed as most of the significant factor in learning

(Ausubel, 1968). Moreover it was stated that meaningful learning occurs when the new knowledge and students' existing relevant knowledge are related. Therefore, students' existing knowledge or their prior knowledge has become very important in science learning. Students' existing knowledge which appears them logical, sensible, and valuable, may be differing from the definitions accepted by experts and scientific definitions. In other words, students' preexisting cognitive structures may include some misconceptions about the related subject matter. Identifying these misconceptions in science has been one of the aims of research community in science education. With the identification of these misconceptions, science educators and science teachers realize these misconceptions and design their lesson with respect to elimination of them. One of the aims of this study is to identify and present students' misconceptions about state of matter and solubility concept.

It was accepted that misconceptions are persuasive, stable, and resistant to change via traditional instructional strategies and these beliefs may be found in individuals' cognitive structure even after completion of years of formal science instruction (Champagne et al., 1982, Clement, 1982; Guzzetti, 2000; Halloun & Hestenes, 1985a, Hewson & Hewson, 1984, Osborne & Cosgrove, 1983; Stavy, 1991; Tsai, 1996; Wandersee, Mintzes, & Novak, 1994). Therefore, designing an instruction that provide both to identify and eliminate these misconceptions is very necessary. In this study, an instruction based on 5E learning cycle model that give importance of identification and elimination of these misconception was designed. In this instruction, laboratory activities, demonstrations, hands-on activities were carried out for instructors to remediate misconceptions and to promote students' conceptual change. At the end of this study, the critical aspects of this instruction were stated. Moreover, the question whether the use of laboratory activities, hands-on activities, and demonstrations within the learning cycle approach (5E learning cycle model) is different from and more effective than traditional instructional approaches that use laboratory activities, hands-on activities, or demonstrations was discussed.

Instruction based on 5E learning cycle model consists of activities that attract students' interest and curiosity on the instructional task. These activities are generally related to everyday events that students experienced. Students' misconceptions were modified to accommodate new ones by using these activities. The sequence of 5E learning cycle model and these activities help students in remediation of misconceptions about state of matter and solubility concepts. Students find chances to explore their conceptions and the inadequacies of these conceptions, to construct their own conception, to explain and discuss new conceptions with their friends and teachers, to develop them with additional activities, and to assess new conceptions with activities and take feedback from their peers in 5E learning cycle model.

The secondary school chemistry curriculum in Turkey have been modified and revised with respect to contemporary approaches in science education. This study also has a potential to give some ideas to curriculum developers about how to design an instruction to eliminate students' misconceptions in state of matter and solubility concepts. Moreover, in science methods course at science education departments, this study will be presented as an example that is better than traditional methods with respect to eliminating students' misconceptions about state of matter and solubility. In other words, instruction based on 5E learning cycle model can be given special attention by pre-service teachers.

In the literature, it was stated that students' attitudes toward science and their motivation were asserted not only have catalyst property in learning but also they are recognized as one of the necessary condition for learning to occur (Perrier & Nsengiyunva, 2003). Glynn and Koballa (2007) stated that instructions that include hands on science activities, laboratory work, field study, and inquiry oriented lessons have potential to students' attitudes toward science and students' motivation. Instruction based on 5E instructional model has a potential to attract students' interest and curiosity on the instructional task. Therefore, in this study, instruction based on 5E learning cycle model fosters teachers to arrange environment in a way that students improve their attitude towards chemistry and their motivation.

1.3 Definition of the Terms

The terms that needed to be defined are stated in the following part;

Accommodation: reconstructing the existing structure when the new knowledge or inputs do not fit existing structure (Duit & Treagust, 1998).

Assimilation: the adaptation of new knowledge when it fit the existing cognitive structure (Duit & Treagust, 1998).

Attitude: a general and enduring positive and negative feeling about some person, object, or issue (Petty & Cacioppo, 1981).

Cognitive Conflict: inconsistency between the existing cognitive structure and new information (Duit & Treagust, 1998).

Conception: particular interpretation of a concept by a person (Kaplan, 1964).

Constructivism: a theory rest on the assumption that knowledge is constructed by learners as they attempt to make sense of their experiences.

Equilibration: a balance between new information and the existing structure (Duit & Treagsut, 1998; Yıldırım, Güneri & Sümer, 2002).

Misconception: students' conceptions or ideas that are differ from the definitions accepted by experts or scientific community (Driver & Easley, 1978; Hewson &

Hewson, 1984; Treagust, 1988; Nakhleh, 1992, Lawson and Thompson, 1988; Schmidt, 1997).

Preconception: students' conceptual framework that already present from everyday experience and from previous formal and informal education (Teichert & Stacy, 2002).

Solubility: the amount of a substance that dissolves in a given quantity of solvent (such as water) at a given temperature to give a saturated solution (Ebbing & Gommon, 2005).

State of Matter: three forms matter, solid, liquid, and gas (Ebbing & Gommon, 2005).

Traditional Teaching: teaching method based on lecture and discussion, use of textbooks, include strategies relied on teacher explanation without considerations of students' alternative conceptions.

CHAPTER 2

REVIEW OF LITERATURE

The review of the related literature is presented in this chapter. In the following part, the fundamentals of constructivism such as Piaget ideas of learning, assumptions of constructivism about learning, many faces of constructivism were presented to create a base for learning cycle and 5E learning cycle model. Since the learning cycle constituted the point of origin of 5E learning cycle model, the learning cycle approach and researches about learning cycle that have been conducted so far were presented before 5E learning cycle model. In addition, since some of the affective domains of the students such as students' perceived motivations and attitudes involve in this study, some studies related students affective domains are presented at the end of this chapter.

2.1 Constructivism

In the first half of this century, the pioneer learning theory was the behaviorism. The influences of changing from behaviorism to cognitive theories on science education community can be also found from the research literature on learning in science education. At the end of 1960, with the arising of the Piaget ideas on intellectual development, science education were not influenced by behaviorist theories as it had occurred (Duit & Treagsut, 1998). Science education community has been accepted and benefited his idea of equilibration of assimilation and accommodation (Lawson, 1994).

And also, in science education community, Piaget has been accepted as one of the fathers of the variants of constructivism that dominated science education through the last decades (Von Glasersfeld, 1992).

2.1.1 Piaget's Ideas of Learning

Although there are many critiques of his approach, the impacts of Piaget's thinking including his idea of stages of cognitive development on contemporary view of learning can not be denied. Piaget, a Swiss psychologist, tried to answer the questions such as "do all human beings have similar abilities in thinking?", "does the thinking abilities change with respect to age?" (Yıldırım, Güneri, & Sümer, 2002). To understand Piaget's ideas more effectively, it is necessary to consider his ideas not psychological aspects but epistemological aspects (Bliss, 1995). It was claimed that Piaget desired to improve epistemology from a mere philosophical enterprise to an empirical domain (Lawson, 1994). Therefore, he is remembered as empirical epistemologist who denoted his life to make research on knowledge in humans (Metz, 1998). His views about epistemology are strongly influenced by Immanuel Kant who is accepted as a constructivist by some researchers (Lawson, 1994; von Glasersfeld, 1992). Kant also asserted that knowledge is necessarily determined by the knower's ways of perceiving and conceiving. Piaget is trained in biology that influenced his views about knowledge construction. For example; he related the knowledge construction process and the adaptation of living beings to their environment. In one of his writings, he (1952) stated that "I decided to consecrate my life to the biological explanation of knowledge" (p.240). The adaptation of information becomes most obvious in his distinction of assimilation and accommodation and the idea of equilibration which is the kernel of Piagetian thinking.

According to the Piaget there are two basic tendencies in thinking that all human beings have naturally; organization and adaptation (Pulaski, 1980). These functions are gradually changed by biological maturation and environmental factors (Yıldırım, Güneri, & Sümer, 2002).

Human beings require organizing frameworks as they gain new knowledge to use them effectively. This process is called organization. Yıldırım, Güneri, and Sümer (2002) gave the example that the term apple is stored in our mind with the relation of other fruits, it was not processing as an independent unit. The terms can be used more effectively by the ability of systematically organize knowledge such as combining, categorizing, selecting, comparing them (Yıldırım, Güneri, & Sümer, 2002).

All human beings have a tendency to adapt themselves to the environment. Therefore, all human beings try to find ways to adjust themselves to external conditions such as new information, new behaviors, new people or new context. This process is called adaptation. Assimilation and accommodation defined as two ways of adaptation (Yıldırım, Güneri, & Sümer, 2002). When the new knowledge or input fit the existing cognitive structure, the new sense impressions are processed to adapt, not changed, human beings existing cognitive structure (Duit & Treagsut, 1998). This process is called assimilation which is one of the ways of adaptation. In other words, if the new experience fits the existing pattern of thoughts, assimilation is needed. For instance, teacher or parent explains the child the word 'mouse' that is not heard before by child. The mouse explained as a small animal. Since the child already knows about the animals or the term animal exists in his cognitive structure, he will try to fit the term 'mouse' into his existing cognitive structure to reach a generalization that a mouse is an animal (Yıldırım, Güneri, & Sümer, 2002).

On the other hand, accommodation, the other way of adaptation process, defined as when the new knowledge or inputs do not fit existing structure, there is a need to reconstruct the existing structure. This process called accommodation (Duit & Treagsut, 1998). In other words, existing pattern of thoughts are reformulated or rearranged in the process of accommodation. For instance, a person needs to modify or restructure the generalization about the past forms of the regular verbs, when he is confronted with the past forms of irregular verbs (Yıldırım, Güneri, & Sümer, 2002).

The other terms that Piaget presented to explain cognitive or intellectual development are the equilibration and disequilibration. If there is a balance between new information and the existing structure, individuals will able to make sense of new information. This situation is called equilibration. On the other hand, if there is no consistency between the existing cognitive structure and new information; student could not make sense of new information, cognitive conflict will occur. This situation is called disequilibration. When disequilibration occurs, student tries to learn more and enlarges or modifies his/her existing structure. When student comprehends new phenomena completely, it means the balance was restored by reaching the process called equilibration again (Duit & Treagsut, 1998, Yıldırım, Güneri, & Sümer, 2002). Piaget asserted that the elimination disequilibration and reaching the equilibration processes is stimulated by biological structure, individual activity and social interaction with others.

2.1.2 Constructivist Assumptions about Learning

Contemporary constructivist approaches benefit from these Piagetian key views. For instance, Piaget's views constitute the kernel of the learning cycle which is stated as one of the influential instructional strategy (Lawson, Abraham & Renner, 1989). When constructivist approaches of 1980s and the learning cycle are compared, it is easily seen that cognitive conflict was employed in all of them (Driver, 1989), and also it is easily realized minor differences exist in instruction that based on them.

In most of the literature related to constructivism, the ideas underlying constructivism were contrasted with the ideas that represent objectivism. Objectivism is the view that knowledge of the world comes through individuals' experiences. As the experience grows broader and deeper, knowledge is represented in the individual's mind as an ever closer approximation of how the world really is. In a sense, then, knowledge is thought to exist independently of learners, and learning consists of transferring that knowledge from outside to within the learner. Both behavioral and cognitive information-processing theories of learning emerged based on the objectivist tradition. In contrast to the objectivist view, constructivist theory rest on the assumption that knowledge is constructed by learners as they attempt to make sense of their experiences. Learners are not viewed as an empty vessels waiting to be filled, but rather they are viewed as an active organism seeking meaning. Regardless of what is being learned, constructive processes operate and learners form elaborate, and test candidate mental structures until satisfactory one emerges (Perkins, 1991).

The fundamental idea of constructivism stated as; understanding of something is guided by conceptions that held by each individual (Tobin, 1993; Treagust, Duit & Fraser, 1996). The idea that individual views knowledge about the world as human construction has been accepted as one of key aspect of constructivism. In constructivism, although it is believed that all the knowledge about the reality is tentative construction of ours, a reality outside the individual is not denied. Duit and Tregaust (1998) assert that "in constructivism, learning is not viewed as transfer of knowledge but the learner actively constructing, or even creating, his or her knowledge on the basis of the knowledge already held" (p.8).

In addition, Von Glasersfeld (1989) described constructivism as "theory of knowledge with rots in philosophy, psychology and cybernetics" (p.162). In constructivist perspective learners construct their own knowledge with the interaction of his/her environment. The notion that learners construct new knowledge through the combination of their previous learning, new information, and readiness to learn was accepted. Students own knowledge should be constructed based on their prior knowledge. In traditional view, although new information is explicitly presented by teacher or textbooks, interpretation and integration which is guided by learner's prior knowledge is required to reach meaningful learning acquisition. On the other hand, in constructivism, in spite of absorbing knowledge from a teacher or textbook, knowledge is actively constructed by learner from using sensory experiences. It is required that the learner relate their existing knowledge with the new knowledge to be taught (Brown, 1978).

In spite of identifying the entities, relations, and attributes that the learner must know like emphasized in objectivist approach, learning in context is encouraged and learning goals identified with respect to that. Knowledge should be developed and changed with the actively involvement of the learner. Learning is defined as a continuous and life-long process that results actively involve in situations (Brown & Clement, 1989). Perkins (1991) stated that the three basic goals of education are; education strives for the retention, understanding, and active use of knowledge and skills. The primary goals of constructivism are the thinking activities such as; the ability to write persuasive essays, engage in informal reasoning, explain how data relate to theory in scientific investigations, and formulate and solve moderately complex problems. In addition to these, acquiring cognitive flexibility, ability to identify and use different ways of knowing is also stated to be improved by constructivist pedagogy (Morrison & Collins, 1996). Moreover, constructivists support students to acquire the ability to identify and pursue their own learning goals. This process defined to improve students' self-regulation in learning.

2.1.3 Types of Constructivism

In literature, there are different types of constructivism these alternative forms of constructivism emerge from their different focus on the process of knowledge construction. Some of the alternative forms of constructivism stated as; Piagetian or personal constructivism, social constructivism and radical constructivism.

In Piagetian or personal constructivism, the idea of "individual construct knowledge to meet their own needs" was accepted. The Piaget's model of cognitive structures which was defined as collection of "schemes" or "schema" was excluded in this type of constructivism. Schema is defined as the components of an individual's general knowledge structure that relate to that individual's knowledge of the world. According to Piaget, when the preexisting schema or mental structure is used to interpret sensory data for which the schema might not be appropriate, assimilation occurs. If the experiences are not assimilated into preexisting schemes, disequilibration occurs. Preexisting schemes are modified by a process known as accommodation which provides equilibrium. Conceptual change pedagogy was based on Piagets' model of personal constructivism.

Social constructivists' believe that knowledge construction process is influenced by social interactions. Several studies investigated the potentials of the social constructivist perspective to support meaning construction in learning communities (Roth, 1994; McGinn, Roth, Boutonne, & Woszczyna, 1995). Meaning-negotiation process in which students discuss and test their views and consider the views of others should be provided to evolve students' understandings (Bayer, 1990). Multimodel process of communication which is expressive and interpretive between students and teacher, among all students is essential during the process of science learning (Glasson & Lalik, 1993). Vygotsky (1978) stated the importance of speech in learning as:

1. A child's speech is as important as the role of action in attaining the goal. Children not only speak about what they are doing; their speech and action are part of one and the same complex psychological function, directed toward the solution of problem at hand.
2. The more complex the action demanded by situation and the less directs its solution, the greater the importance played by speech in the operation as a whole. Sometimes speech becomes such a vital importance if not permitted to use it, young children can not accomplish the given task.

Moreover, with respect to Vygotsky's theory, social interaction is essential for learners to internalize new or difficult understandings, problems, and processes. However, the social aspects of the construction process were neglected throughout the 1980s. Nevertheless, the social aspects of the construction process have gained growing attention in the science education over the past years (Hennessy, 1993; Roth, 1994).

Ernst Von Glasersfeld, who has built his constructivist view on two principles, is associated with radical constructivism. He stated in his first principle that individuals do not receive knowledge passively, it is an active process. In second principle, he defined the goal of cognition as organization of our experiences of the world by making these experiences meaningful. Radical constructivism sated as a theory of knowing that provides a pragmatic approaches to questions about reality, truth, language, and human understanding (Von Glasersfeld, 1992).

2.1.4 Conditions for Learning in Constructivism

The major goals of constructivist instruction can be stated as; promoting students' problem solving skills, critical thinking skills, reasoning skills, using knowledge actively and reflectively. In an instruction, the process of learning should be focus rather than the products of learning to reach these goals. Constructivist conditions of learning can be summarized as:

1. Embed learning in complex, realistic, and relevant environments: Constructivist believed that if simple tasks are presented to the students this will prevent students from learning how to solve the complex problems they will face real life. For example, some students believe that if math problems could not solved in 5 minutes or less, students attribute them as unsolvable (Shoenfeld, 1985). In spite of presenting only simple questions, teacher should present more complicated and realistic problems to prevent students such erroneous ideas.

2. Provide for social negotiation as an integral part of learning: Vygotsky (1962) asserts that social interaction provide development of higher mental processes. Therefore, collaboration is a critical feature in a learning environment. Not only collaboration means working together and sharing individual's knowledge with each other, it also enables insights and solutions to arise synergistically (Brown & Clement, 1989). In addition to these, students find have a chance to judge the quality of their responses and learn more effective strategies for problem solving when they hear variety of other perspectives.
3. Support multiple perspectives and the use of multiple modes of representation: Different aspect of the content can be seen when the same content is viewed with different sensory modes such as visual, auditory, tactile. Therefore, applying different strategies in instruction promote students conceptual change.
4. Ownership in learning: One of the underlying ideas in constructivism is to meet individual students need. In constructivism, student is seen as a person who makes judgments about what, when, and how learning occur (Hannafin, 1992). Students are actively involved in determining what their own learning needs are and how these needs best be satisfied.
5. Self-Awareness of knowledge construction: The capability of to be aware of one's own thinking and learning process is defined as metacognition. In constructivism, the ability of students to be aware of their own role in the knowledge construction process is promoted.

It was indicated that knowledge is constructed in science learning and this construction require active participation of learner and teacher (Inhelder & Piaget, 1958; Piaget, 1964). Students should identify and test their understandings, interpret the meaning of ongoing experiences, and adjust their knowledge frameworks accordingly to construct knowledge (Glasson & Lalik, 1993). On the other hand, teachers struggle to explicit the ways of students' ideas, propose alternative frameworks, create conflict among students' views, and develop classroom tasks to improve students' knowledge construction process (Vosniadou & Brewer, 1987). These are the commonly shared views of constructivists.

Venville and Dawson (2004) stated the emphasized principles of personal constructivist view:

1. Beside the learning environment, the knowledge of the leaner is the other factor that influences learning outcomes. Learning can be assisted or interfered by the knowledge of the learner.
2. Learning is a process of construction of meaning and students construct these meanings from what they see and hear. The existing knowledge influences the constructed meaning which may different from their intended meaning.
3. The construction process which is an active process initiated at the beginning of a person's life to construct meaning about their world. This process not only takes place inside the school, but also it continues out of school.
4. Teacher evaluates the promoted knowledge in the science classroom and may accept and reject them.
5. Students responsible for their own learning. Instruction is never designed more than the promotion of opportunities, and support for learning.

Jonassen (1991) proposed some principles to design learning environments which are based on constructivism.

1. Real world environments, which are relevant to learning context, should be created.
2. In order to solve real-world problems, realistic approaches should be focused.
3. The instructor should act as a coach and analyzer of the strategies when solving the problems.

4. Multiple representations and perspectives on the content should be presented.
5. Instructional goals and objectives should be negotiated.
6. Tools and environment should be provided to help learners interpret the multiple perspective of the world.
7. Learning should be internally controlled and mediated by the learner.

The knowledge that students already have is very important in teaching. Using language to represent current understandings should be encouraged by teachers to develop students' understandings in science (Glasson & Lalik, 1993).

2.2 The Learning Cycle Approach

The learning cycle, based on constructivist epistemology, is an instructional model in which conceptual change is facilitated (Boylan, 1988). Robert Karplus, professor of physics and accepted as the father of modern learning cycle, proposed a learning model based on pupils' own observations and experiences along with teacher directed assistance in interpreting those observations in an analytical manner. In 1962, together with Atkin from the University of Illinois, Karplus firstly propose two phases and the term "leaning cycle" was not used. The first phase was the initial introduction of a concept which they called invention and the second phase was the subsequent verification, which the authors called discovery (Hanley, 1997). As the students could not invent modern scientific concepts in their own, it was required that teacher introduce the concepts based o interpretations of students' initial observations. After the concept introduction, new patterns would be discovered which could be interpreted with the same concept (Lawson, Abraham, & Renner, 1989).

After this period, Karplus understood that children need time to explore a given concept or area of interest at their own pace and with their own preconceived notions before a more analytical or scientific point of view was introduced. In 1967, Karplus and

Their clarified the phases of new learning approach stated the sequence of instruction as exploration, invention, and discovery (Lawson, Abraham, & Renner, 1989). However, in 1977, since the complexity of the phases meanings, Karplus revised the phases of learning cycle as exploration, concept introduction, and concept application (Hanley, 1977).

Most of the research in science education literature featured instructional strategies as formed of one or three phases: (1) identification of a concept; (2) demonstration of the concept; (3) application of the concept (Abraham, 1998). Although instructional strategies have been divided into more components based on these phases (Bybee & Landes, 1990; Hewson, 1981; Karplus & Thier, 1967; Torrance, 1979), they differ with respect to their arrangement, type of the activities in each phase, and the number of different phases utilized in instruction.

Learning cycle was accepted not only a method of teaching, it was also approved as a curriculum organization model derived from Piaget's mental functioning model (Abraham, 1989; Purser & Renner, 1983; Renner, Abraham, & Birnie, 1988; Scharmann, 1991, Sunal & Haas, 1992). During the Science Curriculum Improvement Study (SCIS), was a primary school science curriculum project initiated at the late 1950s, the learning cycle approach was accepted as an instructional strategy (Atkin & Karplus, 1962). The term "learning cycle" can be seen in early teacher's guides for the SCIS instructional units. Originally the three phases of the learning cycle were stated as "preliminary exploration, invention, and discovery". These terms were converted as "exploration, concept introduction, and concept application" (Karplus, Lawson, Wollman, Appel, Bernoff, Howe, Rusch & Sullivan, 1977). The names of the phases have been modified since then (Abraham & Renner, 1986; Glassson & Lalik, 1993; Lawson, 1988).

It was stated that learning cycle approach lean its roots on philosophy of science and psychology of learning, and it was found that there was consistency between the developmental psychology of Jean Piaget and learning cycle approach (Abraham, 1998). Piaget (1970) mentioned about the mental structures that all human beings have. Information, available in our environment, is assimilated or transformed into our existing mental structures. Assimilated information is run by our mental structures and transformed to in a process of accommodation. The information from the environment and our mental structures transform each other mutually. This phase was defined as the process of disequilibration. Then, assimilated information has been accommodated to our mental structures, this state was defined as equilibrium, and an "accord of thoughts with things" (Piaget, 1963, p.8) has been reached. However, during the state of accommodation, disequilibration occurs between altered mental structure and related existing mental structures. The organization of new structure with respect to the old structures must be done to develop a new equilibrated organization. This was defined by Piaget (Piaget, 1963, p.8) as "accord of thoughts with itself". Moreover, it was stated that Karplus who proposed learning cycle as an instructional model began his works by connecting the development psychology Jean Piaget to design of instructional materials and science teaching (Bybee et al., 2006). In brief, many researchers agree that elements of Piaget's mental functioning model correspond directly with the phases of learning cycle: in the exploration phase, assimilation and disequilibration occur; in the concept introduction phase accommodation occurs; and in the concept application phase, organization occurs (Abraham & Renner, 1986; Abraham & Renner, 1983).

The instruction can be designed to facilitate assimilation accommodation, and organization. The information has a potential to demonstrate to be accommodated should be exposed to learner as a segment of the environment by appropriate instructional activities. Then, the activities which help the learner to accommodate to the information should be presented. And finally, instructional activities, present the relation between new information and previously learned information, should be developed to help the learner in order to organize the accommodated information (Abraham, 1998).

It was stated that the learning cycle approach categorized as an inquiry-based instructional strategy which consist of three phases: First phase is the exploration phase in which students have an initial experience with phenomena, usually involving laboratory experiment. Second is the conceptual invention phase in which students are introduced to new terms associated with concepts that derives from data and usually carried out during a classroom discussion. Last one is the application phase in which students apply concepts and use terms in related but new situations (Abraham, 1998; Bybee et al., 2006). During the exploration phase, cognitive disequilibrium is stimulated by involving students with experiences and concrete materials (Lawson & Renner, 1975). In invention phase, teachers propose activities to improve equilibrium by introducing a new concept or term to account for phenomena under study. During discovery, students are engaged in related activities to self-regulate and reach to new understandings (Glasson & Lalik, 1993). The phases of learning cycle were slightly modified by some researchers (Lawson, 1988). The new terms expressed as exploration, term introduction, and concept application. Although the name of the phases were changed, the meaning and conceptual foundation of learning cycle remained completely same.

Instruction based on learning cycle facilitates to develop new knowledge and reasoning patterns directs the students to apply newly gained knowledge to related areas. If the students aware of their own reasoning patterns and apply new knowledge successfully, they will be more effective in searching of new patterns. Understanding only principles and procedures are discoursed in an instruction based on learning cycle (Boylan, 1988; Sunal & Haas, 1992).

Exploration:

Exploration phase defined as acquiring new information through relatively unstructured experiences (Bybee et al., 2006). The primary purpose of this phase is to provide students with opportunities to manipulate materials and objects distributed by the instructor. Common set of experiences that raise questions the students can not resolve with their cognitive patterns are developed (Lawson, Abraham, & Renner, 1989; Renner, Abraham, & Birnie, 1986; Sunal & Haas, 1987). Instructors minimally guide to students to explore new materials and new ideas. Teachers should design new experiences to raise questions and complexities that students can not resolve ways of thinking (Rutherford, 1999). Ideas or hypotheses which are different from students own introduce to them (Ward & Herron, 1980) and student encounter with their inadequate knowledge in this phase (Lawson, Abraham, & Renner, 1989; Sunal & Haas; 1992). Assimilation and disequilibrium occur in this phase (Marek, Eubanks & Gallaher, 1990; Renner, Abraham, & Birnie, 1986).

The first phase is usually used to create interest and get curiosity. It was reported that using a minds-on approach or interactive student-teacher verbal exchange was found successful in this phase (Lawson, Abraham, & Renner, 1989; Renner & Marek, 1990). Behind hands-on activities, minds-on activities may take many forms such as; an analogy, an opinion statement, or a situational context that requires a reaction, critical appraisal, or independent decision-making process among students. During the activities in the exploration phase, students should found the activities fun and nonthreatening. Students should feel comfortable to state their ideas without the anxiety to find correct answer (Glasson & Lalik, 1993).

Invention (Term Introduction):

Invention phase described as defining and explaining the new terms. In this phase, students are allowed to interpret newly acquired information through the restructuring of prior concepts (Bybee et al., 2006). Students have an opportunity to reexamine and determine the validity of their ideas from their teachers who traditionally assist students in this phase (Karplus & Their, 1967; Lawson, Abraham, & Renner, 1989; Rener & Marek, 1990). The ideas and skills developed in this phase should be associated with the activities that have been engaged during the first phase (Lawson, Abraham, & Renner, 1989). Accommodation occurs in this phase, so this phase is very crucial in learning cycle. Discussion and interpretation of data which allows students to accommodate the concept occurs in this phase (Marek, Eubanks, & Gallaher, 1990).

Direct teaching or expository format with a supplemental sequence of probing questions to direct the students toward the introduction of new terms and eventual development of the concepts under investigation is the most common format that is employed. However, teachers who have lack of understanding of learning cycle believe little involvement of students in this phase (Hanley, 1997). Although concept invention or term introduction can be done through any medium such as film, or book; the language, label and focus of this phase is usually provided by the teacher (Karplus, 1977; Lawson, Abraham, & Renner, 1989; Sunal & Haas; 1992).

Discovery (Concept Application):

Discovery phase defined as applying new concepts to another, novel, and real world situation. Developing a new level of cognitive organization and attempts to transfer what students learned to new situation were carried on by students during this phase (Bybee et al., 2006). Moreover, the concepts that have been explored and the terms that have been introduced in the previous phases were extended and expanded (Barman, 1989; Renner & Marek, 1990). During this phase, using of key concepts and its associated terminology should be permitted to students to enhance and reinforce mental images (Lawson, Abraham, & Renner, 1989). The main purpose is to provide condition to internalize the new view of these concepts and their associated terminology by applying them in novel situations (Scharmann, 1991). Organization in Piaget's mental functioning model occurs in this phase (Marek, Eubanks, & Gallaher, 1990).

The activities that can be used in this phase include the same type of activities as found in the exploration phase. These are used to amplify something the students have already experienced (Schneider & Renner, 1980). This phase is also used as exploratory phase of a new lesson.

Teaching learning cycle to prospective teachers and experienced teacher who are not aware of this method is not easy. It is very difficult for experienced teacher to abandon their teaching experiences that developed through their trials. Moreover, prospective teachers who are familiar other strategies in their lessons may be confused during learning of learning cycle based instructional model. Lindgren and Bleicher (2005) investigated the prospective teachers' difficulties during the understanding of learning cycle teaching strategies. 83 prospective teachers, in multiple sections of a science method course, taught by same professor, were used in this study. Prospective teachers were categorized into four groups with respect to their enthusiasm to the lesson, their content backgrounds, and their attitudes to science. The results showed that students who were successful in science courses felt confused by learning cycle. One of the reasons of this stated as learning cycle was so different from their science learning experiences. This difference also caused mindsets against learning it. On the other hand, students who expressed disinterest to science claimed learning cycle as their first successful science experience.

In the Table 2.1, the teachers' role that is consistent and not consistent with the learning cycle approach was identified (Rutherford, 1999).

Table 2.1 The Learning Cycle Instructional Model: Teacher's Role

	Teachers Actions	
	Consistent with Model	Inconsistent with Model
Exploration	• Creates interest • Generate curiosity • Raises questions • Elicits responses that uncover what the students know or think about the concept or topic • Encourages students to work together without direct instruction	• Explain concepts • Provides definitions and answers • Stats conclusions • Lectures • Provides answers • Tells or explains how to work through problems • Provides closure

Table 2.1 cont'd

	• Observes and listens to student interaction • Asks probing questions to redirect students' investigations when necessary • Provides time for students to puzzle through problems	• Tells students that they are wrong • Gives information or facts that solve problems • Leads students step by step to a solution
Invention (Term Introduction)	• Encourages students to explain concepts and definitions in their own words • Asks for justification (evidence) and clarification from students • Formally provides definitions, explanations, and new labels	• Accepts explanations that have no justification • Neglects to solicit students' explanations • Introduces unrelated concepts or skills • Provides definitive answers • Tells students that they are wrong
Discovery (Concept Application)	• Expects students to use formal labels, definitions, and explanations provided previously • Encourages students to apply or extend concepts and skills in new situations • Refers students to existing data and asks, "What do you already know? Why do think? (exploration strategies apply here also)	• Provides definitive answers • Tells students that they are wrong • Lectures • Leads students step by step to a solution • Explains how to work through problems

Glasson and Lalik (1993) stated that SCIS learning cycle is a useful framework because students engage in activities that require expressive and interpretive language to develop their personal understandings of science. It was found that SCIS program (Science Curriculum Improvement Study) which was a curriculum project, the activities in it were designed based on learning cycle approach, was superior in developing attitudes towards science (Brown, 1973; Lowery, Bowyer, & Padilla, 1980) better motivation towards learning (Allen, 1973a), higher levels of self concept (Malcolm, 1976), and more positive attitudes towards experimentation (Lowery, Bowyer, & Padilla, 1980).

Lawson (1995) stated that learning cycle classified three different types; descriptive learning cycle, empirical-abductive learning cycle, and hypothetical-deductive learning cycles. These three types learning cycles differs in their effectiveness at generating disequilibrium, argumentation, and the use of thinking pattern to examine alternative conceptions or misconceptions.

Students who are taught with descriptive learning cycles observe small part of the world, discover a pattern, name it, and look for the pattern elsewhere. Since the students will most likely not a strong expectations of what will be found, disequilibrium may not be occur. For example, if a graph of a frequency distribution of the length of a sample of seashells is distributed to students, this will allow introduction of the term normal distribution without proving much argumentation among the students (Lawson, 1995).Small part of the world were examined by students in this type of learning cycle. Students only discover and name patterns, and search the same pattern elsewhere (Lawson, Abraham, & Renner, 1989). Students answer "what" questions, not "why" questions in this type of learning cycle (Lawson, Abraham, & Renner, 1989; Westbrook & Rogers, 1991).

Another type of learning cycle lessons, empirical-abductive learning cycle, has a property of asking causal questions to the students. Patterns are discovered and described, causes are generated, and explanations provided by students. In this type of learning cycle students look empirically to the world. The experiments that the students organize are not designed with well-formulated hypothesis in mind. Students use induction to answer the cause of some event. Students need hints and encouraged to think further about the problem in order “hit” on a hypothesis. The reason of using the term empirical-abductive is the “hitting” on the right idea involves abduction, not induction (Lawson, 1995).

Third type of the learning cycle lessons, hypothetical-deductive learning cycle, involves explanation of some phenomenon. Alternative conceptions and misconceptions may occur and that leads argumentation, disequilibrium, and analysis of data to resolve this conflicts. In this type of learning cycles, alternative hypothesis are created and tested to explain a phenomenon. In brief, a causal question is raised, and students must propose alternative hypothesis. These, in turn, must be tested through the deduction of predicted consequences and experimentation (Lawson, 1995).

2.2.1 Research on Science Curriculum Improvement Study (SCIS)

Many of the studies which involve the learning cycle approach were used assessed students’ content and process of leaning gains. Students who were exposure the SCIS program based on learning cycle approach showed significant gains in basic process skills and content knowledge. Moreover, students who are thought with SCIS program had superior attainment of scientific process skills compared with non-SCIS students (Bybee et al., 2006). In addition, when compared SCIS students with the students who were thought with traditional methods, SCIS students showed superior inquiry skills, figural creativity abilities, ability to isolate and control variables, ability to describe objects by their properties, ability to describe similarities and differences between different forms of the same substance, ability to observe an experiment and use observations to describe what happened in the experiment (Bybee et al., 2006). Finally, the superior effect of SCIS program on primary school children was confirmed by two longitudinal studies (Bybee et al., 2006).

The teacher who used learning cycle approach spent more time on teaching science compared with teachers who were not use (Campbell, 1977). The reason of this stated as teachers who used learning cycle approach focused more on students higher-order thinking skills, asked open-ended questions rather than fact oriented questions (Bybee et al., 2006), and used more student oriented activities such as hands-on and laboratory activities (Abraham, 1998). On the other hand, the learning cycle approach presents flexible instructional strategy that posses the ability to improve conceptual change. In learning cycle approach, the instructors are free to use their own instructional strengths through the use of several instructional formats such as lecture, laboratory, discussion, and reading. Moreover, creativity in designing new learning experiences to promote conceptual change is increased without limiting learning activities and experiences previously found effective. Former experiences can be easily integrated in the learning cycle's phases (Scharmann, 1991). However, whatever the instructional formats are, the sequence of phases of the learning cycle should not be changed or deleted. It will be not an instruction based on learning cycle if the sequence of the phases is changed, or a phase is deleted (Lawson, Abraham, & Renner, 1989). In addition to these, it was expressed that the responsibility of learning cycle' positive gains in achievement belongs to its' phases sequence (Saunders & Shepardson, 1987).

2.2.2 Learning Cycle Research

In this part of the study, the positive effects of learning cycle as an instructional method on students' achievement and their attitudes towards science are reported and examined first, and then the negative effects on students' achievement and attitudes towards science are presented.

After the success of the SCIS program, many groups developed their instruction and curriculum based on learning cycle approach. Moreover, researches were done studies to test effectiveness of these programs (Abraham, 1998). As a result of these studies, it was seen that curricula based on learning cycle approach improved students attitudes towards science and science instruction compared with curricula based on traditional approaches on primary to college level students (Campbell, 1977; Cumo, 1991; Davis, 1978; Klindienst, 1993; Shadburn, 1990). Moreover, students who were thought using learning cycle approach exhibited improvements in their process skill development (Cumo, 1991; Davison, 1989), content learning (Campbell, 1977; Kurey, 1991; Purser & Renner, 1983; Saunders & Shepardson, 1987; Schneider & Renner, 1980; Shadburn, 1990), and in reducing misconceptions (Lawson & Thompson, 1988; Marek, Cowan, & Cavollo, 1994; Scharmann, 1991, Gang, 1995). Learning cycle approach can result on greater achievement in science, better retention of concepts, improved attitudes towards science and science learning, improved reasoning ability and superior process skills than would be the case with traditional instructional approaches (Abraham & Renner, 1986; Iwins, 1986; McComas III, 1992; Raghubir, 1979, Renner, Abraham, & Birnie, 1985).

Campbell (1977) carried out a study to understand the effectiveness of learning cycle on some aspects by comparing two groups in an introductory physic course for college students at two universities. In the first group, the students were instructed by using learning cycle whereas traditional instruction was used in the second group. Results showed that students who were instructed by learning cycle exposed more consistent attitude toward the laboratory experience, scored higher on the lab final and had a low tendency to withdraw from the course when compared with students who were instructed traditionally. Campbell (1977) noted that instruction, especially a laboratory course, based on learning cycle offers students opportunities for concrete experiences, assists students in the development of reasoning abilities, improve students' social skills that are helpful in mastery of content, and promote their cognitive growth.

Klindienst (1993) conducted a study to examine the effectiveness of learning cycle with respect to middle school students' cognitive structures regarding electricity as evidenced by changes in concept maps, content achievement, and attitudes towards learning science. The results showed that students who were taught via learning cycle have more complex cognitive structures when compared with students taught via traditional instruction. Moreover, students in the learning cycle instruction group acquired higher scores on a teacher made test than students in traditionally instructed group. In addition to these, it was found that students who were taught by learning cycle based instruction gained significantly higher scores when compared with students in traditional instruction group. The reason of having more complex cognitive structures in learning cycle group students stated as requirement from student to process information in a variety of ways in learning cycle based instruction. The sense of control over learning that the instruction based on learning cycle gives to leaner was stated as a reason of exposing better attitudes toward learning science. Klindienst (1993) argued that instruction based on learning cycle is more appropriate for difficult learning situation such as students who possess low socioeconomic status.

Scharmann (1991) carried out a study to understand the effectiveness of learning cycle approach which consist of three phases; exploration, term introduction, and concept application in eliminating misconceptions and promoting conceptual change on angiosperm reproduction unit. It was reported that students who were exposed to the instruction based on learning cycle more successfully classify objects as fruits versus vegetables when compared the other students who receive traditional lecture instruction.

Gang (1995) conducted a study to evaluate the effectiveness of the learning cycle in removing students' alternative conceptions on Archimedes' principles. Gang (1995) stated that "by applying the learning cycle in this teaching experiment, I experienced for the first time in my career the real significance of the pedagogic distinctions that guide our philosophies of physics teaching. I experienced the value of students-centered over teacher centered instruction; constructivist over transmissionist, guided inquiry over random trial or mechanistic experimentation; and student active engagement in cognitive skill development, articulation, and evaluation over student-passive-reception" (p.354).

Cumo (1991) believed that science instruction based on lecture and teacher discourse has not a potential to establish conditions for active learning. Therefore, Cumo (1991) tested the effectiveness of instruction based on learning cycle on the cognitive development, and the development of science process skills, content achievement, and attitude towards science of seven graders. The results of the study showed that students who were in learning cycle group statistically develop more science process skills than students in control group. However, Cumo (1991) stated that there was no significant difference between two groups with respect to students' attitudes toward science. On the other hand, students who were in the learning cycle group showed superior cognitive development when compared with the students who were in control group.

Kurey (1991) investigated effectives of learning cycle based instruction by comparing with traditional approach in chemistry's four topic such as; expansion of gases, density, molecular models, and the gas laws. In this study, Kurey (1991) identified students as concrete, transitional, or formal and alternatively assigned to each treatment. The results indicated that there was no significant difference with respect to students' performance between two groups based on developmental level of expansion of gases and density topics. However, the performances of the students were enhanced when cognitive development is considered for the molecular models and gas laws unit. Hence, Kurey (1991) concluded that learning topic can be appropriate both concrete and formal chemistry topics.

Davison (1989) carried out a study to assess students' level of intellectual development, spatial ability, and the development of process skills. Behind that, the other objective of Davidson was to improve these students' characteristics by creating learning cycle lab activities. Students who did learning cycle lab activities were compared with students who did traditional lab activities. The results showed that there was statistically significant difference on the test scores of the students who were in experimental group and students who were in control group. However, experimental group students showed superior performance on items called for operationally defining variables, interpreting data and graphs, and designing experiments. Davison (1989) stated that intellectual development of learning cycle students was not improved because the reason of improvement of intellectual development is a slow process, and the treatment of this study was too short to make an impact.

Saunders and Shepardson (1987) organized a study to understand the effects of learning cycle on content achievement and intellectual development of six graders. Students who were in the experimental group acquired higher scores on science achievement and exposed better cognitive development than the control group. The number of students who pass from concrete to transitional reasoning was greater in experimental group. The reason of these positive gains in achievement was attributed to combined sequence of the activities in learning cycle.

Purser and Renner (1983) examined the effectiveness of different teaching methods on content achievement of ninth grade and tenth grade students who posses to different developmental level. It was concluded that learning cycle fosters students' intellectual development when compared with formal instruction.

Ward and Herron (1980) conducted a study to compare the effectiveness of learning cycle laboratory format with traditional lab format. There experiments were conducted which require the use of formal reasoning abilities. Learning cycle was only effective in one of three experiments. However, students who were in the learning cycle group had higher mean score than students who were in control group. As a result of the study, researchers concluded that tasks that require formal reasoning were performed better by formal students when compared with concrete students. However, it was stated learning cycle have a capacity to reduce the differences between the groups because formal concepts are made more appropriate for students to understand by learning cycle.

Shadburn (1990) carried out a study to investigate the effectiveness of learning cycle in promoting cognitive development among physical science students at a two year community college. The results showed that although there was no significant difference between students who were in learning cycle and those who were in control group with respect to students' improvement of formal reasoning ability, there were small differences. Moreover, it was indicated that there were small differences between groups with respect to students' physics content achievement and it was reported that there was no significant difference between two groups with respect to students' attitudes toward science. However there was a significant difference between two groups with respect to attitudes toward their laboratory in favor of learning cycle group.

Marek, Cowan and Cavallo (1994) tested the effectiveness of learning cycle to eliminate nine grades students' misconceptions about diffusion. There were two groups in this study: Class A in which 16 students received instruction about the concept of diffusion using the learning cycle. Class B in which 19 students instructed same concept by using expository teaching practices. The Concept Evaluation Statement (CES) which validated in other studies (Marek, 1986b; Simpson & Marek, 1988; Westbrook & Marek, 1991) was used a pretest and a posttest to determine what students know about diffusion. Pretest revealed that some types of misconceptions were held by all of the students in both groups. The results showed that while %42 of the students in Class B held some kind of misunderstanding, %6 of the students in Class A held some kind of misunderstanding. The researchers stated that if the newly acquired concepts are linked with the other concepts that students know, students tend to correct their misconceptions and develop meaningful understanding of science concepts. In the learning cycle students were allowed to make the linkages about the ideas and facts of diffusion for themselves through the laboratory experimentation and discussions. On the other hand, students in expository teaching group teacher presented the linkages through a lecture. Therefore, the students in learning cycle group eliminated more misconceptions than those in the expository group.

Johnson and Lawson (1998) stated with supports of related literature, probably in the classes that employed expository teaching, domain specific prior knowledge is the best predictor that explains achievement. On the other hand, they stated that since the inquiry instruction focuses more on how science is done, probably reasoning ability is the best predictor that explains achievement in inquiry classes. They designed a study to test these hypotheses. Initially, students' prior knowledge, the number of biology courses taken by the students, and students' reasoning abilities were determined. During a semester, while 181 students were taught by using expository instruction, 185 students were taught by inquiry (learning cycle) instruction. A comprehensive final examination was administered to both groups. Results revealed that a significant amount of variance in final examination score in both instructional methods were explained by reasoning ability, but not prior knowledge or number of previous biology courses. Explained variance in final examination scores by reasoning ability was greater in expository classes (18.8%) than in inquiry classes (7.2%). On the other hand, while there was a significant improvement of scientific reasoning in inquiry class, there was no improvement of scientific reasoning in expository class.

Odom and Kelly (2001) carried out a study to investigate the effectiveness of concept mapping, the learning cycle, expository instruction, and a combination of concept mapping/learning cycle in promoting conceptual understanding of diffusion and osmosis in high school biology course. 108 secondary students who are taught by same teacher participated in this study. Diffusion and Osmosis Diagnostic Test (DODT), which was developed and appraised as a good indicator of students understanding of diffusion and osmosis, administered to students immediately after the treatment and 7 weeks after treatment to appraise retention of the concepts. The results showed that students who were instructed by concept mapping/learning cycle and concept mapping performed significantly better than students who were instructed by expository instruction with respect to students' conceptual understandings of diffusion and osmosis. Moreover, it was stated that two treatments that were applied in concept mapping/learning cycle group and concept mapping group were not significantly different than the learning cycle treatment. The researchers assert that while the connections between concepts were provided by concept mapping, concrete experiences with the concepts provided by learning cycle. The key reason of students outperforms may be attributed these features of both methods. Finally, Odom and Kelly believed that only a partial framework of knowing provided to learner if learning cycle and concept mapping is used alone without the other. The foundation of this rationale was derived from Ausbel's and Piaget's distinct methodologies in which the requirement of both a verbal and a process oriented approach for an effective instruction and meaningful learning was defended.

Ates (2005) preformed a study to investigate the effectiveness of learning cycle method on direct current circuits concepts at university level. 120 freshmen students from four intact classes were used in this study. Two of these groups randomly assigned as experimental group in which students were taught by using learning cycle based instruction, other two groups randomly assigned as control group in which students were instructed by using traditional instruction. Electric circuits concept test was administered as pretest before the instruction to both groups and as posttest after the instruction to both groups. The results revealed that when the students' pretest scores on electric circuits concept test were used as covariate, significant difference was found between experimental groups and the control groups with respect to students posttest scores on electric circuits concept test, favoring experimental group which constituted learning cycle instructional method.

Musheno and Lawson (1999) investigated the effectiveness of learning cycle when it can be applied into science text. So, the texts were prepared with respect to learning cycle and traditional approach. 123 high school students were used in this study. Before the instruction Lawson's Classroom Test of Scientific Reasoning was applied to students to classify them such as empirical inductive, transitional, or hypothetical-deductive reasoners. Both the learning cycle text and traditional text constituted 751 words in length to teach the concepts of symbiosis, mutualism, commensalism, and parasitism. Posttest in which one of dimension was concept comprehension was administered to students immediately after the treatments and one week later. The results showed that students who were instructed by reading learning cycle passage performed superior to those who were taught by reading traditional passage with respect to concept comprehension questions. Also, the learning cycle text was found more comprehensible by readers at all reasoning levels.

Champion (1993) carried out a study to compare the learning cycle approach with the expository method with respect to their effectiveness on understanding of contents and experimental design. Champion concluded that students' understandings of experimental design were improved by instruction based on learning cycle, whereas data analysis techniques were promoted by expository methods.

However, none of the student in both groups produced student mastery of concepts. In addition to this, Jackman, Moellenberg and Drabson (1990) investigated the effects of three instructional strategies which were learning cycle, traditional approach, and the use of computer simulations on the achievement of general chemistry students. The results showed that students who were instructed by learning cycle were not significantly different from students who were instructed by the other two methods with respect to their scores.

Vermont (1985) tested three instructional strategies such as learning cycle, cognitive learning and development strategy, and lecture-laboratory method to understand their effectiveness of learning the mole concept and eliminating misconceptions about the mole. The results showed that there were no significant difference between three methods on understanding of the mole concept and elimination of misconceptions about mole.

Since the development of SCIS, the learning cycle has been modified by many researchers (Barman, 1989; Lawson et al., 1989; Renner & Marek, 1990). Inductive use of laboratory and defined phases of instruction were showed as the most critical characteristics of the learning cycle approach. However, there is a need to research into the aspects of instruction that characterize and explain the success of learning (Abraham, 1998). Westbrook and Rogers (1991) proposed new learning cycle to modify expansion phase and gave students opportunities for hypothesis testing and designing experiments. It was proposed that involving cooperative learning activities in learning cycle improve students' self-esteem. On the other hand, Westbrook and Rogers (1991) proposed to adding concept mapping activities in learning cycle approach. Moreover, additional phases of instruction have suggested improving learning cycle. Engagement and evaluation phases were added to learning cycle. Engagement phase designed as an introductory activity to involve students in the learning cycle lessons (Abraham, 1998).

Lavoie (1999) tested the effects of adding a prediction/discussion phase at the beginning of a three phase-learning cycle which involves exploration, term introduction, and concept application. This was also done by comparing and contrasting prediction/discussion based learning cycle instruction with traditional learning cycle instruction in high school biology classroom with respect to students' attitudes and motivations towards science, students' ability to use process skills, and demonstrate conceptual understanding in biology. In prediction and discussion phase, predictions with explanatory hypothesis about the genetics, homeostasis, ecosystems, and natural selection were written by students. Interactive debate of predictions and reasons took part immediately after predictions. Approximately 250 students were used in this study. Both qualitative and quantitative research methods were used in this study. Questionnaires, field observations, teacher/researcher daily log reports and a battery of tests that assess cognitive changes were used to collect data. The results showed that students who were taught by using prediction/discussion-based learning cycle instruction showed superior performance when compared with students who were taught by using traditional learning cycle instruction with respect to students' process skills, logical thinking skills, science concepts, and scientific attitudes.

2.3 5E Learning Cycle Model

An instructional learning model based on 5E learning cycle has been used by Biological Sciences Curriculum Study (BSCS) as one of the instructional model to develop new curriculum materials since 1980's. This model accepted as BSCS 5E learning cycle model. Bybee (1997) stated that this model was influenced by the works of German philosopher Johann Friedrich Herbart, in addition to that of John Dewey and also Jean Piaget. The modifications of this model such 3E, 4E, and 5E can be found in the related literature. It was said that 5E model is rooted its' fundamentals in constructivism and it facilitates conceptual change.

Bybee and Landes (1990) stated that "the objective in a constructivist program is often to challenge students' current conceptions by providing data that conflict with students' current thinking or experiences that provide an alternative way of thinking about objects and phenomena" (p.96). In the Karplus and Atkin's learning cycle and BSCS 5E instructional model, students' initial concepts are redefined, reorganized, elaborated and changed through self-reflection and interaction with their peers and their environments which promotes conceptual change (Bybee, 1997).

As indicated its name, this model consist of five phases: engagement, exploration, elaboration, and evaluation. 5E learning cycle model was designed based on SCIS learning cycle. When the SCIS learning cycle model and 5E instructional model are compared, the commonalities will be easily seen. The middle three phases of both models are fundamentally equivalent to each other (Bybee et al., 2006). Table 2.2 represents the comparison of the phases of SCIS leaning cycle and BSCS 5E instructional model.

Table 2.2 Comparisons of the Phases of SCIS and BSCS 5E Learning Cycle Model

SCIS Learning Cycle Model	BSCS 5E learning cycle model
	Engagement (New Phase)
Exploration	Exploration
Invention (Term Introduction)	Explanation
Discovery (Concept Application)	Elaboration
	Evaluation (New Phase)

Instructional models based on learning cycle considered to be important and became popular as it use of coordinated and coherent sequencing lessons. 5E instructional model has a potential to be applied several levels in the design of curriculum materials and instructional sequences. Each phase in the 5E instructional model contributes learners to better understand scientific and technological knowledge and each phase has a different function.

Engagement: In this phase, students are engaged to the learning task. The activities should be developed to create interest and generate curiosity which can be including a problem, s situation, or an event. The activities that are employed in these phase expose students' prior knowledge and make connections to present and future topics. Present a discrepant event, defining a problem, asking a question can be sated as the ways to attract students' interest and curiosity on the instructional task. Identifying and presenting the situation are the instructor's role. Instructors are expected to raise questions and problems, create interest, generate curiosity, and elicit responses that uncover students' current knowledge (Bybee, 1997). Students should be puzzled and actively motivated to the learning activity in successful engagement. In addition, since this phase has a potential to being one of the most critical phase of the model, materials should be presented well to make the other phases meaningful. Disequilibrium occurs in this phase.

Exploration: In this phase, students are exposed to activities to explore the ideas. The activities which are common for all students in class are designed for students to identify the current concepts, may include misconceptions, processes and skills and facilitate conceptual change. Exploration phase correspond the first phase of learning cycle. The process of equilibration is initiated by the exploration activities. The activities which are designed for this phase should be concrete and hands on. Tangible materials and concrete experiences should be used in this phase. The main aim of these activities is to establish that teachers and students can use later to formally introduce and discuss concepts, process, and skills (Bybee et al, 2006).

Teachers should behave as a facilitator or a coach and ask guiding questions to encourage cooperative group discussion. Teacher provides students needed time and opportunity to investigate objects, materials, and situations based on student's own ideas of the phenomena. Lab activities, educational software can be used to help student to use prior knowledge for generating new ideas. Teacher should also design this kind of activities for students to assist them to explore questions and possibilities, design and conduct a preliminary investigation (Bybee, 1997; Bybee et al., 2006).

Explanation: In this phase, the concepts, processes, or skills become plain, comprehensible, and clear. Teacher presents concepts simply, clearly, and directly by attracting students' attention to specific aspects of engagement and exploration experiences. Firstly, students are asked to give their explanations and then scientific or technological explanations are presented to students in direct, explicit and formal manner. Experiences that are gained in exploration phase are ordered in this phase. The experiences that are acquired in engagement and exploration phases and students' explanations occur in this phase constitute the fundamentals of starting point of teacher's explanation. Teacher should present the concepts, processes, or skills in a brief, simple, clear, and direct way to move on to the next phase. Therefore, the role of the teacher is very crucial in this phase. Teachers try to explain the students the connections between their own interpretations and scientific phenomena. Although teachers prefer to use verbal explanations, variety of techniques and strategies such as videos, films, and educational courseware can be employed. At the end of this phase, explanatory experiences and experiences that have engagement phase should be able to explained with using common terms by students (Bybee et al., 2006). Also, it's expected that students criticize and question others explanations which lead to promote their own learning (Campbell,2000).

Elaboration: After acquiring explanation and terms for the learning task, it is very important for students to involve further experiences that extend, or elaborate, the concepts, processes, or skills. In brief, the elaboration phase refers the extension of concepts that have experienced through the previous three stages. Students try to transfer of concepts to closely related but new situations. Bybee (1997) stated that "generalization of concepts, processes, and skills is the primary goal of the elaboration phase" (p.181). Elaboration activities provide additional time for students, who may still have some misconceptions or may only understand a concept in terms of the exploratory experience, to remedy misconceptions and comprehend their understandings.

Champagne (1987) stated the description of this phase very clearly:

"During the elaboration phase, students engage in discussions and informationseeking activities. The group's goal is to identify and execute a small number of promising approaches to the task. During the group discussion, students present and defend their approaches to the instructional task. This discussion results in better definition of the task as well as the identification and gathering of information that is necessary for successful completion of the task. The teaching cycle is not closed to information from the outside. Students get information from each other, the teacher, printed materials, experts, electronic databases, and experiments that they conduct. This is called the information base. As a result of participation in the group's discussion, individual students are able to elaborate upon the conception of the tasks, information bases, and possible strategies for its [the task's] completion. (p. 82)."

Using formal science terms during the completion of related activitities and identification of alternative ways of explain phenomena should be encouraged by teacher (Bybee, 1997). Group discussions and cooparative learning situations considered to be appropriate for this phase to give students one more chance to experess their understaning of the subject and receive feedbaks from other students (Bybee et al., 2006).

Evaluation: Most of the effective instructional methods include a phase that guage students outcomes. In 5E learning cycle model, students find opportunity to eveluate their understanding, ehich were gained in previous phases (Campbell, 2000). In addition, feedback on the adequacy of students explanation should be provided by teacher. Although informal evaluation can be done at he beinnng and throughout the 5E learning cycle model, a formal evaluation should be done to assess educational outcomes in eveluation phase. In other words, student's level of understading is determined by administering assesments (Bybee, et al., 2006). Instead of multiple-choice test, open-ended questions and demonstrations and often-times probing questions should be used to lead the next inquiry. Moreover, teacher should give opprotunities to students to eveluate their own understanding (Bybee, 1997).

It was stated that teachers' role in the classrooms is very important to lead discussions; answer questions, and model the ideas that supports nature of science. The appropriateness of teacher actions or behaviors will guide students toward a more conceptual understanding of science (Bianchini & Colburn, 2000). The chart that was developed by BSCS to show the salient characteristics of each step with respect to teacher's perspective is presented in Table 2.3.

Table 2.3 The BSCS 5E Learning Cycle: What the Teacher Does

Stages of the Instructional Model	The BSCS 5E Instructional Model Teachers Actions	
	Consistent with Model	Inconsistent with Model
Engagement	• Creates interest • Generate curiosity • Raise questions.	• Explain concepts • Provides definitions and answers.

Table 2.3 cont'd

	• Elicit responses that uncover what the students know or think about the concept or topic	• States conclusions • Lectures • Provides closure
Exploration	• Encourages the students to work together without direct instruction from the teacher • Observes and listen students as they interact • Asks probing questions to redirect the students' investigations when necessary • Provides times for students to puzzle through problems • Acts as a consultant for students • Creates a "need to know" setting	• Provide answers • Tells and explains how to work through the problem • Provides closure • Directly tells the students that they are wrong • Gives information or facts that solve the problem • Leads the students step by step to a solution.
Explanation	• Encourages students to explain concepts and definitions in their own words • Asks for justification (evidence) and clarification from students • Formally provides definitions, explanations, and new labels when needed • Uses students' previous experiences as the basis for explaining concepts • Assess students' growing understanding	• Accepts explanations that have no justification • Neglects to solicit the students' explanations • Introduced unrelated concepts or skills
Elaboration	• Expect to students to use formal labels, definitions, and explanations provided previously • Encourages the students to apply or extend the concepts and skills in new situations • Reminds the students of alternate explanations • Refer the students to existing data and evidence and ask "what do you already know?" "Why do you think…?" (Strategies from exploration also apply here.)	• Provides definitive answers • Directly tells the students that they are wrong • Lectures • Leads students step by step to a solution • Explains how to work through the problem
Evaluation	• Observes the students as they apply new concepts and skills • Assesses the students' knowledge and skills • Looks for evidence that the students have changed their thinking or behaviors • Allows students to assess their own	• Test vocabulary words, terms, and isolated facts • Introduces new ideas or concepts • Creates ambiguity • Promotes open-ended discussions unrelated to the concept or skill.

Table 2.3 cont'd

	learning and group-process skills • Asks open ended questions such as, "why do you think…?" "What evidence do you have?" "What do you know about x?" "How would you explain about x?"

The commonalities and differences between the SCIS learning cycle and the BSCS 5E learning cycle model are; both model use a sequence and emphasis the phases in this sequences, both models use the work of Jean Piaget (Piaget & Inhelder, 1969; Piaget, 1975), both models view learning as dynamic and interactive process, both models believe that changing and improving conceptions often require to challenge students' current conceptions and to show students the inadequacies of these concepts. Bybee (2006) stated that "the students' construction of knowledge can be assisted by using sequences of lessons designed to challenge current conceptions and provide time and opportunities for reconstruction to occur" (p.11).

BSCS (2006) presented rationales to explain the reasons of changing learning cycle phases with 5E learning cycle model. They stated that engagement phase was exposed to cover the requirement of students to deal with their prior knowledge (Champagne, 1988). The term exploration and the original intent of the phase were maintained. However, cooperative learning was incorporated based on the research of Johnson, Johnson, and Holubec (1986). The invention or concept introduction phase was maintained, however the term name was changed as explanation to emphasize the development of scientific explanations. Cooperative learning was again incorporated into the discovery phase and the name of this phase was also changed as elaboration to emphasize the application and transfer of ideas to further develop current understanding. Finally, the evaluation phase was added to ensure the demonstration of students' understandings and abilities through a new activity. The requirement of formal assessment opportunities that were integral to the instructional plan was the one of the reason for adding this phase. In addition, this phase also provides opportunities for self reflection which was stated as an essential component of learning revealed by studies on metacognition.

Since BSCS 5E learning cycle model is young when compared with the learning cycle, there are fewer published studies that examine the effectiveness of this model. However, the studies stated that BSCS 5E learning cycle model is effective than alternative teaching methods with respect to reaching important learning outcomes in science. Akar (2005) stated that 5E learning cycle model is more effective than alternative approaches with respect to students' mastery of science subjects. Coulson (2002) conducted a study to explore how varying levels of fidelity to the BSCS 5E learning cycle model affected student learning. The results showed that students who were taught BSCS 5E learning cycle model with medium or high levels of fidelity experienced learning gains that were nearly double than the students who were taught not using 5E learning cycle model or taught with low levels fidelity. It was stated that BSCS 5E learning cycle model have positive impact on scientific reasoning (Boddy, Watson, & Aubusson, 2003), and on interest and attitudes toward science (Akar, 2005; Boddy et. all, 2003).

Garcia (2005) carried out a study to compare the effectiveness of using 5Es learning cycle instructional model with the traditional Hunter lesson plan to teach evolution concepts and enhance students' attitudes toward the subject of science. 160 seventh-grade life science students were used in this study as a sample. The results showed that although there was no significant difference between students who were instructed by 5Es learning cycle model and students who were instructed by traditionally designed instruction with respect to understanding evolution concepts and students attitudes towards science, a significant change was found based on paired pretest and posttest caparison. In addition it was reveled that 5E learning cycle model had some positive effects on lower level of students. The results may be affected by level of treatment fidelity that was discussed by Coulson's (2002) study.

Campbell (2000) conducted a study to investigate the fifth grade students understanding of force and motion concepts when they were instructed by inquiry based science investigations through the use of 5E learning cycle model. The students understanding were evaluated by a posttest, a review of lab activity sheets, other classroom-based assessments, and interviews. 520 students with the age of 10-12 were used in this study as a sample. The results showed that students who were instructed by inquiry based science investigations through the use of 5E learning cycle model increased their knowledge about force and motion concepts.

Balcı, Çakıroğlu and Tekkaya (2006) carried out a study to investigate the effects of the 5E learning cycle model, conceptual change text, and traditional instructions on 8^{th} grade students understanding of photosynthesis and respiration in plants. 101 8^{th} grade students in three intact classes of the same school were used in this study. There were three groups in this study. Two of the groups were assigned as experimental groups in one of which 5E learning cycle model was used and in the other experimental group conceptual change text instruction was used. The third group was defined as control group in which the traditionally designed instruction was used. The results showed that there was a significant difference between experimental and control groups in favor of experimental groups with respect to students' understanding of photosynthesis and respiration in plants. On the other hand, there were no statistically significant difference between the students who were instructed 5E learning cycle and students who were instructed by conceptual change texts with respect to students' understanding of photosynthesis and respiration in plants.

Lord (1997) tested the effectiveness of instruction based on 5E learning cycle model by comparing it with the traditionally designed instruction. The traditional designed instruction constituted based on teacher-centered and lecturing methods. Thought-provoking scenarios, critical thinking questions, and constructed concepts maps were used in 5E learning cycle instructional model's phases. The results revealed that students in the 5E learning cycle model group had much greater understanding of the information covered especially on questions that required interpretation. It was stated that students who were taught with the 5E learning cycle model understood the course material in a much deeper, more comprehensive way. Moreover, vast majority of the students who were taught with 5E learning cycle model feel positive about the course. On the other hand, half of the students in traditionally designed instruction group did not make any comments, and few expressed positive feelings.

Mecit (2006) compared the effect of 7E learning cycle model as an inquiry based learning and traditional designed instruction on the improvement of 5^{th} grade students' critical thinking skills. 46 fifth grade students were used as a sample of this study. Two groups which were defined as experimental and control group were used in this study. The Cornell Conditional Reasoning Test, from the Cornell Critical Thinking Skills Tests Series was used to evaluate students' critical thinking skills and administered to both experimental and control group students as pretest and posttest. The results showed that students who were instructed by 7E learning cycle model showed better performance than the students who were instructed by traditionally designed instruction on students critical thinking skills.

It was stated that development of students own frames of thought is encouraged by using 5E lerning cycle instructional model (Bevenino, Dengel & Adams, 1999). Colburn and Clough (1997) also found 5E learning cycle model appropriate for the middle school and high school science students because of its flexibility and its realistic nature. They sated that 5E learning cycle is effective way to develop science enjoymeny of students, understanding of concepts, and application of scientific processes and concepts to authentic situations.

2.4 Misconceptions

Duit and Treagust (1998) stated that "learning science is related to students' and teachers' conceptions of science content, the nature of science conceptions, the aims of science instruction, the purpose of particular teaching events, and nature of the learning process" (p.5). Many students interpret science learning as conceptualizing provided knowledge and then storing in the memory. Moreover, they believe accumulation of facts refer the science learning (Sutton, 1998). As a result of these, students' classroom discussions of alternative viewpoints and negotiated consensus are seemed as wasted time that hinders efficient progress (Baird & Mitchell, 1986).

Ausubel (1968) explained and differentiated meaningful learning and rote learning by stating the importance of prior knowledge. Whereas new knowledge and students' existing relevant knowledge are related in meaningful learning, the importance of prior knowledge and its relation with new knowledge is neglected in rote learning. Therefore, Ausubel (1968) stated that "the most significant factor influencing learning is what the leaner already knows". Moreover, Hewson (1992) stated that interaction between new and existing conceptions constitute one side of learning, and the outcome depends on the nature of this interaction.

When two individual exposed the same events, these events may be perceived and interpreted in very different ways. One of the reasons of this stated as individuals may have different knowledge and beliefs and these beliefs may influence or be influenced by social interactions in different ways (Hewson, 1992). In other words, knowledge which is constructed by learner is affected by the learner's prior knowledge and experience and the social context in which learning takes place (Grayson et al., 2001; von Glasersfeld, 1992). Moreover, it was stated that learning new scientific knowledge is strongly influenced by students' preexisting beliefs and preexisting beliefs have a crucial role in subsequent learning (Arnaudin & Mintez, 1985; Boujaoude, 1991; Driver & Oldham, 1986; Shuell, 1987; Tsai, 1996). Hunt and Minstrel (1997) stated that since students preexisting concepts and beliefs is ignored before the instruction, students encounter with difficulties in science learning, and this cause loosing communication between teachers and learners.

Students' preexisting beliefs and ideas appear them as logical, sensible, and valuable. However, ideas that are held bys students may be differ from the definitions accepted by experts and scientific definitions (Osborne, 1982; Schoon and Boone, 1998). It was stated that these beliefs are persuasive, stable, and resistant to change via traditional instructional strategies and these beliefs may be found in individuals' cognitive structure even after completion of years of formal science instruction (Champagne et al., 1982, Clement, 1982; Guzzetti, 2000, Hewson & Hewson, 1984, Osborne & Cosgrove, 1983; Stavy, 1991; Tsai, 1996; Wandersee et al., 1994). Students conceptions or ideas that is differ from the definitions accepted by experts or scientific community are generally called misconceptions (Driver & Easley, 1978; Hewson & Hewson, 1984; Treagust, 1988; Nakhleh, 1992, Lawson & Thompson, 1988; Schmidt, 1997), alternative conceptions (Driver & Easley, 1978; Taber, 2001), preconceptions (Novak, 1977), alternative frameworks (Driver & Ericson, 1983; Kuiper, 1994; Gonzalez, 1997; Taber, 2001), naive conceptions (Champagne, Klopfer, & Gunstone, 1982), children's science (Gilbert et al., 1982; Osborne & Cosgrove,1983), alternative conceptual framework (Taber, 1998), intuitive conceptions (Lee & Law, 2001), intuitive science (Preece, 1984), students descriptive and explanatory system (Champagne, Klopfer, & Gunstone, 1982). However, misconceptions and mistakes should not be confused. Mistakes can be recognized by the students themselves when presented with a accepted conception (Abimbola, 1988). In this study, the term of misconception which means that differ from the commonly accepted scientific understanding of the term will be used.

Students' concepts, generalizations, and theories are developed through their observations the quality of observations depends on the quality of preexisting knowledge (Gilbert, Watts & Osborne, 1982). Therefore, one of the sources of students' misconception is students' observation of environment. Moreover, everyday knowledge can be stated as another source of misconceptions. For example, in chemistry classrooms words that has different meanings used from everyday language. In addition, Prieto, Watson, and Dillon (1992) stated that students' social knowledge and school knowledge interact to form students' ideas. On the other hand, students come to classrooms with ideas about science that have been influenced by their prior experiences, textbooks, teachers' explanations, or everyday language. Knowing the sources of misconceptions is very important to overcome them easily.

Students' prior knowledge can be sated as one of the source of misconceptions. Students come into classroom with a conceptual framework already present, from everyday experience and from previous formal and informal education (Teichert & Stacy, 2002). Teichert and Stacy (2002) express two important points to the teachers: "(a) Students have preconceptions or prior existing knowledge of many chemistry concepts, which may or may not be scientifically correct, and (b) students may or may nor integrate this prior knowledge with the new material being covered in class" (p.470). The other source of misconception may be the language. Scientific meaning and common meaning of a term may show a difference. For example, it is stated in common language that 'sugar melts in water', but in chemistry it have to be stated as 'sugar dissolved in water' (Abraham et al., 1992).

It was stated that one of the major source of misconception is instruction (Haidar, 1997). This source causes two difficulties. Students fail to apply correct information and use the closest available information to solve given problem, stated as the first problem. Second difficulty stated as the knowledge of concepts was divided into parts. In addition, instructors may also be another source of misconceptions. Ginns and Watters (1995) stated that students' teachers may cause the students' alternative conceptions. It was stated that since the teachers may misunderstand the concepts which they will teach may cause students to create misconceptions (Taber, 2001).

Terminology which is used by teacher and textbooks may be another source of misconception. Since the students have original concepts in their mind, students may have difficulties in understanding the new concepts (Schmidt, Baumgartner, & Eybe, 2003). This may cause to change the meaning of the terms. The others source of misconception can be the interaction with friends, parents, media such as television, newspapers, internet, etc. Since, children get lots of idea from their peers, family and the media, the potential to direct students through misconceptions is quite high. In addition, everyday science and language which are related to pupils' ideas are stated as another source of misconceptions (Johnstone, 1992). Lastly, textbooks which are the general source of any subject area can be stated one of the source of misconceptions. For example, Mayer (2002) stated that diagrams and models used in textbooks may cause misconceptions in students mind. If these tools are not properly constructed, they will result misconceptions.

2.4.1 Misconceptions in Chemistry

Discovering the reasons of why many students not being successful in learning chemistry although they strive too much, has been the target of many studies. One of the possible answers stated as appropriate understandings of fundamental concepts that are evolved beginning of their studies are not constructed appropriately. Therefore, advanced concepts that that build upon these fundamentals are not fully understood. In addition, as the students construct their own concepts, misconceptions which are stated as one of the obstacle in learning may arise (Nakhleh, 1992).

In literature, many studies have been carried out to identify or overcome students' misconceptions in chemistry. Some of the different kind of methods such as interviews (Bowen, 1992; Osborne & Gilbert, 1980; Posner & Gertzog, 1982; Sutton, 1980), paper-and pencil tests like multiple choice and free response tests, concept maps (Novak & Growin, 1984), word association tests (Sutton, 1980), combination of these methods have been used to identify and analyze the misconceptions. These studies can be summarized with respect to subject areas as: electrochemistry (Garnett & Treagust, 1992; Sanger & Greenbowe, 1997), acid-base chemistry (Cakir, Uzuntiryaki & Geban, 2002; Cros, Chastrette & Fayol, 1988; Hand & Treagust, 1988; Ross & Munby, 1991), particulate and molecular views of matter (Novick & Nussbaum, 1978; Novick &

Nussbaum, 1981), entropy (Frazer, 1980), chemical equations (Ben-Zvi, Eylon & Silberstein, 1987), nature of matter (Andersson, 1990; Gabel, Samuel & Hunn, 1987; Novick & Nussbaum, 1981; Tvieta, 1990), chemical equilibrium (Banerjee, 1991; Camacho & Good, 1989; Gussarsky & Gorodetsky, 1988; Gussarsky & Gorodetsky, 1990; Chiu, Chou & Liu, 2002; Hackling & Garnett, 1985; Huddle & Pilay, 1996; Johnstone, Macdonald & Webb, 1977; Wheeler & Kass, 1978), bonding (Nicoll, 2001), thermochemistry (Boo, 1998), molecular geometry and polarity (Furio, 1998), and solubility equilibrium (Ravioli & Alexander, 2001), mole concept (Duncan & Johnstone, 1979; Griffiths & Preston, 1992; Harrison & Treagust, 1995), chemical change (Hesse & Anderson, 1992). In addition to these, Kind (2004) summarized all the misconceptions about all subjects in chemistry.

2.4.2 Misconceptions in State of Matter and Solubility

Chemistry curriculum includes topics such as the behavior of solutions during phase changes, the concentration of solutions, electrical properties of liquid and solids, and the solubility of ionic compounds. The conceptual and procedural knowledge about solubility and solutions are associated with these topics. Therefore, it is very crucial to obtain better understanding of state of matter and solubility concepts to overcome difficulties in subsequent learning related to these concepts. As in the other topics in chemistry, students hold lots of misconceptions in state of matter and solubility topics. In the following part, studies that specify related misconceptions will be presented.

Russell, Harlen, and Watt (1989) reported the young children ideas about evaporation. They stated that one fifth of the 7-9 years old children thought that the evaporated water has gone. However, they believed that an outside agent like another person or sun responsible of that. On the other hand, although water is boiled in front of the children, some of them think that the water is sucked by a pan (Beveridge, 1985) or went into the plate (Cosgrove & Osborne, 1981). In addition, in another study, it was investigated that while 28% of the children who are in the primary age believe that water transform into mist, steam, or spray, 17% of the children describe water as changing to an imperceptible form (Russell & Watt, 1990). Moreover, same explanations were produced by older children but in different proportions. For instance, the idea of outside agent is thought by 57% of the children who were in the 9-11 age group. It was indicated that there is a relationship between understanding conservation of water and children's ideas about evaporation. When the outside agent was removed, children seem to conserve the amount of material, but a faulty explanation about why the water disappears was offered (Kind, 2004).

Children initiate to gain experience about evaporation at their early age. Russel and Watt (1990) indicated in their study that 28% of the students who were in their primary age and participated this study believed that water transforms into mist, steam of spray during the process of evaporation, 17% of the students describe water as changing to an imperceptible form such as water vapor or gas.

Kruger and Summers (1989) carried out a study to understand how the primary schools teacher teach the concept of evaporation. The results showed that teachers prefer to explain the phenomenon of evaporation in macroscopic terms rather use particle ideas. This result is shown as evidence to indicate that people do not readily change their naïve ideas about particles and matter, retaining child-like perceptions into adulthood.

Stavy (1990) carried out a study to unveil the mental image regarding matter and its properties held by children between the ages of 9 and 15. In this study, the change of state in a closed system from liquid to invisible gas and from solid to visible gas were presented to children and some questions about conservation of matter, its properties, and weight during these transformations were asked them to reveal their mental images about matter and its properties. There were six age groups involve students who were 9-10 years old and students who were 14-15 years old and each age group comprised 20 students. The tasks were change of state of acetone (evaporation) and change of state of iodine (sublimation). The results of the first task which was change of state of acetone (evaporation) showed that 30% of the students in 4th grade (ages 9-10), 25% of the students in 5th grade (ages 10-11), 10% of the students in both 6th and 7th grade (ages 11-13) believe that when matter is invisible it does not exist and that its weight and properties disappear with it. In addition, 45% of the students in the 4th grade (ages 9-10), 25% of the students in the 5th grade (ages 10-11), 20% of the students in the 6th grade (ages 11-12), and 5% of the students in the 8th grade (ages 13-14) believed that the acetone disappears along with its weight but leaves its property of smell behind. Moreover, 15% of the students in 4th grade (ages 9-10), 30% of the students in 5th grade and 6th grade (ages 10-12), 40% of the students in 7th grade (ages 12-13), 30% of the students in 8th grade (ages 13-14), and 20% of the students in 8th grade 8 (ages 14-15) perceived the conservation of matter and its properties but not its weight. On the other hand, students who perceived the conservation of matter, properties, and weight rose from 5% in the fourth grade (ages 9-10) to 75% in the ninth grade (ages 14-15). Furthermore, she stated that the confusion is related to students' ideas about density and weight. Students believed that "gas weighs less than liquid", therefore students prefer to explain evaporation with respect to weight change rather than density change.

Osborne and Cosgrove (1983) conducted a demonstration in front of students in which water in an electric kettle was boiled to allow students to realize the bubbles during the process of boiling. Than, students whose age ranged from 8 to 17 years were asked to answer 'what the bubbles made of?'. The answers of the students' show some variety include bubbles made of heat, air, oxygen or hydrogen and steam. 700 students participated this study and their responses distributed with respect to their answers as: 30% heat, 30% air, 25% oxygen/hydrogen, 15% steam in 12 years old students, while 10% heat, 20% air, 40% oxygen/hydrogen, 30% steam in 17 years old students. Although as the students age increase the students tended to select correct answer, which is steam, the study revealed that most of the 17 years of students either think that water can be split into its component elements by heating, or heat is a substance, air is contained in the water.

Moreover, Bodner (1991) examined the exam results of 132 students who took this exam to entering graduate students at Purdue University during the orientation program for new teaching assistants. One of the question asked what the bubbles that arise during the boiling process are made of. The answer which was “the bubbles contain water, steam, or molecules of water” was stated by slightly more than 70% of the graduate students. 20% of the students indicated that these bubbles consisted of air and oxygen while 5% believed that a mixture of H_2 and O_2 constitute these bubbles. Some of the students’ explanations who believed the assumption that boiling water contains bubbles of air are stated as;

“These are air bubbles. With increasing temperature, the solubility of air in the water decreases and since at room temperature there is always some air dissolved in water, it gets pushed out of solution”.(p.385) Or

“Most of the containers have small packets of air trapped inside. And so when the water is boiling this air gets heated and the hot air rises up which is seen in the form of bubbles”. (p.385).

Osborne and Cosgrove (1983) conducted another demonstration in their study. A saucer was hold above of the boiling kettle and students ask to describe what on the saucer is. Some of the students stated that the plane had become sweaty or simply wet. Others said that ‘the steam turns back into water’ or ‘the oxygen and hydrogen recombine to form water’, the proportion of the students who gave the correct response was 25%. In addition, in this study, major explanations about the origin of the water condensing on the outside surface of a sealed class jar containing ice were identified with respect students’ age. The major explanations that students expose in the age between 8-15 was ‘water comes through the glass, in the age between 12-17 were ‘coldness comes through the glass’ and ‘the cold surface and dry air (oxygen and hydrogen) react to form water’, in the age between 14-17 was ‘water in the air sticks to the glass’. Though the proportion of students who thought the coldness or water came through the glass was very small, approximately 30% of the students thought that gases recombine on the surface to give water.

Osborne and Cosgrove (1983) show students a simple demonstration in which ice melting on a teaspoon. It was revealed that most of the 12-13 years old students believe that ice is above its melting temperature while 14-17 years old students thought commonly that the heat makes the particles move further apart. On the other hand, particle ideas were used by small number of 14-17 years old students.

Mulford and Robinson (2002) developed a test, named Chemistry Concepts Inventory, to investigate first semester general chemistry students' alternative conceptions. This inventory was applied 928 students as pretest before the general chemistry course and as a posttest after this course. One of the question in this inventory asked students to identify the source of the sweat on the outside of a glass of cold milk. Although 67% of the students in pretest and 72% of the students in posttest answered correctly by attributing the sweat to condensation, 25% of students in pretest and 18% of students in posttest answer this question incorrectly by selecting the reason "the coldness causes oxygen and hydrogen from the air to combine on the glass forming water". This choice shows a consistency with the alternative conception that water dissociates to hydrogen and oxygen when it evaporates. In addition, two of the questions, which were paired, were asked about the change in weight when a sealed tube contain 1 gram of solid iodine is heated and the iodine vaporized. 68% of the students in pretest and 73% of the students in posttest selected the correct answer which indicated the weight would be the same while 29% of the students in pretest and 24% of students in posttest selected the incorrect choice which indicated the weight would be less. Moreover, the contents of water in boiling water were identified only by 40% of the students in pretest and 47% of the students in the posttest. Students preferred to answer commonly as it includes hydrogen and oxygen gas or oxygen gas and air. Furthermore, the change in water level as the ice melts in a mixture of ice and water was asked the students. The correct answer that was “it would stay the same” was only selected by 36% of the students in pretest and 44% of the students in posttest.

Brook, Briggs, and Driver (1984) conducted a study to examine students’ ideas about particulate nature of matter. In this study, students were asked to explain what happens to ice when it is removed from a freezer at -10 ^{o}C left to warm -1 ^{o}C. Some of the students answered this by stating “the blocks of ice cools and the particles are beginning to break away from each other (other) to form gases” (p. 53) and “the particle start to break away from each other because of the rise in temperature. When they have broken away from each other, they turn from a crystal form to a solution form” (p.53). as it is seen, students confused melting with evaporation and changing of state with dissolving. On the other hand, some students tried to answer this question in macroscopic view. Some of them stated that “as the temperature rises, the particles take in the heat and begin to expand” and “when a block of ice taken out of a freezer the sudden change of temperature reacts on particles making them decrease in size”.

Andersson (1990) classified students ideas about transformations of matter in physical and chemical phenomena as disappearance (evaporation of water), displacement (drops of water on the surface of a bottle which includes ice cubes come from inside of bottle), modification (students claim that water is modified into vapor during the boiling process of water), transmutation (students define vapour as a different substance from water), chemical interaction (bubbles arise during the boiling of water are made of oxygen or hydrogen). Moreover, students’ responses about the changes of matter can be categorized with respect to the criterion of what is conserved and what alters as: form, arrangement, location, and making. Students prefer to use first category when confronted with non-familiar systems, and usually operates at the macro level. However, last categories are used in order to explain the changes when confronted familiar systems, operates at the micro level (Kokkotas, Vlachos, & Koulaidis, 1998).

Ure and Colinvaux (1989) carried out a study to describe 15-27 years old 15 students' alternative conception of changes of the physical state in water and discussed the evolution of these concepts within the dynamics of a classroom situation. The activities involve some demonstrations. In one of these demonstrations, a jar with ice cubes and water was showed to students. It was asked to students to explain where the water that appears on outside of the jar comes from. Some students preferred to explain it with using the terms sweating. The other explanation of some students was that water passes through the glass to the outside. None of the students' answer referred to the possible existing of water in the form of vapor in the air. In addition, the nature of bubbles that appear when water is boiling was asked to students. Some of the students said that these bubbles made of water while the others stated that they were made of air, smoke, and water in the form of air. Moreover, in another demonstration, a mirror was put over the boiling water and it was asked to students where the water appeared on the mirror had come from. Some of the students claimed that it was the boiling water that goes up in smoke even though these students were not able to explain what happened when this smoke came in contact with the mirror. Ure and Colinvaux (1989) found that students showed a lack of differentiation between water in the form of air and air.

Kind (2004) investigated students' misconceptions about state of matter and summarized students' key difficulties. She found that particle ideas are not used by students to explain state changes. Though students express these ideas to explain state changes, these are frequently incorrect. Students believe that particles can expand, contract, break up, and static. In addition, reversibility of state changes is seemed very difficult by students and students prefer to think each process in state change as a separate event. Moreover, state changes are often explained to students by presenting the water example. Even though students' ideas are improved about understanding of behavior of water, students are not able to transfer same reasoning to other substances. In other words, state changes of water have only been learned by students rather than having learned and understood state changes in general. Furthermore, students generally believe that molecules are breaking up on boiling and reforming on condensing during the state change of matter. 12-15 years old students are not able to comprehend where the condensed substance come from. Lastly, students have some difficulties about the ideas of melting and freezing. Students generally think that ice particles can shrink, expand, dissolve, or melt when changing to liquid water. Melting and dissolving terms are used to refer the same thing. Students believed that freezing always occurs at cold temperatures and boiling occurs at hot temperatures.

It was found that children classify substances as solids with respect to a wide range of criteria (Krnel, Watson, Glazar, 1998). These criteria generally were related their intensive properties. If children can hold or break a substance, they usually classify these substances as solids. Mortimer (1993) stated that if substances could be held, were rigid etc. children (14-15 years old) classify these substances as solid objects. The form of a substance is more important than its volume while classifying the object as solid. Most of the children asserted that if a substance can be seen or touch, it can be simply defined as solid. In addition, children generally prefer to use the adjectives such as "heavy" and "hard" when they mention about the properties of solids. In addition, although it was found that children from 7 years old to 12 years old had few problems to differentiate liquid and solids, especially with hard and rigid objects, substances which had no shape, could be kneaded, or could be easily melted, or were powders caused more problems (Stavy & Stachel, 1985; Jones, Lynch, & Reesink, 1989). Stavy and Stachel (1985) found that while half of the 12 years old children were able to classify soft objects correctly, 60% of the students classified powdered objects liquids and solids. Metals were the easily classified as solids by these children. Ryan (1990) found that 9% of the first year university students were not able to classify granular and powdery substances as solids.

It was stated that weight is another property that was used to classify substances as solids (Krnel, Watson, & Glazar, 1998). The concept of solid was linked with the concept of weight by large number of children while determining criteria for classifying solid substances (Russell et al. 1991). Moreover, it was found that students have some difficulties in conserving weight between phase changes from liquid to solid. Hatzinikita and Koulaidis (1995) found that nearly 70% of the 11-12 years old students believed that the weight increases when a liquid changes into a solid. On the other hand, 60% of the students' answers revealed that students claim the weight decreases in the reverse process (closed system). The same result was confirmed by other studies (Lee et al., 1993). In these studies it was expressed that students believe if ice is melted, the resulting water will weigh less than ice. Another common belief among students stated that since solid substances stick together better than water, they are heavier (Lee et al., 1993). BouJaoude (1991) stated that students who were 13 years old thought that liquid wax in a burning candle is lighter than solid wax, therefore the weigh of a candle decreases on melting.

Piaget and Inhelder (1974) stated that when sugar is dissolved in water young children think that sugar disappears. Students believe that since the substance disappears, mass of water would not change. It was identified that this idea and other explanations are prevalent among older children (Driver, 1985; Cosgrove & Osborne, 1981). It was found that about two thirds of 9-14 years old students generally believe the mass of sugar and water solution is less than mass of the sugar and water (Driver, 1985).Moreover it was found that the non-conserving idea of dissolving continued to a latter stage than Piaget had found (Cosgrove & Osborne, 1981; Andersson, 1984; Wightman et al., 1986). Furthermore, Andersson (1984) found the same problem among the 15 years old students. Over half of the sample in Anderson's study thought the mass of the solution would be less. Some of the students stated that "the sugar will decompose and form a liquid with the water and so will weigh less" (p.154). Conservation of mass was ignored by students and it was found that these beliefs have not been changed from their early childhood.

Cosgrove and Osborne (1981) stated that when students are asked to explain what happened to sugar; one quarter of the respondents used the word 'melting'. Students stated that "the sugar is dissolving…the water is sort of melting the sugar crystals" (Cosgrove & Osborne, 1981, p.18). Though the synonymous usage of 'dissolve' and 'melt' declines with age, most of the students use these terms interchangeably.

On the other hand, Barker (1995) asked 250 students to compare mass of a solution of sodium chloride with the mass of solute and solvent. 57% of 16 years old students thought that the masses would have the same value. However, several misconceptions was found such as 16% of the students thought that a gas would be released when the salt dissolve which indicate students think dissolving as a chemical reaction. In addition, 7% of the students believed that the mass was lost in dissolving. Although the percentage of the students who gave the correct answer to this question increased 62% in 18 years old students, 15% still believed that a gas was produced during dissolving process and about 4% thought mass was lost.

Mulford and Robinson (2002) asked 928 general chemistry students to identify the weigh of a solution formed by adding 1 pound of salt to 20 pound of water. Although 73% of the students in pretest and 75% of the students in posttest were answered correctly, the incorrect answer which indicated that the solution would weigh less than 21 pounds was selected by 25% of students on both pretest and posttest. Furthermore, when students are asked to explain the concentration behavior of a saturated solution only 32% of the students in pretest and 34% of the students in the posttest indicated the correct answer which was "the concentration of a saturated solution stays the same as water evaporates" while 64% of the students in pretest and 61% of the students in posttest indicated the concentration increases and less than 5% of the students in both test indicated it decreases. The following question in this inventory asked the reason of the answer.40% of the students in pretest and 48% of the students in the posttest select the incorrect choice which was "there was the same amount of salt in less water". The correct answer which was "more solid salt forms" was selected by only 25% of the students in pretest and 26% of the students in posttest. These results indicated that the behavior of solutions is hard to grasp for students.

Bodner (1991) examined the answers of the questions which were answered by graduate students. One of the questions was about the melting of ice with salt. It was asked students to explain how placing salt on the surface of ice can melt the ice. The majority of the students explained this question based on colligative property by stating salt lower the freezing point of water or the melting point of ice. However, some of the students gave incorrect answers that some of them based on mechanical explanation such as;

"The weigh of the salt on the surface of the ice disrupts the lattice structure and the ice melts-this this is analogous to the blades of ice stakes…"(p.386) and

"The weigh of the salt on the ice surface generates heat to melt some of the ice which then dissolves the salt to give a liquid which has lower freezing point than water" (p.386) and

"When you put salt (or anything really) on the ice, it disrupts the crystal structure of the ice. The water molecules can no longer get into a nice perfect array and so ice becomes a liquid" (p.386)

Some of the students explained this question based on thermodynamic arguments such as;

"The salt that is added goes into solution in some of the water that is present. Due to this, a certain amount of heat of solution is released. This help in melting the ice" (p.386).

As Novick and Nussbaum (1978) stated that the concept of interactions among particles is one the least assimilated concept in chemistry, Haidar and Abraham (1991) expressed in their study that practically none of the students had a satisfactory grasp of what dissolution is. Prieto et al (1992) asserted that the meaning of "dissolving" has been referred to outside action such as stirring, mixing, and in some cases heating. Young students generally define dissolving simply as "it means to pour one substance into another and stirring them" or "to dissolve means to mix". The importance of stirring expressed by majority of the students as "stirring makes the substance distribute itself through the water", "stirring divides the solute" or " stirring makes it dissolve better". On the other hand, Cosgrove and Osborne (1981) stated that some students believe that heat causes the sugar dissolve in water.

Holding (1987) and Prieto et al. (1992) particularly studied about students' ideas of the process of dissolving. They claimed that students generally believe that sugar disappears, liquefies, reduces to smaller sized pieces or mixes with water when it is stirred with a solvent such as water. Students generally do not take into account conservation of mass on dissolving (Driver, 1993; Stavy, 1987). Blanco and Prieto (1997) carried out a study to examine students' views on how two external factors, stirring and an increase in temperature, affect the process of dissolution of a solid in a liquid. 458 students between the ages of 12 and 18 years enrolled in this study. There were four different levels in the sample of the study. As results of the study, four explanatory patterns that emerge from the students' explanations have been identified. It was concluded that students in this study thought that a high temperature or stirring are necessary for dissolving. Moreover, students generally use the process of melting and dissolving interchangeably. Furthermore, the simple particulate model of matter is not completely assimilated by students (Kabapınar, 2004). The nature of matter as assemblies of particles is not conceptualized by students (Griffiths & Preston, 1992; Johnston, 1998; Novick & Nussbaum, 1981). The everyday and scientific meaning of the word "particle" is not differentiated by students (Ebenezer & Ericson, 1996). Therefore, this causes some problems to explain macroscopic properties of matter in terms of submicroscopic particles.

Ebenezer and Ericson (1996) identified a number of conceptions of solubility and group them into six categories with respect to students' preferred explanations for solubility phenomena. These categories are (a) physical transformation from solid to liquid; (b) chemical transformation of solute; (c) density of solute; (d) amount of space available in solution; (e) properties of solute, (f) size of solute particles. Thirteen grade 11 students who were volunteer and interviewed during the launch hour and after school participated this study. The results showed that dissolving is viewed as a process of a solid transforming into a liquid form. Part of conversation between researcher and one of the students stated as (p.187):

R: Let me stir the sugar and hot water solution and let us see what happens. What is happening?

S: There are no more crystals. Mixed in with hot water.

R: What do you mean by saying “mixed in with the hot water”.

S: It liquefies like the hot water.

R: Do you think the sugar is in the liquid state?

S: Yes.

Since the students can not see the solid sugar after it is completely dissolved in water, the word “melting” was preferred instead of using the word “dissolving”. Moreover, for example, in everyday talk, when a piece of candy is sucked, it is said by children as it is melting in the mouth. So, everyday language may cause the wrong usage of this kind of words.

In addition to these, Ebenezer and Ericson (1996) found that some students believed that when sugar is added to the water some type of chemical reaction or combination is taking place. They stated that half of the students in their sample sated that dissolving is a process of combining two or more substances. One of the student in this study stated that “new substance is being formed (sugar water) when sugar is dissolved in water” and she add “sugar is no longer solid anymore”. She also used the word “combining” to explain dissolving of sugar in water. And she also thought that the combination of sugar and water was chemical. Moreover, it was found that the reason of the substances not to dissolve claimed as they do not find sufficient space in the dissolving medium. Furthermore, it was stated that students believed that if the solute is broken in tiny pieces, it will dissolve in the solvent. So, according to the students, size of the solute is only the necessary thing to dissolve in a solvent. Lastly, the results of the study showed that some students believed that solute must possess certain properties to dissolve substance. However, they could not define these properties clearly. Ebenezer and Ericson (1996) identified three pedagogical issues with respect to the research findings stated above. These are stated as (a) the relationship between student explanations and their experiences; (b) the tendency for students to extend macroscopic properties of matter to the microscopic level; and (c) the differences in meaning between the students' use of chemical language and that used in their science classrooms.

Longden (1984) stated that although students always confront dissolving experience at home and at school, some everyday instances of dissolving is not fully recognized by 11 and 12 years old children. It was also found that if the dissolving is examined beyond the point, saturation simple examples of dissolving become problematic. In this study, different children exposed to different instances of dissolving. For example, one experienced dissolving with a half –spoonful of sugar stirred into a cup of tea while the other one experienced same dissolving process with three spoonfuls. It was found that since there is a dissolving with a residue in the latter instance, these children may develop a different idea of dissolving from each other.

Longden, Black, and Solomon (1991) conducted a study to identified 11-12 years old and 13-14 years old pupils' conceptions about dissolving by asking questions in the line of everyday representation, observable process and with respect to representation of dissolving in particle terms. In other words, each group of questions includes questions in non-scientific way, and also with reference to a particle theory. 246 first-year students and 196 third-year students from three different schools were used in this study as sample. The results revealed that the number of pupils in both ages holding a correct view of dissolving at the every day level is actually less than those getting the particle interpretation of dissolving correct. Moreover, it was found that the number of first-year students who have alternative ideas about dissolving with respect to everyday representation was more than the number of third-year students who have alternative ideas about dissolving with respect to everyday representation. On the other hand, the number of first- students who have alternative ideas about dissolving with respect to particle terms was less than the number of third-year students who have alternative ideas about dissolving with respect to particle terms. These changes were statistically significant at $p<0.001$ level.

Abraham and Williamson (1994) carried out a study to trace the number and type of alternative conceptions about chemical change, dissolution of solid in water, conservations of atoms, periodicity, and phase change concepts held by students after varying amounts of instruction in chemistry. The dissolution of solid topic involved the process of dissolving where the crystalline solute is broken up by intermolecular forces and evenly mixed with the solvent at a molecular level. The phase change topic covered the usage of heat energy to change the phase of a substance rather than to raise its temperature during that phase change. This study involved 100 junior high school students, 100 high school students, and 100 college students. The item related to dissolution of solid concept required students to explain the dissolution of sugar cube in water. The item related to phase change concept required students to explain why the temperature remains constant when an ice cube melts. The results revealed that 11.3% of the students did not understand the concept that related dissolution of solid topic. In addition it was found that 28% of the students had misconceptions about this topic. The idea that sugar particles floated or sank at the bottom of the beaker instead of evenly mixing stated as the predominant misconception. 9% of the junior high school students, 17% of the high school students, and 9% of the college students held this misconception. The source of this misconception stated by the authors as “the ideas that sugar sinks at the bottom might come from the students’ experiences with oversaturation of drinks and cereal with sugar” (p.160). The other misconceptions that held by students stated as: students believed that (1) the sugar changes chemically into a new substance; (2) or that sugar breaks down into its ions or elements; (3) sugar undergoes a phase change, melts, or evaporates, (4) water absorbed the sugar similar to the action of a sponge. Moreover, students used the term “solute” and “solvent” interchangeably and students generally referred sugar as “sugar atoms”. On the other hand, the results indicated that 40.3% of the students and 47.7% of the students did not understand the concept that related phase change topic. The idea that the ice or the cold water from the ice prevented the water’s temperature from rising was identified as the predominant misconception. 23 % of the junior high school students, 26% of the high school students, and 21% of the college students held this misconception. Moreover, some students believed that the reason for constant temperature was due to the thermometer being in the ice cube.

2.5 Affective Domain

Some of most important variables that affect students' science learning are attitude and motivation. Although many researchers have recognized their effectiveness in science learning, attitudinal and motivational constructs have received much less attention by researchers than have the cognitive dimensions (Koballa & Glynn, 2007). However, contemporary views indicated not only the catalyst property of affective dimension in learning but also recognize their necessary condition for learning to occur (Perrier & Nsengiyumva, 2003). In addition, Pintrich, Marx, and Boyle (1993) defined attitudinal and motivational constructs as moderators of a learner's conceptual change.

Affective characteristics become more important than ever as views of learning become increasingly constructivist. Related literature in science education revealed that science learning can not be explained solely by examination of cognitive factors. Especially, it is very clear that students' attitudes and motivation strongly related with their science learning. Meaningful relationships among affective constructs and cognition are become more explicit than ever in the research on science learning (Glynn & Koballa, 2007).

Considering improving attitudes toward science and heightening motivation to learn science are the key factors to design effective science instruction. Instructions that include hands on science activities, laboratory work, field study, and inquiry oriented lessons have potential to reach these goals. On the other hand, students' actions and behaviors that are pioneers of students' science learning and achievement are strongly related with attitudinal and motivational constructs (Koballa & Glynn, 2007).

2.5.1 Attitude toward Science

Attitude has been defined in several ways and often been used interchangeably with the terms such as interest, value, motivation, and opinion. In attitude literature, quite specific definition of attitude specified as "a general and enduring positive and negative feeling about some person, object, or issue" (Petty & Cacioppo, 1981, p.7). Expressing general positive and negative feelings such as "I love science, I hate my science teacher, and science experiments are wonderful" reflect attitude.

Improving students' attitudes toward school subjects is one of desirable outcome in education. There are some recent studies that deal with the influence of attitudes on students decisions' such as enrolling in an elective science course and pursuing careers in science (Shringley, 1990; Robertson, 2000). In some studies that are related students' attitudes toward science it was expressed that attitude towards science may be related to students' science course enrollment (Cavallo & Laubach, 2001). Moreover, Webster and Fisher (2007) conducted a study, using data collected as a part of the Third International Mathematics and Science Study (TIMSS), revealed that attitudes towards science have strong effect on science achievement.

Self-concept of ability, accepted as one of the components of student attitudes towards science, defined as students' perceptions of their ability to achieve in science (Cavallo & Laubach, 2001). Also, in Freedman's (2002) study, the positive relationship between students' self concept of ability and their science achievement was mentioned. Moreover, it was reported that students who feel less confident about their abilities in science have a tendency to low attitude towards science (Piburn & Baker, 1993). On the other hand, academic motivation is guided by expectations for behavior that produced by self concept (Stipek, 1996). Achievement and attitude are directly affected by academic motivation which effects leaning directly (Simpson & Oliver, 1990). Simpson and Oliver (1990) supported the relationships between science self concept and academic motivation to achievement.

Another component that constitutes attitude towards science is science enjoyment and defined as the gladness and happiness students feel resulting their experiences in science (Cavallo & Laubach, 2001). In many study, it was stated that science enjoyment was related to type of instruction experienced by them (Fouts & Myers, 1992; Freedman, 1997; Gallagher, 1994; Ledbetter, 1993). Freedman (1997) conducted a study which involves an experimental group and a control group. In experimental group, laboratory activities were used, whereas in control group there was no laboratory activities. It was found that the students in experimental group showed a higher level of involvement and they enjoy their science class more compared with control group whose students did not receive laboratory instruction. In addition, it was stated that students showed positive attitudes toward doing science and learn more in inquiry-based classes (Ledbetter, 1993).

It was found that students in classrooms using the learning cycle had more positive attitudes towards science and science instruction than other approaches usually identified as traditional (Lawson, Abraham, & Renner; 1989). Moreover, it was stated that students in learning cycle group had more positive attitudes towards laboratory work, scored higher in laboratory exam, and were not likely to withdraw from the course (Campel, 1997).

Lack of anxiety, defined as students positive comfort level when pursuing science, can be sated other component of attitude towards science (Cavallo & Laubach, 2001). Atwater, Gardner, and Wiggins (1995) stated that students with high anxiety toward science had low attitude towards science. On the other hand, students who were less stressed or anxious about doing science had high attitude toward science and their achievement level were high.

Some studies such as activity-based practical work (Thompson & Soyibo, 2002), learning cycle classes (Cavallo & Laubach, 2001-1), formally teaching ethical issues (Choi & Cho, 2002) cooperative learning groups (De Baz, 2001), student- and teacher-constructed self-teaching resources (McManus, Dunn, & Denig, 2003), video technologies (Escalada & Zollman, 1998), inquiry based summer camps (Gibson & Chase, 2002), and computer assisted instruction (Soyibo & Hudson, 2000) are the studies that evaluate attitude change interventions in recent years. Studies that engage learners in hands on science activities and that stress the relevance of science through issue based experiences are more successful studies than others (eg., Haussler & Hoffman, 2002; Perrier & Nsengiyunva, 2003; Siegel & Ranney, 2003).

2.5.2 Motivation

Motivation can be separated into two parts such as intrinsic and extrinsic motivation. According to Pintrich and Schunk (2002) motivation to engage in an activity for its own sake defined as intrinsic motivation, whereas motivation to engage in an activity as a means to an end defined as extrinsic motivation. Students who work on a task because of its enjoyable manner are intrinsically motivated. On the other hand, students who work on a task because of desirable outcomes such as a reward, teacher praise, or avoidance of punishment after completing this task are extrinsically motivated.

There are variety of specific actions can be taken to increase students' intrinsic motivation can be stated as explaining or showing why learning of particular content and skill is important, creating and maintaining curiosity, providing a variety of activities, providing games and simulations, setting goals for learning, relating learning to students need, helping students develop plan of action. On the other hand, actions that increase students' extrinsic motivation can be specified as providing clear expectations, giving corrective feedback, providing valuable reward, making rewards available.

Brophy (1987, p. 205-206) described motivation to learn as "a student tendency to find academic activities meaningful and worthwhile and to try to derive the intended academic benefits from them". Constructs such as arousal, anxiety, interest and curiosity play important role in the creation of intrinsic motivation.

Arousal plays an important role in initiating and regulating of motivation, defined as student's level of alertness and activation (Anderson, 1990). Students who have much anxiety have a tendency to feel general uneasiness, foreboding, and tension on something. The constructs interest and curiosity have been used in same meaning in science education literature. Readiness to pursue a science topic defined as a students' interest or curiosity (Koballa & Glynn, 2007). Pintrich and Schunk (1997) stated that activities that present information or ideas differ from their present knowledge or beliefs and appear surprising and incongruous have potential to reveal students' interest or curiosity.

Also, in related literature, it was stated that students' self determination, goal directed behavior, self regulation, self-efficacy, teachers expectations influence students' intrinsic motivation (Koballa & Glynn, 2007).The ability of students to have choices and some degree of control in what they do and how they do it is defined as self-determination. (Reeve, Hamm & Nix, 2003). Students are more likely to benefit from educational activities when they have the opportunity to contribute their designing. Moreover, it was stated that students who were allowed to organize their own activities showed greater interest than students who were required to follow rote direction (Rainey, 1965).

Goal is defined as a science objective or outcome, and the process of pursuing to reach that goal is defined goal directed behavior (Pintrich & Schunk, 2002). Researchers stated that it is beneficial to set goals for students to focus their attention, organize their efforts, persist longer, and develop new strategies (Covington, 2000; Linnenbrink & Pintrich, 2002; Locke & Latham, 2002).

Self-Regulation defined as to knowing what to accomplish to learn science, bringing appropriate strategies to bear and continually monitoring the progress toward the goals. Students who feel they are in control of their learning increase the likelihood of their success in future, whereas students who feel they are not in control of their learning deal with their own limitations and become apathetic about learning science (Koballa & Glynn, 2007). Bandura (1997) defined self efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3).

As it was stated in the related literature above, the importance of students' prior knowledge developed while they experience with the environment and construct their knowledge expressed by many researchers includes Ausubel (1968), Piaget (1970), and Karplus (1977) etc. In addition, meaningful learning requires actively linking new information with prior knowledge. Therefore, having appropriate and scientifically correct prior knowledge is very crucial to promote meaningful learning. However, some of the students' prior knowledge appears students logical, sensible, and valuable while these concepts may be differing from the definitions accepted by experts and scientific definitions. In some circumstances, as it was stated above in litreture about misconceptions, the concepts involve in students prior knowledge are persuasive, stable, and resistant to change and can not be easily eliminated by traditional methods since they are not taken into consideration. Learning strategies based on constructivist view approach students' prior knowledge as a point of origin of learning since the constructivism rest on the assumption that knowledge is actively constructed by learner on the basis of the knowledge that individual already held. Leaning cycle model based instruction which is also based on constructivist epistemology is an instructional model in which conceptual change is facilitated. Therefore, in this study, instruction based on 5E learning cycle was developed to facilitate meaningful learning in state of matter and solubility concepts. Although state of matter and solubility concepts constitutes one of the fundamental topics of the chemistry education there are limited studies when the literature is examined. So, developing teaching methods that deals with students misconceptions and eliminate these misconceptions about state of matter and solubility is very necessary. In addition, since affective domains of the students' recognized as one of the necessary condition for learning to occur. Therefore, in this study, the instruction based on 5E learning cycle model is taken into consideration of students affective domains.

CHAPTER 3

PROBLEMS AND HYPOTHESES

3.1 The Main Problem and Sub-problems

3.1.1 The Main Problem

1. What is the effect of instruction based on 5E learning cycle model and gender on students' understanding of state of matter and solubility concepts and students' attitude toward chemistry as a school subject?

2. What is the effect of instruction based on 5E learning cycle model and gender on students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety)?

3. What is the effect of instruction based on 5E learning cycle model and gender on students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking)?

3.1.2 The Sub-problems

1. Is there a significant mean difference between the groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject?

2. Is there a significant mean difference between boys and girls with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject?

3. Is there any interaction between treatment and gender with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject?

4. Is there a significant mean difference between the groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety)?

5. Is there a significant mean difference between males and females with respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety)?

6. Is there any interaction between treatment and gender with respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety)?

7. Is there a significant mean difference between the groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking)?

8. Is there a significant mean difference between males and females with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking)?

9. Is there any interaction between treatment and gender with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking)?

3.2 Hypothesis

H_o1: There is no significant mean diffrence between the groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o2: There is no significant mean difference between boys and girls with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o3: There is no interaction between treatment and gender with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o4: There is no significant mean difference between the groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety) in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o5: There is no significant mean difference between males and females with respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety) in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o6: There is no interaction between treatment and gender with respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety) in the population of all the 10th grade Anatolian High School students in Ankara.

H_o7: There is no significant mean difference between groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking) in the population of all the 10th grade Anatolian High School students in Ankara.

H_o8: There is no significant mean difference between males and females with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking) in the population of all the 10th grade Anatolian High School students in Ankara.

H_o9: There is no interaction between treatment and gender with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking) in the population of all the 10th grade Anatolian High School students in Ankara.

CHAPTER 4

DESIGN OF THE STUDY

4.1 The Experimental Design of the Study

Non-equivalent control group design as a part of quasi experimental design was used in this study (Gay, 1987). Since the school administration already formed the classes at the beginning of the semester, students were not randomly assigned to experimental and control groups. However, two of the classes from same school were randomly assigned as control groups (CG) and two of the classes in the same school were randomly assigned as experimental groups (EG). Table 4.1 presents the design of the study.

Table 4.1 Research Design of the Study

Groups	Pre-test	Treatment	Post-test
Experimental Groups (EG)	SMSCT MSLQ ASTC SPST	5EIM	SMSCT MSLQ ASTC
Control Groups (CG)	SMSCT MSLQ ASTC SPST	TM	SMSCT MSLQ ASTC

The meanings of the abbreviations in the table are presented below:
SMSCT: State of Matter and Solubility Concept Test
MSLQ: Motivated Strategies for Learning Questionnaire
ASTC: Attitude Scale toward Chemistry
SPST: Science Process Skill Test
5EIM: Instruction based on 5E Learning Cycle Model
TM: Instruction based on Traditional Methods

4.2 Population and Subjects

All tenth grade students in Ankara which is the capital city of Turkey were identified as the target population of the study. However, since it is not easy to contact with this target population, it is coherent to define an accessible population. All tenth grade students in Çankaya which is one of the districts in Ankara were defined as accessible population. The results of this study will be generalized to this population.

Atatürk Anatolian High School was chosen from the schools in Çankaya district. Four classes of chemistry course were selected randomly from the 12 possible classes in Atatürk Anatolian High School. Since the classes were formed at the beginning of the semester by school administration, it was not possible to assign students randomly to both experimental and control group. However, the classes were randomly assigned as control and experimental group. 119 tenth grade students that involve 69 male and 50 female students participated this study. Students ages ranged from 15 to 16 years old. The experimental groups in which instruction based on 5E learning cycle model was implemented consisted of 59 tenth grade students while the control groups in which instruction based on traditional methods was implemented consisted of 60 grade students.

4.3 Variables

4.3.1 Independent Variables

The independent variables of this study were types of instruction methods which were instruction based on traditional method and instruction based on 5E instructional model and gender.

4.3.2 Dependent Variables

The dependent variables of this study were identified as; students' understating of state of matter and solubility concept, students' attitudes toward chemistry as a school subject. In addition, students' intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety, rehearsal**,** elaboration, organization, critical thinking, metacognitive selfregulation, time and study environment, effort regulation, peer learning, and help seeking measured by the MSLQ defined as the other dependent variables. In the MSLQ, the motivation section consists of intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self -efficacy for learning and performance, and test anxiety constructs whereas the learning strategies section consists of rehearsal**,** elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking constructs. For the sake of simplicity, tames of the sections which are motivation sections and learning strategies sections were stated as the dependent variables instead of the great number of variables. In fact, 18 variables were identified as dependent variables in this study.

4.4 Instruments

The classes in the school were already formed by school administration at the beginning of the semester. Therefore, the random assignment of the individuals to the experimental and control groups was not possible. So, SPST and SMSCT were administered to both groups to control the preexisting differences in groups. Since preventing the possibility of any differences that can result from the nature of groups, science process skills of the students and achievement of the students in both groups were defined as covariates. SMSCT was also administered to both groups to evaluate students' achievements on state of matter and solubility concept after the treatment. In addition, MSLQ was administered as pretest and posttest to both groups to assess the differences on motivational constructs of students. Moreover, ASTC was administered to both groups before and after the treatment.

4.4.1 State of Matter and Solubility Concept Test

This test consisted of 20 multiple choice and 2 open-ended questions, five of them taken from literature (Mulford & Robinson, 2002; Ebbing & Gommon, 2005), and the rest of the questions were developed by researcher by examining related literature, textbooks (ex: Ebbing & Gommon, 2005) and several test books (see Appendix B). The test includes State of Matter which include solid and liquids, phase transitions, boiling point and melting point, heat of phase transition subtopics; Solubility which include solubility and the solution process, colligative properties of solutions, boiling point elevation and freezing point depression subtopics. The multiple choice items in the test included one correct answer and three or four distracters that reflected students' probable alternative conceptions identified in the related literature and during interview sessions. During the development stage of the test, firstly, the alternative conceptions of the students about State of Matter and Solubility concepts were determined from the related literature (Piaget and Inhelder, 1974; Osborne & Cosgrove, 1983; Kind, 2004; Driver, 1993; Stavy, 1990; Bodner, 1991; Mulford & Robinson, 2002; Andersson, 1992; Kokkotas, Vlachos, & Koulaidis, 1998; Krnel, Watson, and Glazar, 1998; Blanco and Prieto,1997; Kabapınar, 2004; Ebenezer and Ericson, 1996) and during interview sessions. During the test development, which constituted qualitative part of the study, instructional objectives related to the State of Matter and Solutions were developed with respect to national curriculum. Then, related literature about the alternative conceptions of chemical reactions and energy concepts were examined, finally interviews were conducted with teachers to investigate teachers' opinions about alternative conceptions of students. Each question in the test was corresponded at least one alternative conception, identified as a result of both reviews of related literature and teachers' interviews, specified in table of alternative conceptions (see Appendix A) about state of matter and solubility concepts concepts, might used as evidence for test validity. Moreover, to establish face and content validity, the prepared test was examined by two chemistry professors, a professor who is specialist in chemistry education, two research assistant from chemistry education department, and two chemistry teachers. Their recommendations were taken into account; corrections were done with respect to their feedbacks. In addition to these, two high school chemistry teachers checked this test with respect to its grammatical and understandable aspects. Before using of this test in its actual aim, a pilot test was conducted to evaluate its reliability and validity aspects. Cronbach-alpha reliability of the pilot scores was found 0,673.

4.4.2 Motivated Strategies for Learning Questionnaire (MSLQ)

This questionnaire is a self-report instrument developed by Pintrich, Smith, Garci, and McKeachie (1991) to assess college students' motivational orientations and their use of different learning strategies for a college course. A motivation section and a learning strategies section were defined as two sections of MSLQ. The first part of this scale is the motivation section. Three general motivational constructs are proposed based on general social-cognitive model of motivation in motivational scales and also this scale (Pintrich, Smith, Garcia, & McKeachie, 1993). These were stated as (1) expectancy, (2) value; (3) affect. The expectancy related subscales were consisted of students' (a) perceptions of self efficacy and students' (b) control beliefs for learning. Why students engage in an academic task is focused in value components which subscales defined as (a) intrinsic goal orientation is focus on learning and mastery, (b) extrinsic goal orientation is focus on grades and approval from others, (c) task value beliefs is judgments of how interesting, useful, and important the course content. The third general motivational construct was stated as affect which has been identified with respect to responses to the test anxiety scale (Pintrich, Smith, Garcia, & McKeachie, 1993).

The second part of the questionnaire is learning strategies section based on a general cognitive model of learning and information processing (Pintrich, Smith, Garcia, and McKeachie, 1993). (1) Cognitive which consist of rehearsal, elaboration, organization, and critical thinking constructs; (2) metacognitive which involve metacognitive self-regulation construct, (3) resource management which consist of time and study environment, effort regulation, peer learning and help seeking constructs are stated as three general types of scale.

MSLQ is a seven point Likert scale from "not at all true of me" to "very true of me" concerning above aspects of students' learning. This instrument is originally developed in English.Confirmatory factor analysis was conducted and fit statistics for the English version of the questionnaire was calculated for motivation section consist of 31 items (n=356) by Pintrich, Smith, Garcia, and McKeachie (1993). It was stated that if the χ^2/df ratio is less than 5 is considered to be indicative of a good fit between the observed and reproduced correlation matrices (Hayduk, 1987). The model that proposed for confirmatory factor analysis generated a χ^2/df = 3.49. A GFI and AGFI index values above 0.9 and SRMR and RMSA index values below 0.5 indicate that the model "fits" the input data well (Steiger, 1990). The model yielded a GFI of 0.77, an AGFI of 0.73, and an RMR of 0.07. These indices indicated that they are not acceptable limits. However, when it is thought that motivational attitudes may differ depending upon course characteristics, teacher characteristics, and individual student characteristics, it can be concluded that these values are quite reasonable (Pintrich, Garcia, & McKeachie, 1991).

Sungur (2004) translated and adapted into Turkish. Sungur (2004) carried out confirmatory factor analysis using LISREL with six factors for 31 motivation items to assess the fit with the participation of 319 tenth grade and 169 eleventh grade students. These factors were Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Values, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, and Test Anxiety. The fit indices for the Turkish version calculated as: $\chi^2/df = 5.3$, GFI = 0.77 and RMR = 0.11 by Sungur (2004). When these values are compared with the indices for English version, it can be said that these values are acceptable. However, both English and Turkish version does not yield appropriate and ideal fit indices. Fit indices of Turkish and English version of the MSLQ's motivation section in Table 4.2.

Table 4.2 Comparison of fit indices for Turkish version and English version of MSLQ's motivation section (50 items)

	N (sample size)	χ^2/df	GFI	RMR
ENG	356	3.49	0.77	0.07
TUR	488	5.3	0.77	0.11

In this study, the Turkish version of MSLQ translated by Sungur (2004) was used with minor changes (see Appendix C). Pilot study was conducted by using 159 tenth grade students enrolled in Anatolian High School. The questionnaire was administered to entire classes at one time. Students were warned not to discuss their responses to other students, and respond as accurate as possible. SPSS was used to calculate the reliability coefficients. Reliability coefficients (Cronbach alphas) were also calculated for English version, Turkish version, and current (applied) version of the questionnaire. Table 4.3 presents these Cronbach alpha values for motivation section's constructs of MSLQ.

Table 4.3: Reliability Coefficients

	N(sample size)	IGO	EGO	TV	CLB	SELP	TA
ENG	356	0.74	0.62	0.90	0.68	0.93	0.80
TUR(Sungur's)	488	0.73	0.54	0.87	0.62	0.89	0.62
TUR (current)	159	0.71	0.56	0.84	0.63	0.86	0.68

Confirmatory factor analysis was also conducted for English version of questionnaire's learning strategy section that consist of 31 items regarding students' use of different cognitive and metacognitive strategies such as; Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self –Regulation and 19 items concerning student management of different resources such as; Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking. The fit indices for the Turkish version's learning strategy section yielded as: χ^2/df = 2.26, GFI = 0.78 and RMR = 0.08 (Pintrich, Smith, Garcia, and McKeachie, 1993). On the other hand, Sungur (2004) also calculated the fit indices for the Turkish version's learning strategy section. The indices were found as: χ^2/df = 4.5, GFI = 0.71 and RMR = 0.08. When the values of fit indices for Turkish version and English version of the test, it was concluded that the Turkish version of the test yielded reasonable values of fit indices and it was decided not to made any modifications. Fit indices of Turkish and English version of the MSLQ's learning strategy section in Table 4.4.

Table 4.4 Comparison of fit indices for Turkish version and English version of MSLQ's learning strategy section (50 items)

	N (sample size)	χ^2/df	GFI	RMR
ENG	356	2.26	0.78	0.08
TUR	488	4.5	0.71	0.08

Table 4.5 presents these Cronbach alpha values for learning strategy section's constructs of MSLQ.

Table 4.5 Reliability Coefficients

	N	R	E	O	CT	MSR	TSE	ER	PL	HS
ENG	356	0.69	0.76	0.64	0.80	0.79	0.76	0.69	0.76	0.52
TUR(Sungur's)	488	0.73	0.78	0.71	0.81	0.81	0.73	0.62	0.61	0.57
TUR (current)	159	0.71	0.71	0.66	0.82	0.79	0.74	0.70	0.66	0.55

The Turkish version of MSLQ that was translated by Sungur (2004) was used in the current study with minor changes to investigate the effect of 5E learning cycle model on students' motivation, and learning strategies.

4.4.3 Attitude Scale Toward Chemistry (ASTC)

This scale was developed by Geban et al. (1994) to measure students' attitudes toward chemistry as a school subject. This scale consisted of 15 items in 5-point likert type scale in which each item expresses agreement or disagreement (strongly agree, agree undecided, disagree, and strongly disagree). The reliability was found to be 0.83. This test was given to students in both groups before and after the treatment (see Appendix D).

4.4.4 Science Process Skill Test (SPST)

The test was developed by Okey, Wise and Burns (1982). This test consisted of 36 four-alternative multiple choice questions. It was translated and adopted into Turkish by Geban, Aşkar, and Özkan (1992). The reliability of the test was found to be 0, 85. Since the reliability of instrument is above 0.80, it was decided to use this instrument. This test includes five subsets designed to measure the different aspects of science process skills. These are identifying variables, identifying and stating hypothesis, defining operationally, designing investigations, graphing and interpreting data. This test was given the students in both experimental and control group before the treatment (see Appendix E).

4.5 Procedures

The ERIC, Social Science Citation Index, and Dissertation Abstracts International databases were searched by using the keywords that researcher identified (Frankel & Wallen, 2001). In addition, national database in YOK were searched with respect to these keywords. Moreover, several national journals such as Hacettepe

Üniversitesi Eğitim Fakültesi Dergisi, Eğitim ve Bilim Dergisi,, and Milli eğitim Dergisi were searched. Furthermore, Yahoo, Google, and Altavista search engines were used periodically. The keywords that was used to search these engines are; traditional teaching and learning, learning theories, constructivism, learning cycle, 5E Instructional Model, 5E learning cycle Model, 3E learning cycle, 3E learning cycle model, 7E learning cycle model, cognitive conflict, conceptual change approach, conceptual change models, misconception, alternative conceptions, conception, concept, state of matter, freezing point, melting point, phase diagrams, solid and liquids, evaporation, particulate nature of matter, solubility, dissolving, saturated solutions, concentration, demonstration, video animations in chemistry concepts, hands-on activities, laboratory activities, discussion, attitude, motivation, science process skill, MSLQ, metacognition, self-efficacy, self-regulation.

4.6 Activities

Demonstrations, laboratory activities, and hands on activities were developed to use in the phases of 5E learning cycle model. The main purpose of these demonstrations, laboratory activities, and hands on activities was to remediate students' misconceptions obtained from the literature review and student interviews before the study. These activities were designed to expose students' misconceptions and their prior knowledge. In addition, these activities were also carried out to help students to realize these conceptions' deficiencies and inadequacies to explain some conceptions. Moreover, remediation of these misconceptions was the other aim of these activities. Activities that were developed for this study displays some different purposes with respect to stages of 5E learning cycle model they were applied. Some of these activities were used in engagement stage of 5E learning cycle model to promote curiosity and elicit students' prior knowledge. The activities used in engagement stage made some connections between students' past and present learning experiences, expose prior conceptions, and organize students thinking toward the learning outcomes of current activities. Some activities used in exploration stage facilitate conceptual change. These activities help students to use their prior knowledge to generate new ideas, explore questions and possibilities, and conduct a preliminary investigation. Activities that are used in explanation phase provided opportunities to students to demonstrate their conceptual understanding, process skills, or behaviors. The activities used in elaboration stage were the new experiences for students to help them to develop deeper and broader understanding, more information, and adequate skills. The activities were used in evaluation phase provides students opportunities to assess their understanding and abilities. And, these activities were also used by teacher to evaluate students' progress toward achieving the educational objectives (Bybee et al., 2006). Students' grade level and students' prior knowledge were taken into consideration during the process of designing these activities. Activities were developed with respect to students' ability levels to conduct them and appropriateness of the content. Two chemistry teachers, a professor who is specialist in chemistry education, and two research assistant in chemistry education field examined these activities with respect to their appropriateness of the students' grade level and the state of matter and solubility content. Their views also had taken into consideration before the activities conducted.

4.7 Methods

State of matter and solubility concepts were taught to students in experimental group by using 5E learning cycle model (5EIM) while traditional method was used to teach state of matter and solubility concepts in control group. One teacher participated to the study. Two experimental groups and two control groups were instructed by the same teacher. The traditional method that was used in control groups consist of lecture and discussion method to teach state of matter and solubility concepts where students were passive listeners. The students were instructed with respect to teaching strategies that are relied on teacher explanation and textbooks without considerations of students' alternative conceptions. 5E learning cycle model was used to teach state of matter and solubility in experimental groups. In this method, the instruction was designed with respect to 5E learning cycle model to help students realize that some of their preconceptions are wrong and help them to remedy these misconceptions by embedding some kind of activities such demonstrations, hands-on activities, laboratory activities in certain phases of 5E learning cycle model. In addition, instruction was designed to maximize student active involvement in the learning process. Moreover, the state of matter and solubility concepts were instructed in both experimental and control group two hours a week, over 6 weeks period (12 consecutive chemistry lessons).

4.8 Treatment (Research Methodology)

It was stated that semi-structured interviews are flexible and allow researcher to ask new questions during the interview as a result of what the interviewee says and interviews are carried out based on several questions to get specific answers on respondents. Therefore high school chemistry teachers and several prospective teachers were interviewed whether they have observed any misconceptions about state of matter and solubility during their chemistry teaching session to students. The list of misconceptions was formed about state of matter and solubility concepts with respect to related literature and interview sessions of 10^{th} grade students, prospective chemistry teachers, and chemistry teachers. And, this list was given to teacher who implemented teaching in control groups and experimental groups of the study. Before the instruction, the teacher was trained about how to implement 5E learning cycle model based instruction in experimental groups. The teacher was trained about three hours. In this training, the teacher was informed about constructivist learning strategies, how to implement lesson that was design based on 5E learning cycle model, and in which stage the activities will be performed. In addition, the teacher was also informed how to administer the SMSCT. The experimental and control groups were determined by assigning randomly two of the chemistry classes as experimental groups and two of the classes as control groups. Students in the control groups were instructed by receiving materials and assignments based on traditional method and students in experimental group were instructed by receiving instruction based on 5E learning cycle model. State of matter and solubility concepts were taught to both groups in coherence with the schools curriculum. SPST, MSLQ, SMSCT, and ASTC were administered to both experimental and control groups to determine whether there was any difference between two groups with respect to understanding of state of matter and solubility concept, students' motivational constructs, students' science process skills, and their attitudes towards chemistry as a school subject. In the control groups, the teacher used lecture/discussion method to teach state of matter and solubility concepts. The students were instructed with respect to teaching strategies that are relied on teacher explanation and textbooks without considerations of students' alternative conceptions. Before the lessons, reading the related topics in the textbooks on their own was offered to the students. The definitions of the concepts and chemical reactions were written to the chalkboard and worksheets were passed out for students to complete. The main underlying principle was that the whole knowledge about the subject was known only by teacher and it is the teacher's responsibility to transfer that knowledge as fact to students. After teacher's explanations of concepts, discussion environment was directed by teacher's questions to discuss some concepts that were not understood completely by students. The worksheets involved some practice activities, open-ended questions to reinforce the concepts presented in the classroom sessions. In the experimental groups, the alternative conceptions were taken into account and the plausibility of scientific conceptions was provided. In addition, instruction was designed to maximize student active involvement in the learning process. The 5E learning cycle model consists of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. In the first phase (1) of this model (engagement) activities were used to make connections to past experiences and expose students' misconceptions. In this phase, the teacher started the lecture with inquiry questions with respect to the list of alternative conceptions to activate students' prior knowledge and misconceptions and promote the interaction in class. Teacher attempted to create a discussion environment and tried to explore students' inappropriate conceptions about the related concepts with these questions. The teacher took some notes about the responses and used these answers (both the correct and incorrect) in the class discussions. Teacher acted as a guide in this discussion and directed students to understand their conceptions were not sufficient to explain some phenomena. In other words, students were puzzled and actively motivated by these discussions. Disequilibrium was created in this phase. In the exploration phase (2), activities were designed for students to acquire concrete experiences upon which concepts, processes, and skills formulated. Bybee et al. (2006) stated this phase should consist of concrete and hands-on activities. Therefore, demonstrations, hands-on activities, and laboratory activities were used in this phase. These activities had conducted by teacher before they were conducted in class to confirm whether it works and some questions prepared to attract students' attention. Some of these activities were about phase changes, melting point and boiling point, colorimeter, vapour pressure, dissolving of NaCl in water, unsaturated solutions, saturated solutions, supersaturated solutions, and boiling point elevation and freezing point depression. Students were actively involved mentally and physically in the activity. These activities helped students to establish relationships, observe patterns, identify variables and question events. Teacher behaved as a facilitator and coach in this phase. The activities initiated by the teacher. Moreover, the teacher supplied sufficient time and opportunity to students for investigating objects and materials. The process of equilibration is initiated in exploration phase (Bybee et al., 2006). In the exploration (3) phase, students attention was directed to specific aspects of the engagement and exploration experiences. First, teacher gave opportunities to students to explain their opinions and ideas. Second, scientific and technological explanations are introduced in a direct, explicit, and formal manner. The experiences that are acquired in exploration phase were ordered in this phase. Teacher's explanations and the experiences that were gained in engagement and exploration phase were clearly connected by the teacher. In addition, video animations such as changes of state, solution formation by dilution, dissolution of NaCl in water, solution formation from a solid were used to present concepts and skills briefly, simply, clearly, and directly. In other words, the teacher explained phenomena and concepts related to state of matter and solubility in an interactive, direct, simple, and clear way in order to made students to aware some fundamental concepts about state of matter and solubility concepts. In the elaboration phase (4), students were involved further experiences to extent or elaborate the concepts, processes, or skills. The activities that were used in this phases were closely related to activities that were presented in exploration phase, but they were completely based on new situation. Teacher gave students time to deal with these activities and also created discussion environment based on these activities. As in the exploration phase, these activities were some laboratory activities, hands-on activities, demonstrations, or discussion of an event. Students defended and presented their ideas and approaches on new situation. Students found opportunities to gain information from each other, the teacher, and activities they conducted during the discussion sessions. The tasks, information bases, and possible strategies were also elaborated as a result of participation in the group's discussion (Champagne, 1987). In addition, this discussion gave students opportunities to receive feedbacks from other students who are very close to their own level of understanding. Furthermore, it was observed that students generalized the concepts, processes, and skills in this phase. The last phase of the 5E instructional model is evaluation phase (5). In this phase, teacher gave students opportunities to evaluate their understanding and skills that they acquired during previous phases. In addition, students received feedback about their understanding and skills. The educational outcomes and misconceptions that were identified at the beginning of the instruction were assessed with formal evaluation after the elaboration phase. Moreover, concept maps were used as a tool to evaluate students' understanding and skills about state of matter and solubility concepts. At the end of the treatment, SMSCT, MSLQ, and ASTC were administered to both experimental and control groups. The correlation between students' midterm examination results and students' scores on SMSCT was very high as expected. The Pearson correlation coefficient found 0.914. The results were investigated deeply in next chapter.

4.9 Treatment Fidelity and Treatment Verification

Treatment fidelity provide researcher to ensure that another factor except treatment is not responsible the difference in the dependent variable before study is conducted (Borrelli et al., 2005; Detrich, 1999; Hennessey & Rumrill, 2003). A criterion list that explains the methods for both EGs and CGs was formed. This criterion list involved not only what should be required in both EGs and CGs but also involved what should not be required in the methods implemented in both EGs and CGs. In the next step to ensure treatment fidelity, a lesson plan that integrated with the criterion list and objectives of the lesson was prepared. One chemistry professor, one chemistry education professor, two research assistant from chemistry education department, and two teachers reviewed the activities (see Appendix F) and the instruments whether they were appropriate for the purpose of the study. Their feedbacks were taken into consideration. The last step to ensure treatment fidelity was to train the teacher with respect to lesson plan and activities that implemented in both EGs and CGs.

Treatment verification provides researcher to ensure that treatment was implemented as defined in the study (Shaver, 1983). An observation checklist that consisted of 15 items with 5 point Likert type scale (Excellent, Above Average, Average, Below Average, Poor) was formed. Researcher and a research assistant from chemistry education rated this checklist. The minimum criterion was determined as al least 75% of the items were expected to be marked as average or above to say that the treatment was implemented as intended. Moreover, teacher and some students were interviewed to evaluate whether the treatment was implemented as expected. The interviews confirmed the checklist results which indicated that treatment was done as it was expected.

4.10 Ethical Concerns

This study does not cause any physical or psychological harm, discomfort, or danger that may arise due to research procedures. The proposal of the study, the instruments that used in this study and the lesson plans that implemented in both experimental group and control group were examined by ethic committee that constituted five professors from education faculty to assess whether there is possible harm to participants. This committee approved my study with respect to ethical issues.

Moreover, names of the subjects were removed from the all instruments by assigning numbers to each form to ensure confidentiality. Furthermore, no one else except researcher had a chance to reach or access data.

4.11 Threats to Internal Validity

Internal validity means independent variables, not some other unintended variables, directly explain the observed differences on the dependent variable (Frankel & Wallen, 2001). Therefore, it is very crucial to control internal validity threats in a study. Frankel and Wallen (2001) identified internal validity threats as subject characteristics, mortality, location, instrumentation, testing, history, maturation, attitude of subjects, regression and implementation.

Subject characteristic threat treat defined as the possibility of difference between individual in the sample with respect to such as their age, intelligence, previous knowledge about specific subject matter, science process skills etc (Frankel & Wallen, 2001). In this study, students' previous achievement and students' science process skills in both EGs and CGs were assessed at the beginning of the study. And, these variables used as covariate to minimize the prior differences that may effect observed differences on post test at the end of the study. In addition, all the students in both EGs and CGs were the same grade level and almost the same age (15-16 years old). However, since the students were not randomly assigned to both EGs and CGs other subject characteristics may correlate with dependent variable.

There was not any missing subject in both pre-tests and post tests in this study. In addition, all individuals answered all of the items. Therefore the mortality effect which means lose of subject during the study was controlled.

Since students received both tests and instruction in their regular classes at school, location threat which means the possibility of effects of locations on students' responds was controlled.

Since the instruments that were used in this study were designed as multiple choice format (SPST, SMSCT) and Likert scale (ASTC, MSLQ), instrumentation decay threat which means that changing the nature of the instruments construct and scoring was not a problem for this study. In addition, data collection characteristics threat was defined as the nature of data may be affected by data gatherers characteristics such as their gender, age ethnicity, language patterns etc (Frankel & Wallen, 2001). Same data collector (the teacher) was used to administer the instruments in both EGs and CGs to overcome this threat. The teacher was informed how to administer the instruments and trained with respect to standard procedures of test administration in order to control data collector bias threat. These procedures were taken from the procedures that implement in Student University Placement Examination (ÖSS) in Turkey.

The improvement of students in post tests may due to the pre-test that was administered at the beginning of the instruction and alerted students about the post test. This effect is defined as testing threat. This can also be one of the reasons of the improvement on dependent variables. In order to control this threat, sufficient time (seven weeks) was allowed for desensitization.

The researcher interviewed with students and teacher during the administration of instruments and during the intervention of the study to understand whether there is any extraordinary event that affect students' performance. The unanticipated and unplanned events that affect the responses of subjects is defined as history threat. The researcher concluded that there was not any extraordinary, unanticipated, and unplanned event during the administration of instruments and implementation of treatment. Therefore, it can be said that the history threat controlled.

Passing of time during intervention may affect dependent variable rather than to intervention itself. This effect defined as maturation threat. In this study, all the students were at the same and age level. In addition, the administration of tests and the interventions in both EGs and CGs were done in the students' regular classrooms at the same time. Therefore, the maturation threat was under control.

Subjects' views about a can create threat to internal validity. This effect is generally defined as attitude of subject threat. In order to reduce the risk of this threat, students were believed that the treatment that was applied in experimental group was not a novel situation and it was just a regular part of instruction. Both EGs and the CGs received materials differing in philosophy.

Since the students were not selected with respect to their low and high scores, there was no regression threat. Also, students' pre-test achievement scores were used as covariate.

The experimental group may be treated in ways that are unintended and not a necessary part of the intervention. So, this may give an advantage to students in experimental groups. This effect is defined as implementation effect. In this study, since one teacher implemented the instruction in both EGs and CGs, the teacher's quality was not differing in groups. In addition, in order to eliminate this threat, teacher was trained about what should be done and what should not be done in both EGs and CGs. Moreover, the EGs and CGs were observed whether the interventions in both of groups were done as intended.

4.12 Assumptions

1. It is assumed that the teacher was no biased during the treatments.
2. It is assumed that students in control groups were not affected by students in experimental group.

3. The instruments were answered seriously and honestly.
4. Standardized conditions were provided during test administrations.

4.13 Limitations

1. This study only covers the “State of Matter and Solubility” unit in chemistry.
2. Random Sampling was not used since the classes had been formed at the beginning of the semester.
3. The number of individuals from one school, just four classes was low.
4. The instruments were administered to both individuals in groups at the same time and some activities were required to do cooperatively in class. Therefore, the assumption of the independent observation in MANOVA may be violated.
5. Fit indices that were obtain from Confirmatory Factor Analysis results were not at the acceptable limits. Since the original English version’s results were nearly the same, it can be said they are reasonable. However, the results should be interpreted cautiously.

CHAPTER 5

RESULTS AND COCLUSIONS

5. 1 Statistical Analysis of Pretest Scores

At the beginning of the study, multiple t-tests were executed with respect to students' pretest scores on SMSCT, ASTC, and SPST. In addition, two different One-Way Multivariate Analysis of Variance (MANOVA) was conducted with respect to students' MSLQ scores.

5.1.1 Statistical Analysis of the SMSCT Scores, ASCT Scores, and SPST Scores (Pre-test)

Prior to treatment, t-test were performed to investigate whether there was a significant mean difference between the control group and experimental group with respect to students' pretest scores on SMSCT. The results revealed that there was no significant difference between CG and EG in terms of students understanding of state of matter and solubility concepts, $t\ (117) = -0.519$, $p > 0.05$. While the experimental group students' pre-test mean (X_{EG}) score was 10.06, the control group students' pre-test mean score (X_{CG}) was 9.92. In addition, t-test was conducted to investigate whether there was a difference between experimental and control group with respect to students' pretest scores on ASTC. t-test results revealed that there was no significant mean difference between EG and CG with respect to students' attitudes toward chemistry as a school subject t (117) = 0.365, $p > 0.05$. The experimental group students' and control group students' pre-test mean scores are, $X_{EG} = 47.42$, $X_{CG} = 47.76$, respectively. Moreover, another t-test was performed to investigate whether there was a significant mean difference between EG and CG with respect to students' scores on SPST. It was found that there was a significant difference between EG and CG groups with respect to students' science process skills, t (117) = 0.019, $p < 0.05$. The EG and CG students' SPST mean scores were found $X_{EG} = 29.45$, $X_{CG} = 28.21$. Therefore, it was decided to use students' science process skills scores as a covariate in the statistical analyses of the posttest's scores in order to control preexisting differences.

5.1.2 Statistical Analysis of the Motivated Strategies for Learning Questionnaire Scores (Pre-test)

Two MANOVAs that were conducted before the treatment were executed to determine whether there was a significant mean difference between control and experimental groups with respect to students' motivation and learning strategies, respectively. In other words, first MANOVA was performed to determine whether there was a significant mean difference between students in the experimental and the control group with respect to motivation collective dependent variables of students' Intrinsic Goal Orientation (IGO), Extrinsic Goal Orientation (EGO), Task Value (TV), Control of Learning Beliefs (CBL), Self-Efficacy for Learning and Performance (SEL), Test Anxiety (TA), and second MANOVA was performed to investigate whether there was significant mean difference between students in the experimental and the control group with respect to collective dependent variables of Rehearsal (R), Elaboration (E), Organization (O), Critical Thinking (CT), Metacognitive Self-Regulation (MSR), Time and Study Environment (TSE), Effort Regulation (ER), Peer Learning (PL), Help Seeking (HS) before the treatment. Table 5.1 shows the descriptive statistics of the motivation based dependent variables.

Table 5.1 Descriptive Statistics with respect to IGO, EGO, TV, CBL, SEL, and TA

	Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG
IGO	17.03	15.98	4.79	4.06	-0.67	0.00	0.51	-0.28
EGO	20.28	20.71	4.92	4.44	-0.61	-0.27	-0.26	-0.29
TV	29.36	27.45	6.84	5.41	-0.64	-0.71	0.52	1.03
CBL	21.23	19.55	4.77	4.12	-0.62	-0.47	0.33	0.18
SEL	41.28	36.45	9.67	8.41	-1.02	-0.18	1.38	-1.01
TA	18.65	20.57	7.05	5.28	0.00	-0.27	-0.58	0.08

Descriptive statistics for the learning strategies based dependent variables that were gathered from second MANOVA are presented in Table 5.2.

Table 5.2 Descriptive Statistics with respect to R, E, O, CT, MSR, TSE, ER, PL, and HS

	Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG
R	15.45	16.7	5.57	3.88	0.13	0.27	-0.79	-0.34
E	25.03	25.03	7.16	6.02	0.00	-1.73	-0.14	-0.22
O	15.01	16.81	5.94	4.09	0.31	0.12	-0.76	-0.65
CT	19.55	19.50	6.71	5.17	-0.12	-0.26	-0.03	-0.71
MSR	46.65	48.96	9.30	7.94	0.99	-0.28	0.98	-0.41
TSE	34.73	34.81	5.99	6.05	-0.25	0.52	-0.06	-0.45
ER	17.88	17.74	4.92	3.34	-0.01	-0.31	-0.77	-0.61
PL	11.31	12.23	3.21	3.13	0.05	-0.32	0.84	-0.39
HS	18.05	17.88	3.57	4.48	0.64	-0.44	0.80	-0.55

It can be derived from the skewness and kurtosis values that the univariate normality assumption was met for all dependent variables of two MANOVAs. The homogeneity of variance and covariance matrices assumption was interpreted by evaluating the Box's Test results that gathered both MANOVAs. The results indicated that Box's Test is significant for both analyses, $F(21, 50317) = 2.55$, $p < 0.05$ and $F(45, 44944) = 1.84$, $p < 0.05$, respectively. It means that homogeneity of variance and covariance matrices assumption was not met.

MANOVA results with respect to students' pretest scores on MSLQ were presented in Table 5.3 and Table 5.4.

Table 5.3 MANOVA results with respect to dependent variables of IGO, EGO, TV, CBL, SEL, and TA

Source	Wilk's Lamda	F	Significance (p)
Treatment	0.91	1.71	0.124

The results indicated that there was no significant mean difference between students in the experimental and the control group with respect to motivation based dependent variables such as IGO, EGO, TV, CBL, SEL, and TA before the treatment. It means that two groups were not different in terms of their motivation in chemistry at the beginning of the treatment. In Table 5.1.2.4 the same results can be seen for using of learning strategies. The results revealed that there was no significant mean difference between students in experimental and the control group with respect to learning strategies based dependent variables such as R, E, O, CT, MSR, TSE, ER, PL, HS before the treatment.

Table 5.4 MANOVA results with respect to dependent variables of R, E, O, CT, MSR, TSE, ER, PL, and HS

Source	Wilk's Lamda	F	Significance (p)
Treatment	0.90	1.24	0.27

After the analyses above, it can be stated that students in experimental and control group were similar with respect to understanding of state of matter and solubility concepts, their attitude toward chemistry, motivation and learning strategies at the beginning of the treatment.

5.2 Statistical Analysis of Posttest Scores

Hypotheses that were stated in Chapter III and the statistical analysis of these hypotheses based on posttest scores are given below:

H_o1: There is no significant mean diffrence between the groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject in the population of all the 10th grade Anatolian High School students in Ankara.

H_o2: There is no significant mean difference between boys and girls with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject in the population of all the 10th grade Anatolian High School students in Ankara.

H_o3: There is no interaction between treatment and gender with respect to students' understanding of state and matter and solubility concepts and students' attitude toward chemistry as a school subject in the population of all the 10th grade Anatolian High School students in Ankara.

Two-way MANCOVA where the treatment and gender were independent variables, students' understanding of state of matter and solubility concepts (concept understanding-CU) and students' attitude scores toward chemistry (attitude toward chemistry-AC) were dependent variables and students science process skills (SPST) was used as covariate was executed to analyze the hypotheses above. Table 5.1 shows the descriptive statistics for the dependent variables across the experimental (n = 59) control groups (n = 60). In addition, descriptive statistics for the dependent variables across the gender (50 girls and 69 boys) were presented in Table 5.2.

Table 5.5 Descriptive statistics with respect to CU and AC across experimental and control groups

	Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG
CU	11.96	17.28	2.02	1.96	0.11	-0.54	-0.58	0.05
AC	45.70	50.05	9.99	11.07	0.63	-0.19	0.32	-0.42

Table 5.6 Descriptive statistics with respect to CU and AC across gender

	Mean		Std. Dev		Skewness		Kurtosis	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
CU	14.25	15.09	3.29	3.35	-0.11	-0.15	-1.40	-1.14
AC	45.76	47.14	11.28	12.43	0.22	0.40	-0.24	-0.68

In Table 5.5, it was indicated that experimental group had higher mean scores on concept understanding and attitude toward chemistry. In a normal distribution, the degree to which a variable's scores fall at the beginning or at the ends of variable's scale is reflected by skewness value. On the other hand, the thickness of the tail regions of a distribution is reflected by kurtosis value. The value of skewness and kurtosis is zero in symmetric distributions. The values displayed in the tables are the tolerable values for stating that the dependent variables are multivariately normally distributed. The homogeneity of variance and covariance matrices assumption was interpreted by evaluating the Box's Test result. The results indicates that Box's test is not significant, F (9, 104807) = 0.58, p = 0.811. So, it means that homogeneity of variance and covariance matrices assumption is met. The results of the Levene's test were displayed in Table 5.7.

Table 5.7 Levene's Test of Equality of Error Variances

	F	df1	df2	*p*
CU	1.671	3	115	0.177
AC	0.458	3	115	0.712

Table 5.7 indicated that homogeneity of variance assumption was met for all dependent variables. It can be said that the univariate normality assumption and the homogeneity of variance and covariance matrices assumptions were met with the respect to the results in these tables. Two-way MANCOVA was performed after the assumptions were checked. Two-way MANCOVA results with respect to posttest scores of dependent variables of concept understanding and attitude toward chemistry were displayed in Table 5.8.

Table 5.8 MANCOVA results with respect to collective dependent variables of CU and AC

Source	Wilks' Lambda	Hypothesis df	Error df	Multivariate F	Sig. *(p)*	Eta Squared	Obs. Power
Treatment	0.31	2	113	122,69	0.000	0.68	1.00
Gender	0.98	2	113	0.83	0.435	0.01	0.19
SPST	0.72	2	113	21.48	0.000	0.27	1.00
Treatment*Gender	0.99	2	113	0.26	0.491	0.01	0.09

The Wilk's Lambda of 0.31 is significant, $F(2, 113) = 122.69$, $p < 0.05$, indicating that there was a significant mean difference between the experimental and control group with respect to understanding state of matter and solubility concepts and students' attitude toward chemistry when science process skills is controlled as covariate. The Eta-squared (η^2) value based on Wilk's Lambda was 0.68 which indicated the difference between experimental and control group was not small. In other words, it means that 68 % of multivariate variance of the dependent variables was associated with the treatment. The power value which was found 1.000 indicate that the difference between experimental and control group arise from the treatment effect and this difference had the practical value. On the other hand, the Wilk's Lambda of 0.98 is not significant for gender, $F(2, 113) = 0.83$, $p > 0.05$ which means that there was no significant mean difference between boys and girls with respect to understanding state of matter and solubility concepts and students' attitude toward chemistry. In addition, there was no interaction between treatment and gender $F(2, 113) = 0.26$, $p > 0.05$. However, the results indicated that there was significant contribution of science process skills on students' understanding of state of matter and solubility concepts and students' attitude toward science, $F(2, 113) = 21.48$, $p < 0.05$.

Multiple univariate ANOVAs were conducted in order to determine the effect of treatment on each dependent variable. The results of the univariate ANOVAs were presented in Table 5.9.

Table 5.9 Follow-up Pairwise Comparisons

Source	Dependent Variable	df	F	Sig.*(p)*	Eta Squared	Observed. Power
Treatment	CU	1	236.32	0.000	0.67	1.000
	AC	1	13.61	0.000	0.10	0.955

The univariate ANOVAs revealed that there was a statistically significant mean difference between the groups with respect to understanding of state of matter a solubility concepts and students' attitude toward chemistry. Table 5.5 indicates that the mean scores of experimental group higher than mean scores of control group for both concept understanding and attitude toward chemistry.

Items in the SMSCT were developed with respect to students' misconceptions in state of matter and solubility concepts and the objectives in the curriculum. The items were also written in terms of levels in Bloom's taxonomy. The proportions of correct responses and alternative conceptions were examined by using item analysis for experimental and control group. The results revealed that whereas the percentages of correct responses are nearly the same in the questions requiring simple recall, define, and label for both experimental and control group students, the percentages of correct responses was higher in the questions requiring interpret, organize, and integrate the knowledge for experimental group students. For instance, one of the items related to temperature changes during the phase changes. In this item (item 3) students were asked to simply to recall whether the temperature changes during phase changes. After the treatment, 60 % of the students in control group answer this question correctly. The percentage of the correct answer for this question was nearly the same for students in experimental group (72.9%). On the other hand, another item related to the relationship between temperature changes and molar concentrations of saturated solutions (item 12). Students required integrating their knowledge about saturated solutions with the effect of temperature on concentration changes of the solutions, and interpreting a graph to answer this item. The percentage of students who answered this item correctly was 38.3%. In experimental group, 71.2% of the students were answered this item correctly.

It was realized that students in control group had some difficulties to integrate and infer their knowledge to answer related questions. This striking difference can be seen in another item related to molecular appearance of the water in different phases (item 13). Students in experimental group were better in understanding phase change concepts in molecular level. After the treatment, while 38.3% of the students in control group selected the desired answer, 59.3% of the students in experimental group answer this item correctly.

In addition, the results indicate that treatment has an effect on remediation of misconceptions. For example, an item was related to students' misconceptions about defining the bubbles that form during the boiling process (item 5). Whereas 40% of the students in control group define these bubbles properly, the percentage of students who define the bubbles that form during the boiling process was 72.9%. Moreover, 58.3% of the students in control group held the alternative conception about the 'condensing water on the outside surface of a sealed class jar containing ice', whereas 40.7% of the students in experimental group held this misconception after the treatment (item 7).

What is more, students in the experimental group used better the relevant information in adressing the problems, interpret the information, and use the priciples to solve the problems in anwering the essay type items. For instance, students required to know some of the principles about the colorimetry to answer one of the essay type question (item 10). The results revealed that while 56.7% of the students in control group responded this item correctly, 67,8% of the students in experimental group answered this item correctly. The percentages of correct responses to the each question in the posttest for experimental and control group is displayed in Figure 5.1.

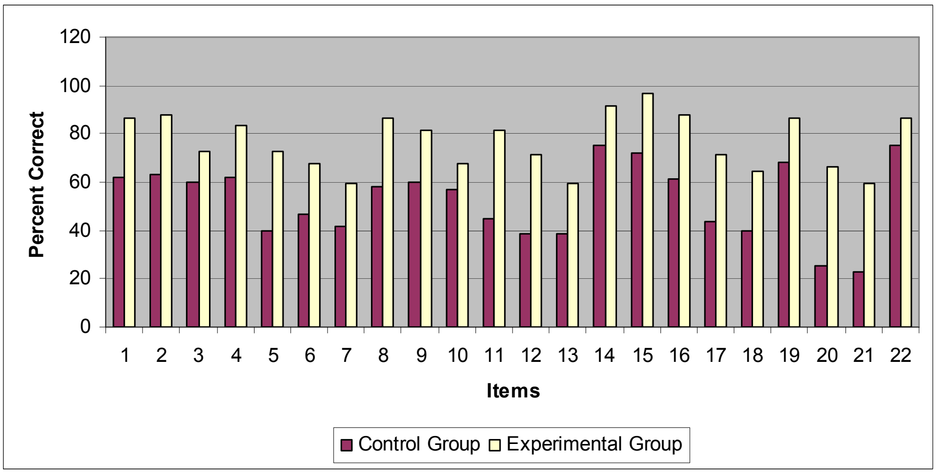

Figure 5.1 Percent Correct versus Post Test Items for EG and CG

5.3 Statistical Analysis of Posttest MSLQ Scores

H_o4: There is no significant mean difference between the groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety) in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o5: There is no significant mean difference between males and females with respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety) in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o6: There is no interaction between treatment and gender with respect to students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety) in the population of all the 10th grade Anatolian High School students in Ankara.

Two-Way Multivariate Analysis of Variance (two-way MANOVA) was performed to evaluate hypothesis 4, hypothesis 5, and hypothesis 6. Treatment and gender were used as independent variables and intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety were used as dependent variables. Table 5.10 and Table 5.11 present descriptive statistics for dependent variables across experimental (n = 59) and control (n = 60) groups and gender (boys = 69, girls = 50).

Table 5.10 Descriptive statistics with respect to IGO, EGO, TV, CBL, SEL, and TA across experimental and control groups

	Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG
IGO	16.96	18.55	4.59	3.76	-0.61	-0.56	0.38	-0.25
EGO	20.73	22.47	4.35	4.71	-0.78	-0.55	0.24	-0.27
TV	27.86	30.79	6.79	4.95	-0.61	0.17	0.20	-0.43
CBL	22.86	21.67	3.73	3.40	-0.27	0.03	-0.82	-0.78
SEL	40.86	40.71	8.99	9.66	-1.07	-0.41	0.55	-0.51
TA	20.01	20.77	6.27	5.27	0.11	0.01	-0.32	-0.74

Table 5.11 Descriptive statistics with respect to IGO, EGO, TV, CBL, SEL, and TA across boys and girls

	Mean		Std. Dev		Skewness		Kurtosis	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
IGO	17.24	18.46	4.03	4.50	-0.46	-1.03	-0.24	1.52
EGO	21.84	21.26	3.92	4.26	-0.66	-0.89	0.40	0.36
TV	28.81	30.02	5.89	6.38	-0.31	-0.96	0.64	1.29
CBL	22.24	22.32	3.73	3.46	-0.15	0.23	-0.85	-0.90
SEL	40.79	40.78	9.50	9.99	-0.84	-0.79	0.34	0.06
TA	21.01	19.54	5.48	6.11	0.23	0.05	-0.64	-0.65

Table 5.10 revealed that experimental group had highest mean scores on some dependent variables such as Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, and Test Anxiety whereas control group had highest mean scores on some dependent variables such as Control Beliefs about Learning and Self-Efficacy for Learning. It can be stated from the skewness and kurtosis values that univariate normality for the individual dependent variables across independent variables assumption was met. Box's M test results were evaluated whether the homogeneity of variance and covariance matrices assumption was provided. Box's Test result was nonsignificant. Therefore, it was concluded that the homogeneity of variance and covariance matrices assumption was met $F(63, 25948) = 1.28$, $p > 0.05$. Table 5.12 presents Levene's Test result to investigate whether each dependent variable has the same variance across groups.

Table 5.12 Levene's Test of Equality of Error Variance

	F	df1	df2	Significance (*p*)
IGO	0,347	3	115	0,791
EGO	0,746	3	115	0,527
TV	0,986	3	115	0,402
CBL	0,238	3	115	0,869
SEL	0,130	3	115	0,942
TA	1,296	3	115	0,279

Levene's Test results revealed that homogeneity of variance assumption was met for all dependent measures of motivation. Two-way MANOVA was performed after checking the assumptions discussed above. Two-way MANOVA results were displayed in Table 5.13.

Table 5.13 MANCOVA results with respect to collective dependent variables of motivation

Source	Wilks' Lambda	Hypothesis df	Error df	Multivariate F	Sig. *(p)*	Eta Squared	Obs. Power
Treatment	0.76	6	110	5.74	0.000	0.23	0.99
Gender	0.92	6	110	1.50	0.185	0.07	0.56
Treatment*Gender	0.94	6	110	0.99	0.430	0.05	0.38

The results revealed that there was a significant mean difference between the experimental and the control group with respect to dependent variables about motivation. The Eta-squared (η^2) value based on Wilk's Lambda was 0.23. This value indicated the difference between experimental and control group was not small. In other words, it means that 23% of multivariate variance of the dependent variables was associated with the treatment. The power value which was found 0.99 indicate that the difference between experimental and control group arise from the treatment effect and this difference had the practical value. On the other hand, the Wilk's Lambda of 0.92 is not significant for gender, $F (6, 110) = 1.50$, $p > 0.05$ which means that there was no significant mean difference between boys and girls with respect to dependent variables about motivation. In addition, there was no interaction between treatment and gender, $F (6, 110) = 0.99$, $p > 0.05$.

Multiple univariate ANOVAs were conducted in order to determine the effect of treatment on each dependent variable. The results of the univariate ANOVAs were presented in Table 5.14.

Table 5.14 Follow-up Pairwise Comparisons

Source	Dependent Variable	df	F	Significance (p)	Eta-Squared	Observed Power
Treatment	IGO	1	4.22	0.042	0.03	0.53
	EGO	1	6.23	0.014	0.05	0.69
	TV	1	6.21	0.014	0.05	0.69
	CBL	1	2.99	0.086	0.02	0.40
	SEL	1	0.10	0.744	0.00	0.06
	TA	1	0.60	0.438	0.05	0.12
Gender	IGO	1	2.38	0.126	0.02	0.33
	EGO	1	0.63	0.429	0.00	0.12
	TV	1	1.14	0.288	0.01	0.15
	CBL	1	0.01	0.901	0.00	0.05
	SEL	1	0.00	0.986	0.00	0.05
	TA	1	1.88	0.172	0.01	0.27
Tretament*Gender	IGO	1	0.02	0.881	0.00	0.05
	EGO	1	0.81	0.370	0.00	0.14
	TV	1	0.87	0.351	0.00	0.15
	CBL	1	0.08	0.768	0.00	0.06
	SEL	1	2.29	0.131	0.02	0.32
	TA	1	0.14	0.709	0.00	0.06

The results of the univatiate ANOVAs revealed that there was no significant mean difference between boys and girls with respect to dependent variables about motivation. As it can be seen in Table 5.11 the mean scores of boys and girls for each dependent variable about motivation nearly the same. Girls' perceived task value mean scores was higher than boys' perceived task value mean score, but the difference was nonsignificant. When the treatment is considered, the results the univariate ANOVAs revealed that the dependent variables of intrinsic goal orientation, extrinsic goal orientation, and task value were significant ($p < 0.05$) indicating that there was a significant mean difference between experimental and control group with respect to dependent variables of intrinsic goal orientation, extrinsic goal orientation, and task value. It can be seen in Table 5.10 that the mean score of perceived intrinsic goal orientation of students in experimental group was higher than that of the control group students. It can be said that students in experimental group were more curious about chemistry, really want to learn chemistry, and challenge the chemistry tasks whatever its difficulty degree is. For instance, the statement of “the most satisfying thing for me in this course is trying to understand the content as thoroughly as possible” (item no: 22) was rated as 6, 7 that means agreement of this statement by 54.2 % of the students in experimental group. %38.3 of the students in control group agreed this statement. In addition, the statement of “in a class like this, I prefer course material that arouses my curiosity even if it is difficult to learn” (item no: 16) was agreed by 33.8 % of the students in experimental group (rated 6, 7), whereas the percentage of students that agree this statement was %21.6. In addition, the mean score of students’ perceived extrinsic goal orientation in experimental group was higher than that of control group students. Although there was a significant mean difference between experimental and control group with respect to students’ perceived extrinsic goal orientation, the percentage of students that rate as 6, 7 that means to agree to the statements under this construct were nearly the same for experimental and control groups. For instance, the statement of “the most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade” (item no: 11) was rated as 6, 7 that means agreement of this statement by 55.9% of the students in experimental group. The percentage of the students that agree this statement in control group was very close (51.7%) to that of experimental group students. Moreover, students’ perceived task value in experimental group was higher than that of the control group students. Students in experimental group tend to perceive chemistry more interesting, more important, and more useful course. For instance, the statement of “understanding the subject matter of this course is very important to me” (item no: 27) was rated as 6, 7 that means agreement of this statement by 61 % of the students in experimental group while 48.4% of the students in control group agreed this statement. Table 5.15 presents the percentages of agreement with the selected items for significant dependent variables such as intrinsic goal orientation, extrinsic goal orientation, and task value across experimental and control groups.

Table 5.15 Percentages of responses to selected items of the IGO, EGO the TV scale

Scale	Item no	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
IGO	22	CG	5	5	16.6	21.6	13.3	20.0	18.3
		EG	0.0	0.0	5.0	6.7	16.9	20.3	33.8
	16	CG	11.6	20.0	16.6	11.6	16.6	11.6	10.0
		EG	6.7	10.2	15.2	16.9	16.9	13.5	20.3
EGO	11	CG	1.7	10.0	3.3	8.3	25.0	21.7	30.0
		EG	0.0	1.7	1.7	16.9	23.7	22.0	33.9
TV	27	CG	1.7	5.0	5.0	16.7	23.3	26.7	21.7
		EG	1.7	3.4	3.4	1.7	28.8	39.0	22.0

On the other hand, the results of ANOVAs revealed that there was no significant difference between experimental and control groups with respect to other dependent variables about motivation such as Control Beliefs about Learning, Self-Efficacy for Learning, and Test Anxiety. In addition, the results showed that there was no significant effect of interaction between gender difference and treatment with respect to dependent variables about motivation such as Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, Test Anxiety.

H_o7: There is no significant mean difference between groups exposed to instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking) in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o8: There is no significant mean difference between males and females with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking) in the population of all the 10^{th} grade Anatolian High School students in Ankara.

H_o9: There is no interaction between treatment and gender with respect to students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment, Effort Regulation, Peer Learning, Help Seeking) in the population of all the 10th grade Anatolian High School students in Ankara.

Two-Way Multivariate Analysis of Variance (two-way MANOVA) was performed to evaluate hypothesis 7, hypothesis 8, and hypothesis 9. Treatment and gender were used as independent variables and rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking were used as dependent variables. Table 5.16 and Table 5.17 present descriptive statistics for dependent variables across experimental (n = 59) and control (n = 60) groups and gender (boys = 69, girls = 50).

Table 5.16 Descriptive statistics with respect to R, E, O, CT, MSR, TSE, ER, PL, and HS across experimental and control groups

	Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG
R	16.55	16.81	4.84	5.30	0.15	-0.37	-0.75	-0.70
E	25.35	28.47	6.07	6.37	-0.20	0.04	-0.44	-0.26
O	15.26	20.32	5.13	4.80	0.07	-0.75	-0.57	0.45
CT	19.08	20.28	6.09	6.09	-0.38	0.24	-0.74	-0.40
MSR	47.45	49.47	10.98	10.39	-0.03	-0.20	-0.60	-0.87
TSE	36.63	37.45	8.09	6.63	-0.17	-0.35	-0.07	0.25
ER	18.16	18.88	4.25	3.52	-0.15	-0.28	-1.05	0.66
PL	11.46	12.47	2.79	3.02	0.60	-0.10	0.38	-0.12
HS	18.80	19.88	4.50	7.90	-0.15	2.86	-0.30	12.23

Table 5.17 Descriptive statistics with respect to R, E, O, CT, MSR, TSE, ER, PL, and HS across boys and girls

	Mean		Std. Dev		Skewness		Kurtosis	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
R	16.34	17.14	4.92	5.25	-0.11	-0.19	-0.43	-1.07
E	26.92	26.86	6.04	6.90	-0.13	0.08	0.01	-0.43
O	17.65	17.94	5.56	5.61	-0.19	-0.39	-0.62	-0.66

Table 5.17 cont'd

CT	19.94	19.32	5.80	6.52	-0.12	0.01	-0.40	-0.50
MSR	48.98	47.72	10.13	11.48	-0.08	-0.12	-0.45	-1.06
TSE	37.28	36.7	6.37	8.65	0.09	-0.41	-0.08	-0.22
ER	18.18	18.98	3.56	4.34	-0.29	-0.32	-0.77	-0.29
PL	12.01	11.9	2.82	3.13	0.12	0.37	-0.17	-0.09
HS	19.42	19.22	7.35	4.90	3.24	-0.60	14.88	-0.04

Table 5.16 revealed that experimental group had highest mean scores on all dependent variables about learning strategy. It can be stated from the skewness and kurtosis values that univariate normality for the individual dependent variables across independent variables assumption was met. The skewness and kurtosis values of the dependent variable of help seeking seem to violate this assumption, but it can be tolerated. Box's M test results were evaluated whether the homogeneity of variance and covariance matrices assumption was provided. Box's Test result was significant. Therefore, it was concluded that the homogeneity of variance and covariance matrices assumption was violated $F(135, 24319) = 1.45$, $p < 0.05$. Table 5.18 presents Levene's Test result to investigate whether each dependent variable has the same variance across groups.

Table 5.18 Levene's Test of Equality of Error Variance

	F	df1	df2	Significance (*p*)
R	0.281	3	115	0.839
E	0.393	3	115	0.758
O	0.413	3	115	0.744
CT	0.889	3	115	0.449
MSR	1.014	3	115	0.389
TSE	2.543	3	115	0.060
ER	1.961	3	115	0.124
PL	0.459	3	115	0.711
HS	1.460	3	115	0.229

Levene's Test results revealed that homogeneity of variance assumption was met for all dependent measures of motivation. Two-way MANOVA was performed after checking the assumptions discussed above. Two-way MANOVA results were displayed in Table 5.19.

Table 5.19 MANCOVA results with respect to collective dependent variables of motivation

Source	Wilks' Lambda	Hypothesis df	Error df	Multivariate F	Sig. *(p)*	Eta Squared	Obs. Power
Treatment	0.67	9	107	5.64	0.00	0.32	1.00
Gender	0.93	9	107	0.89	0.53	0.07	0.42
Treatment*Gender	0.90	9	107	1.23	0.28	0.09	0.57

The results revealed that there was a significant mean difference between the experimental and the control group with respect to dependent variables about motivation. The Eta-squared (η^2) value based on Wilk's Lambda was 0.32. This value indicated the difference between experimental and control group was not small. In other words, it means that 32 % of multivariate variance of the dependent variables was associated with the treatment. The power value which was found 1.00 indicate that the difference between experimental and control group arise from the treatment effect and this difference had the practical value. On the other hand, the Wilk's Lambda of 0.93 is not significant for gender, $F(6, 107) = 0.89$, $p > 0.05$ which means that there was no significant mean difference between boys and girls with respect to dependent variables about motivation. In addition, there was no interaction between treatment and gender, $F(6, 107) = 1.23$, $p > 0.05$.

Multiple univariate ANOVAs were conducted in order to determine the effect of treatment on each dependent variable. The results of the univariate ANOVAs were presented in Table 5.20.

Table 5.20 Follow-up Pairwise Comparisons

Source	Dependent Variable	df	F	Significance (p)	Eta-Squared	Observed Power
Treatment	R	1	0.226	0.635	0.002	0.07
	E	1	7.057	0.009	0.058	0.75
	O	1	28.556	0.000	0.199	1.00
	CT	1	1.122	0.292	0.010	0.18
	MSR	1	1.145	0.287	0.010	0.18
	TSE	1	0.397	0.530	0.003	0.09
	ER	1	0.516	0.474	0.004	0.11
	PL	1	3.414	0.067	0.029	0.44
	HS	1	0.700	0.405	0.006	0.13
Gender	R	1	0.717	0.399	0.006	0.18
	E	1	0.006	0.938	0.000	0.05
	O	1	0.071	0.790	0.001	0.05
	CT	1	0.306	0.581	0.003	0.08
	MSR	1	0.408	0.524	0.004	0.09
	TSE	1	0.184	0.669	0.002	0.07
	ER	1	1.168	0.282	0.010	0.18
	PL	1	0.050	0.824	0.000	0.05
	HS	1	0.031	0.861	0.000	0.05
Tretament*Gender	R	1	1.601	0.208	0.014	0.24
	E	1	0.023	0.880	0.000	0.05
	O	1	0.324	0.570	0.003	0.08
	CT	1	0.000	0.994	0.000	0.05
	MSR	1	0.109	0.042	0.001	0.06
	TSE	1	0.043	0.837	0.000	0.05
	ER	1	2.761	0.099	0.023	0.37
	PL	1	0.000	0.989	0.000	0.05
	HS	1	0.163	0.687	0.001	0.06

The results of the univatiate ANOVAs revealed that there was no significant mean difference between boys and girls with respect to dependent variables about learning strategies. As it can be seen in Table 5.17 the mean scores of boys and girls for each dependent variable about motivation nearly the same. Boys tend to perceived themselves as using the metacognitive self-regulation strategies, time study environment strategies, and peer learning strategies more than the girls, but the difference were nonsignificant. When the treatment is considered, the results the univariate ANOVAs revealed that the dependent variables of elaboration and organization learning strategies were significant ($p < 0.05$) indicating that there was a significant mean difference between experimental and control group with respect to dependent variables of elaboration and organization learning strategies. It can be seen in Table 5.16 that experimental group students appeared to perceive themselves as using the elaboration strategies more than the students in control group. For example, the statement of "when reading for this class, I try to relate the material to what I already know" (item no: 64), was rated as 6, 7 that means agreement of this statement by 49.1 % of the students in experimental group. On the other hand, %36.6 of the students in control group agreed this statement. In addition, the statement of "I try to apply ideas from course readings in other class activities such as lecture and discussion" (item no: 81), was agreed by 33.9 of the students in experimental group (rated 6, 7), whereas the percentage of students that agree this statement was %11.6. Moreover, students in experimental group tend to use organization learning strategies more than the students in control group. For instance, the statement of "when I study the readings for this course, I outline the material to help me organize my thoughts" (item no: 32) was rated as 6, 7 that means agreement of this statement by 54.2 % of the students in experimental group, corresponding percentage of students in control group to agree this statement was 21.7 %. In addition, the statement of "I make simple charts, diagrams, or tables to help me organize course material" was rated as agreement by 42.3 % of the students in experimental group while the percentage of students who agree this statement in control group was 23.3%. Table 5.21 presents the percentages of agreement with the selected items for significant dependent variables of learning strategies such as elaboration and organization across experimental and control groups.

Table 5.21 Percentages of responses to selected items of the IGO, EGO the TV scale

Scale	Item no	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
E	64	CG	3.3	5.0	3.3	23.3	28.3	23.3	13.3
		EG	0.0	10.2	8.5	23.7	8.5	27.1	22.0
	81	CG	15.0	16.7	20.0	18.3	18.3	3.3	8.3
		EG	11.9	15.3	10.2	15.3	13.6	18.6	15.3
R	32	CG	10	16.7	25.0	18.3	8.3	16.7	5.0
		EG	0.0	15.3	6.8	13.6	10.2	30.5	23.7
	49	CG	25.0	25.0	20.0	10.0	11.7	8.3	0.0
		EG	10.2	15.3	8.5	8.5	15.3	23.7	18.6

On the other hand, the results of ANOVAs revealed that there was no significant difference between experimental and control groups with respect to other dependent variables about learning strategies such as rehearsal, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking. In addition, the results showed that there was no significant effect of interaction between gender difference and treatment with respect to dependent variables about learning strategies such as rehearsal, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking.

CHAPTER 6

DISCUSSION, IMPLEMENTATION AND RECOMMENDADTIONS

The results that were acquired in chapter 5 give a way to present discussion in this chapter. Implications and some recommendations for further studies based on the results are also presented in this chapter. Firstly, summary of the study is presented to remind what has been done in this study in order to present discussion and findings apparently.

6.1. Summary of the Study

At the beginning of the study, the related literature about students' misconceptions in state of matter and solubility concepts were examined and semi structured interviews were conducted with teachers to understand whether these misconceptions are valid for their students. 5E instructional model based instruction was used in experimental group was designed with respect to take into consideration of these misconceptions. The main purposes of the study were to investigate the effect of 5E instructional model on students' understanding of state of matter and solubility concepts, elimination of misconceptions related to state of matter and solubility concepts, students' perceived motivation (intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety), and students perceived use of learning strategies (rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, help seeking). Four classes from possible chemistry classes in the school were randomly assigned as experimental and control groups. Two of the classes which were totally involving 59 students were assigned as experimental groups, on the other hand two of the classes which were totally involve 60 students were assigned as control groups. Students in EGs were received instruction based on 5E learning cycle model; on the other hand, students in CGs were received instruction based on TM. The duration of the study was six weeks. SMSCT, ASTC, MSLQ, and SPST were administered at the beginning of the study. t-tests were conducted for the data sets that were obtained from the administration of SMSCT and ASCT to determine whether two groups differed with respect to students' understanding state of matter and solubility concepts and students' attitude toward chemistry at the beginning of the instruction. t-test results revealed that no preexisting differences between two groups with respect to students' understanding state of matter and solubility concepts and students' attitude toward chemistry. In addition, MANOVAs were conducted to understand whether two groups differed with respect to the collective dependent variables about students' motivation and learning strategies. MANOVA results revealed that there was no difference between two groups with respect to students' motivation and learning strategies. After the study, each group received SMSCT, ASTC, and MSLQ as posttest. The items in SMSCT were related about students' misconceptions and objectives that stated in curriculum about state of matter and solubility concepts. The effectiveness of instruction was evaluated by comparing the posttest results while controlling students' science process skills as a covariate in the statistical analysis of the data. Multivariate Analysis of Variances (MANOVAs) were used as a statistical technique to compare two groups wit respect to collective dependent variables of the study.

Students who participated this study were tenth grade students and their age ranges from 16 to 17. The sample of the study consists of 69 male and 50 female students. All the students were tenth grade students in Atatürk Anatolian High School.

The teacher who instructed students in both groups is very experienced chemistry teacher. At the beginning of the instruction teacher was trained how to carry out the lesson in both control and experimental group. Also, the teacher was informed about the instruction based on constructivist notion and 5E learning cycle model. Moreover, the teacher was taken an instruction on standard procedures of test administration.

6.2 Discussion of the Results

One of the purposes of the study was to identify students' misconceptions in state of matter and solubility concepts, investigate the effectiveness of 5E learning cycle model and compare the effectiveness of 5E learning cycle model based instruction to traditional based instruction with respect to understanding state of matter and solubility concepts. The importance of prior knowledge in learning process has been emphasized by several researchers for several decades. It was accepted that the starting point of the learning process is what the learners already know. And it was believed that students do not come to classrooms with blank slates. In other words, students generally come to classroom with well-established understandings about how and why everything behaves as they do (Posner, Strike, Hewson, & Gertzog, 1982; Resnik, 1983; Strike, 1983). Ausubel's (1968) statement of "If I had to reduce all educational psychology to just one principle, I would say this: The most important factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" emphasized the importance of prior knowledge very clearly. Some of these well established conceptions may inconsistent with the scientific views and are labeled as misconceptions. When the importance of the preconception is taken into consideration, it is very clear that misconceptions is an obstacle for further learning since the knowledge constructed on already existing conceptions. Therefore identification and finding ways to elimination of misconceptions for all subject areas is very crucial for meaningful learning. In this study, at the beginning of the instruction tried to find out students' misconceptions about state of matter and solubility by examining related literature and carry out semi structured interviews with experienced chemistry teachers in schools and tenth grade students. In other words a list of misconceptions about state of matter and solubility were created with respect to examining literature in detail and conducted structured interviews. It was understood that students have several misconceptions about state of matter and solubility concepts. It was found that students have difficulties in understanding the concepts related to phase changes such as boiling point, evaporation, melting point, temperature changes during phase changes, vapor pressure, and solutions such as saturated solutions, concentrations of solutions, boiling point elevation, freezing point depression. Misconceptions about the high school chemistry subjects including state of matter and solubility can be found in related literature. However, the misconceptions about the concepts in state of matter and solubility such as boiling point, melting point, phase changes, solutions, and saturated solutions etc. were studied in separate studies. So in this study, all the misconceptions in these concepts were reviewed and with the help of structured interviews a list of misconceptions were developed (see Appendix A). It is very valuable tool for teachers who teach state of matter and solubility concepts. In addition, it will be very beneficial for teachers to be aware of the students' misconceptions about state of matter and solubility for designing their instruction to remedy these misconceptions and overcome the difficulties of students in state of matter and solubility concepts.

Finding ways or in other words developing instructional strategies to remedy these misconceptions and enhance meaningful learning is very crucial as identification of these misconceptions. First of all, the construction process of knowledge should be understood to achieve these aims. The notion of constructivism assumes that knowledge is constructed by learners as they attempt to make sense of their experiences. Piaget's views which constitute fundamentals of constructivism explain the learning process through assimilation, accommodation, and equilibration process. According to Piaget, if the preexisting schema or mental structure is not appropriate to interpret sensory data, assimilation occurs. Disequilibration occurs when the experiences are not assimilated into preexisting schemes. Accommodation which provides equilibrium is a process that preexisting schemas are modified. Therefore as it can be seen from these ideas, further learning is directly affected by the prior knowledge. So, reaching the meaningful learning requires identification of misconceptions and design an instruction based on remediation of these misconceptions.

The sources of the misconceptions are another important issue that should be taken into consideration during designing of an instruction. Students' previous experiences, instruction, teachers' explanations, textbooks, terminology, social interaction, and everyday language can be specified some of the sources of students' misconceptions. Students have a conceptual framework already present from everyday experiences. Therefore, these experiences may be a source of students' misconceptions. Some misconception may arise due to the use of everyday language. Some of the sentences and words used by people may have different meaning from the scientists' used. For instance, people stated generally that "sugar melts in water", but it should be stated as "sugar dissolved in water" with respect to scientific views. In addition, some studies revealed that students have some misconceptions about the related subject matter in chemistry (Stein, Larrabee, & Barman, 2008; Jasien & Oberem, 2002). So, these misconceptions can also lead to occurrence of student misconceptions. Moreover, terminology and textbook may lead misconceptions. The changing nature of the terminology may result misconceptions. Mistakes in the textbooks may be interpreted as appropriate by students and this lead to occurrence of misconceptions.

Conceptual change is facilitated in learning cycle which is an instructional model based on constructivism and constitutes fundamentals of 5E leaning cycle model. The three phases of the learning cycle were stated originally as "preliminary exploration, invention, and discovery". Firstly, the three phases were converted as "exploration, concept introduction, and concept application" and then the names and the phases have been modified through the last three decades. 5E learning cycle model is the one of the latest version of learning cycle which stages were modified and added based on learning cycle. The unchanging thing is, both the learning cycle and 5E learning cycle were proposed as instructional models based on development psychology of Jean Piaget. In other words, Piaget's mental functioning model correspond directly with the phases of learning cycle: in the exploration phase, assimilation and disequilibration occur; in the concept introduction phase accommodation occurs; and in the concept application phase, organization occurs (Abraham & Renner, 1986; Abraham & Renner, 1983). When the starting point of the Piaget's ideas in which it was assumed that "information, available in our environment, is assimilated or transformed into our existing mental structures" leads to paying attention to our existing mental structures in other words our preexisting knowledge. Therefore, learning in a meaningful way requires learner to have appropriate existing mental structures. In other words, an instruction should be design in order to remedy learners' misconceptions to accommodate new ideas. One of the major concerns of 5E learning cycle model is to overcome students' misconceptions to prepare an appropriate base which constitute consistent existing mental structures. So, identification of misconceptions was the necessary and starting point of the instruction based on 5E learning cycle model. In the first phase which was stated as engagement the activities made connections to past experiences and expose students' misconceptions (Bybee et al., 2006). In this phase, students were exposed to an object, problem, situation or events which were prepared to activate students' misconceptions that were identified before the instruction. These activities served to create cognitive conflict and motivate students to learning activity. Creating cognitive conflict is one of the necessary elements of 5E learning cycle model in order to achieve conceptual change and meaningful learning. In brief, disequilibrium which occurs when there is no consistency between the existing cognitive structure and new information resulted in this phase. In addition this phase corresponds the dissatisfaction phase proposed by Posner and his colloquies (1982) in conceptual change approach. Students realized that there was something wrong with their existing mental structure or prior knowledge when the cognitive conflict occurred. Therefore, cognitive conflict leaded students to motivate learning activity. One of the key elements in this phase was the nature of the activities. The activities should create interest and generate curiosity which can be exposed as a problem, situation or event. Moreover, students tried to understand confusing situation and monitor the level of their understanding when they confronted with conflicting situations. Students created cognitive conflict by asking some questions themselves. For instance, when the activity where the relationship between temperature changes and phase transition was given to students, some of the students asked themselves "why does not the temperature change during phase transition?" Students found a chance to monitor themselves and self evaluated their understandings and tried to find ways to correct their error and overcome their misconceptions. In the second phase of 5E learning cycle model which was stated as exploration, the required time to investigate objects, materials, and situations was provided. The process of equilibration which occurs when there is a balance between new information and the existing structure was initiated by the activities presented in exploration phase as Bybee et al. (2006) stated that "Engagement brings about disequilibrium; exploration initiates the process of equilibration" (p.9). In this phase students had a chance to establish relationships, observe patterns, identify variables, and question events as a result of mental and physical involvement in the activity. The activities were tangible, concrete, and related with the misconceptions identified in the former phase. Students tried to find out the rationale behind their ideas to overcome and remedy their misconceptions. It is explained students that they were not the only students who had these misconceptions and some sources leaded them to create misconceptions. In the third phase of the 5E learning cycle model, explanation, concepts, process, and skills were presented simply, clearly, and directly by attracting students' attention to specific aspects of engagement and exploration experiences. The reason of the misconceptions and the correct scientific explanation of the misconception were also explained in this phase. Concepts and skills were presented base on the specific aspects of the engagement and exploration experiences. Firstly, students were asked to give their explanations and then scientific and technological explanations were introduced by teacher in a direct, explicit, and formal manner. In other words, explanatory experiences were ordered by teacher's explanation. Therefore, the process of equilibration was continued in this phase. Video animations, verbal explanations, and demonstrations were used to explain concepts and skills. At the end of this phase, students were encouraged to present their own ideas to understand whether they were able to explain exploratory experiences and experiences that have engaged them by using common and scientific terms. Students' misconceptions were corrected and the ideas behind these misconceptions were exchanged with the scientific ones. This phase corresponds the intelligibility phase proposed in conceptual change approach by Posner and his colloquies (1982). In the fourth phase of 5E learning cycle model, elaboration, students were involved further experiences to extent or elaborate their concepts, skills, and processes. In other words, extension of the concepts was provided in this phase. Daily life examples about state of matter and solubility concepts were given to students realize the importance of understanding these concepts. Additional different activities such as hands-on activities and laboratory activities were presented to students. So, students who had still misconceptions found a chance to remedy these misconceptions and comprehend their understanding. Group discussions were also encouraged in which students were able to express their understanding of the subject and receive feedback from other students who are very close to their own level of understanding. Students tried to generalize their concepts, processes, and skills in this phase. In the last phase of 5E learning cycle model, evaluation, students' misconceptions and educational outcomes that were identified at the beginning of the lesson were evaluated through formative evaluation to give students feedback about their misconceptions that they already had and understandings. Students had opportunities to monitor their own level of understanding and the misconceptions they still had.

Even though implementing 5E learning cycle model is difficult especially in crowded classrooms and it requires enough time, many researcher indicated the effectiveness of instruction based on 5E learning cycle model (Akar, 2005; Coulson, 2002; Boddy et al., 2003; Garcia, 2005; Campbell, 2000; Balcı, Çakıroğlu and Tekkaya, 2005; Lord, 1999; Mecit, 2006; Bevenino, Dengel, & Adams, 1999). In addition to this when the curriculum development studies on chemistry in Turkey taken into consideration, 5E learning cycle model seem to be one of the appropriate model that can be used in new curricula. In this study, students instructed by instruction based on 5E learning cycle model outperformed students instructed with instruction based on traditional methods. In other words, the results that were presented in Chapter V revealed that students who were instructed by instruction based on 5E learning cycle model gain better acquisition of concepts with respect to state of matter and solubility concepts compared to students who were instructed by instruction based on traditional methods. Moreover, proportion of correct responses for each item indicated that elimination and remediation of misconceptions were provided well with the instruction based on 5E learning cycle model when compared to instruction based on traditional model. The results also supported by the related previous studies (Akar, 2005; Coulson, 2002; Boddy, 2003; Garcia, 2005; Campbell, 2000; Balcı, Çakıroğlu and Tekkaya, 2005; Lord, 1999; Mecit, 2006; Bevenino, Dengel, & Adams, 1999, Ateş, 2005). On the other hand, when it is considered that 5E learning cycle model is an instructional model with roots in learning cycle approach proposed by Atkin and Karplus (1962), many researchers indicated the effectiveness of learning cycle with respect to process skill development (Cumo, 1992; Davidson, 1989) content learning (Campbell, 1977; Kurey, 1991; Purser & Renner, 1983; Saunders & Shepardson, 1987; Schneider & Renner, 1980; Shadburn, 1990, Klindienst,1993; Odom and Kelly, 2001), and reducing misconceptions (Lawson & Thompson, 1988; Marek, Cowan, & Cavollo, 1994; Scharmann, 1991, Gang, 1995, Marek, Cowan, & Cavallo, 1994).

At the beginning of the first phase of the 5E learning cycle model, students' misconceptions about state of matter and solubility were identified and the instruction based on 5E learning cycle model were designed to remediate students' misconceptions besides understanding of state and matter and solubility concepts. On the other hand, students' misconceptions about state of matter and solubility concepts were not emphasized in instruction based on traditional method. Therefore, students who were instructed by traditional method would not construct appropriate knowledge since new knowledge is constructed upon on existing mental structures or prior knowledge. As it was mentioned before meaningful learning only occurs in a situations that learners have appropriate mental structures and can relate it with new knowledge. It can obviously seem that students who were instructed traditional method were not directed to prevent and overcome misconceptions.

Posttest scores of the students revealed that instruction based on 5E learning cycle model improved students understanding of state of matter and solubility concepts. In addition, students in EG did well compared to CG students on each item. For instance, in item 1, students were required to simply recall the conservation of mass during phase changes. The misconception which was stated as “the weight or mass of a substance changes as it melts or evaporates, mass not conserved” was identified from literature and structured interviews at the beginning of the study. After the treatment, 26.7 % of the students in control group held this misconception; on the other hand only 6.8 % of the students in experimental group had this misconception. In other words, whereas 61.7% of the students in control group answered this question correctly, the proportion of students in experimental group who answered this item was 86.4%. In addition, 11.7% of the students in control group selected only the correct response, the reason of the correct response were not written. And 6.4% of the students in experimental group did not write the reason of the correct response. Students in experimental group carried on a simple laboratory experiment in which the conservation of mass during phase changes is confirmed. This laboratory activity was conducted at the elaboration phase when the phase changes of matter concepts were taught. In another item (item 18) which is an essay type question, it was aimed to measure students’ performance skills such as use of relevant information in defining the problem, use appropriate information, use the principles that was showed during the instruction. While 40% of the students in control group answered this item correctly, 64.4 % of the students in experimental group answered this item correctly. Therefore, the percentages of correct responses for this item in both groups indicated as evidence to say that instruction based on 5E learning cycle model improve students’ performance skills better when compared with the instruction based on traditional method. In another items, item 21 and 22, it was required thinking critically to answer these items correctly. Whereas 25% of the students in control group answered item 21 correctly, the percentage of correct response for this item was 66.1% in experimental group. In addition, while 23.3% of the students in control group answered item 22 correctly, 59.3% of the students in experimental group answered this item correctly. The results are supported by some researchers. For example, Johnson and Lawson (1998) stated that learning cycle based instruction caused significant improvements in reasoning ability of the students. In other words, it was stated that the reasoning improvement facilitated better for students in the learning cycle based classes.

At the beginning of the study, students' attitude toward chemistry as a school subject was investigated to understand whether there was a significant difference between experimental and control group with respect to students' attitudes towards chemistry as a school subject. The results showed that students who were instructed based on 5E learning cycle model and those who were instructed based on traditional method did not differ significantly before the study. At the end of the study, students' attitude toward chemistry as a school subject in CG and EG were investigated in order to determine whether there was an effect of treatment on students' attitudes toward chemistry. Before the treatment, mean attitude scores of CG and EG students were $X_{CG} = 47.42$ and $X_{EG} = 47.76$, respectively. After the treatment, mean attitude scores of CG and EG students were $X_{CG} = 45.70$ and $X_{EG} = 50.05$, respectively. The mean attitude score of students in CG decreased, but the difference is not statistically significant. On the other hand, the mean score of students' attitudes toward chemistry in EG increased. In addition, there was a significant difference between students who were instructed based on 5E instructional model and those who were instructed based on traditional method with respect to attitudes towards chemistry as a school subject. Many researchers indicated the effectiveness of learning cycle based instruction on students' attitude toward science (Brown, 1973; Lowery, Bowyer, & Padilla, 1980; Garcia, 2005). Bybee et al. (2006) indicated that learning cycle based instruction consistently results in more positive attitudes about science. Lawson (1995) indicated that out 8 of 12 studies that were reviewed found more positive attitudes for students who experienced learning cycle instruction than for those who did not. So, it can be said that the results of the study was supported by many researchers.

The results of the current study revealed that students who were instructed based on 5E learning cycle model caused students to be more curious and to challenge the chemistry tasks. In addition, students in EG were willing to mastery the subject more than students in CG. For instance, the answer of the items such as “in a class like this, I prefer course material that really challenges me so I can learn new things”, “in a class like this, I prefer course material that arouses my curiosity even if it is difficult to learn”, “the most satisfying thing for me in this course is trying to understand the content as thoroughly as possible”, and “when I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade” indicated that students in EG group agreed these items more than students CG. This superiority was supported by statistical analysis. Moreover, Students in experimental group tend to perceive chemistry more interesting, more important, and more useful course. The real life applications or activities tend students to realize that the concepts about state of matter and solubility are related with our daily life experiences. Lawson (1995) supported this results by indicated that college students enrolled in learning cycle sections enjoyed their instructions more than those enrolled in traditional sections. Since the 5E learning cycle model was a student-centered and novel approach, students might believe the activities that were used in EG interesting and useful. In addition, students perceived extrinsic goal orientation showed superiority for EG students. In spite of there was a significant mean difference between experimental and control group with respect to students’ perceived extrinsic goal orientation, the distributions of answers to items that constitute this construct are very similar. On the other hand it should be noted that although current study presents that instruction based on 5E learning cycle model has positive influence on students’ intrinsic goal orientation, extrinsic goal orientation, and task value, it doesn’t have effect on control of learning beliefs, self-efficacy for learning and performance, and test anxiety. Duration of instruction based on 5E learning cycle which was just 6 weeks can be stated one of the reason of this. Students may not realize the critical points of instruction based 5E learning cycle model that emphasize these constructs in such short period.

When the results were examined with respect to students' perceived learning strategies, it was found that instruction based on 5E learning cycle model enhances students' use of elaboration learning strategies and organization learning strategies. In the phases of the 5E learning cycle model, the using the elaboration strategies are emphasized. Especially, in the elaboration phase, students were encouraged to involve further experiences to transfer and relate the new learned concepts in new situations. When the items such as "I try to relate ideas in this subject to those in other courses whenever possible", "when reading for this class, I try to relate the material to what I already know", and "try to apply ideas from course readings in other class activities such as lecture and discussion" which were constitute this construct were examined, it is easily realized that these items emphasizes the same principles that involve in elaboration phase. In addition, in an item which was stated as "when reading for this class, I try to relate the material to what I already know" is the another important thing that emphasized in engagement and exploration phases. Moreover, students in experimental group tend to use organization learning strategies more than the students in control group. In the engagement phase of 5E learning cycle model, students were encouraged to explicit their prior ideas about the subject matter. In the items under this construct, examination of prior undestanding about the related concepts was emphasized.

Coulson (2002) conducted a study to investigate how varying levels of fidelity to the 5E learning cycle model affected student learning. It was found that teachers who taught their students with medium of high levels of fidelity to the 5E learning cycle model contributed students leaning gains nearly double that of teachers did not used the model or used with levels of fidelity. In other words, when teachers implemented the 5E learning cycle model with a medium or high level of fidelity, the learning gains experienced by their students were significantly greater than the learning gains of teachers who did not adhere closely to the 5E learning cycle model. Treatment fidelity and treatment verification techniques were applied for this study (Chapter IV). The lessons that implemented in both experimental and control group were observed by researcher and observation checklist that was prepared by the researcher was completed. The evidences gathered from the results of observations indicated that teacher implemented the 5E learning cycle model with a high level of fidelity for the current study.

Threats to internal validity needed to be controlled to ensure not other some unintended variables explain the observed differences on the dependent variable (Frankel & Wallen, 2001). The study should be carefully designed in order to control internal validity threats. The procedures and precautions that were done to control these threats were presented in Chapter IV. However, some of the difficulties and limitations aroused during to implementation of these procedures. For instance, subject characteristic threats were not controlled completely since the students who constitute the sample were not selected randomly from the population. In addition, even though students in control group were provided with materials designed on TM, some of the students in EG group might realize the materials that provided in instruction based on 5E learning cycle model something different. Therefore, students' attitudes in control group might affected negatively if they were aware this situation or students' attitudes in experimental group might affected positively with the new materials that applied in EG.

At the beginning of the instruction, students' prior knowledge about state of matter and solubility concepts were evaluated by SMSCT to understand whether there was a significant difference between EG and CG with respect to understanding of state of matter and solubility concepts. The results revealed that there was not a significant difference between students in both EG and CG with respect to understanding state of matter and solubility concepts before the study. In other words, students in both EG and

CG showed similarities about their understanding of state of matter and solubility concepts at the beginning of the study.

Before the study, SPST was administered to students in both EG and CG to determine whether there was a significant difference between EG and CG with respect to students' science process skills. The statistical analyses revealed that science process skills of the students in EG and CG differ significantly. Also, the results showed that students' understanding of state of matter and solubility was contributed significantly by students' science process skills. Therefore, it was needed to control students' science process skills while investigating the effectiveness of instruction based on 5E learning cycle model. In statistical terms, the scores of students on SPST in both EG and CG were used as a covariate in statistical analysis. Therefore, MANCOVA analysis was used in order to test hypothesis of the current study.

At the end of the study, the effect of gender on students' understanding of state of matter and solubility concepts was also investigated. The results revealed that there was no significant mean difference between male and female students in understanding state of matter and solubility concepts. In other words, male and female students showed similarities with respect to understanding of state of matter and solubility concepts at the end of the study.

At the end of the study, the interaction between gender difference and treatment with respect to understanding of state of matter and solubility concepts was also assessed. The results revealed that there was no significant interaction.

At the end of the study, the contribution of students' science process skills to understanding of state of matter and solubility concepts was also assessed. It was found that there was a significant contribution of science process skills to understanding of state of matter and solubility concepts. This result indicated that science process skills of the students should be developed in order to enhance students' understanding of state of matter and solubility concepts.

At the end of the study, the effect of gender on students' attitude toward chemistry as a school subject was investigated. It was found that there was no significant difference between male and female with respect to attitude toward chemistry. In other words, male and female students showed similarities with respect to attitude toward chemistry as a school subject at the end of the study.

The interaction between gender difference and treatment with respect to students' attitudes towards chemistry as a school subject was also investigated. No significant interaction was found.

6.3. Implications

In instruction based on 5E learning cycle model, students' prior knowledge were taken into account and integrated with the new knowledge. As it was indicated, it is very difficult to understand concepts in meaningful way when the prior conceptions are inconsistent and students can not link the new knowledge with existing knowledge. Students' misconceptions should be examined by teachers at the beginning of the instruction to avoid students to create more misconceptions in their mind. Well-designed instruction based on 5E learning cycle model is very effective to relate students' new conceptions and prior conceptions. The notion that "students do not come an instruction with blank slates, they usually come to classrooms with some conceptions about the subject matter gathered during their past daily life experiences and other lessons" should not be forgotten. On the other hand, students are not only the individuals that have misconceptions about a subject matter, besides teachers confront some problems since the misconceptions they held. Therefore, teachers should develop themselves and if necessary they should receive courses to recognize and remedy their misconceptions. In addition, teachers should be aware the sources of misconceptions and how to explicit the misconceptions that students have.

Teachers should be trained about how to develop an instruction based on 5E learning cycle model. The principles and the fundamentals of 5E learning cycle model should be explained science and chemistry teachers in in-service teacher training programs. Since 5E learning cycle model with a high level of fidelity contributed students learning gains nearly double that of 5E learning cycle model with medium and low level of fidelity, teachers should apply all the principles of 5E learning cycle model completely when designing their lessons with respect to this model. In addition, teacher education programs in universities especially science methods courses should involve and give examples about how to develop an instruction based on 5E learning cycle model. Science education departments in universities and high schools should work together to design instruction based on 5E instruction model for other chemistry and science concepts. Moreover, researchers in science education departments investigate which subjects in chemistry in high schools appropriate to apply this model and also school administrators should encourage teachers to use learning cycle based instruction.

During implementation of this study, some difficulties raised to implement all phases of 5E instructional model due to overloaded curriculum. Therefore, it is better for student to carry on some additional activities out of class time.

Well designed instruction based on 5E learning cycle model can lead better acquisition of scientific concepts. Therefore, the phases of 5E instructional model should be embedded to instruction carefully.

Students' attitude toward chemistry as a school subject is an important component that affects students' achievements. Therefore, teachers should be aware of students' attitudes towards chemistry as a school subject and seek to improve students' attitudes. In the current study, students attitudes improved by the of 5E learning cycle model.

Science process skills of the students is another component that can be used to predict students achievements. Therefore teachers should seek some ways to improve students' science process skills.

6.4 Recommendations

On the bases of the findings from this study, the researcher recommends that;

Similar studies can be conducted in different school types or different grade levels with a larger sample size to increase generalizability of the study.

Studies can be conducted to investigate the effect of instruction based on 5E learning cycle model on students' understanding of concepts, attitudes and motivations other than state of matter and solubility concepts.

Similar studies can be conducted to investigate the effect of instruction based on 5E learning cycle model on students' understandings of concepts, students' motivation and learning strategies in other subject areas such as biology and physics.

Studies can be conducted to investigate effectiveness of instruction based on 5E instructional model on retention of concepts.

Similar studies with alternative assessment strategies can be carried out.

Long term effects of instructions based on 5E learning cycle model can be investigated by employing longitudinal studies.

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APPENDIX A

MISCONCEPTIONS (STATE OF MATTER AND SOLUBILITY)

1. Evaporation
Water (or alcohol) disappears as it evaporates.
In evaporation, molecules turn into something else; water (or alcohol) "becomes" vapor.
Water is sucked by a pan or went into the plate during the process of evaporation.
Water transform into mist, steam, or spray during the process evaporation
Vapor is something different from water.
The acetone disappears along with its weight but leaves its property of smell behind during its evaporation.
Students prefer to explain evaporation with respect to weight change rather than density change.
The weight or mass of a substance changes as it melts or evaporates. Mass not conserved.
Mass not conserved because “gas weighs less than liquid”
2. Boiling
Bubbles from boiling water made of air.
Bubbles from boiling water made of air and oxygen gas
Bubbles from boiling water madet of hydrogen gas
Bubbles from boiling water made of oxygen and hydrogen gas
Bubbles from boiling water made of heat.
The temperature at which water (or any substance) boils is the maximum temperature to which it can be raised.
Steam is always at more than 100 deg C.
Molecules are breaking up on boiling and reforming on condensing during the state change of matter.
Freezing always occurs at cold temperatures and boiling occurs at hot temperatures.
Freezing and boiling are examples of chemical reactions; a phase change is a kind of chemical reaction.
Intra-molecular bonds are broken when substances change phase.
Freezing must occur at “cold” temperatures, boiling at “hot” temperatures, without

regard for the substance involved.
3. Condensing
Students stated that the plane which was hold above of the boiling kettle had become sweaty or simply wet.
Some students believe that the steam turns back into water.
Some students believe that the oxygen and hydrogen recombine to form water.
Water condensing on the outside surface of a sealed class jar containing ice comes through the glass.
Water condensing on the outside surface of a sealed class jar containing ice formed due to the coldness that comes through the glass.
Water condensing on the outside surface of a sealed class jar containing ice formed due to the cold surface and dry air (oxygen and hydrogen) react to form water.
Water condensing on the outside surface of a sealed class jar containing ice formed due to the water in the air sticks to the glass.
Drops of water on the outside of a cold bottle of water come from inside the bottle.
Drops of water on the outside of a bottle are made by the cold
Drops of water on the outside of a cold bottle are from hydrogen or oxygen combining.
4. Melting
The temperature of the ice melting on a teaspoon is above its melting temperature.
Failure to understand that ice and water stay at the same temperature while the ice melts
The ice or the cold water from the ice prevented the water's temperature from rising during the process of melting.
The reason for constant temperature is due to the thermometer being in the ice cube in the process of melting.
6. Particulate nature of matter
Students confuse melting with evaporation during explaining what happens to ice when the temperature of ice removed from -10 ^{o}C to -1 ^{o}C.
Students confuse changing of state with dissolving during explaining what happens to ice when the temperature of ice removed from -10 ^{o}C to -1 ^{o}C.
The particles take in the heat and begin to expand when the temperature of ice removed from -10 ^{o}C to -1 ^{o}C.
When a block of ice taken out of a freezer the sudden change of temperature reacts on particles making them decrease in size.
Atoms in solids have properties different from atoms in vapors
Atoms in solids have properties different from atoms in liquids
Molecules in solids are slow, molecules in liquids faster, and in a gas they just zip around**.**
7. Solid and Liquid
If substances could be held, were rigid etc. children (14-15 years old) classify these substances as solid objects.
Substances which had no shape, could be kneaded, or could be easily melted, or were powders are not classified appropriately as solid or liquid.

Students believed that the weight increases when a liquid changes into a solid.
Students claim the weight decreases in a solid changes into a liquid.
If ice is melted the resulting water will weigh less.
A sealed container with a bit of liquid in it weighs less after the liquid has evaporated.
Water molecules are largest and heaviest when in the solid phase.
8. Dissolving
The meaning of “dissolving” has been referred to outside action such as stirring, mixing, and in some cases heating or to dissolve means to mix.
When sugar is dissolved in water young children think that sugar disappears so mass of water would not change.
Students generally believe that sugar disappears, liquefies, reduces to smaller sized pieces or mixes with water when it is stirred with a solvent such as water.
Mass of sugar and water solution is less than mass of the sugar and water.
When students are asked to explain what happened to sugar; students respond by using the word ‘melting’. Students generally use the process of melting and dissolving interchangeably.
Students think dissolving as a chemical reaction. When sugar is added to the water some type of chemical reaction or combination is taking place.
Sugar breaks down into its ions or elements during the process of dissolving in water.
Salt becomes liquid salt when it dissolves.
Students generally do not take into account conservation of mass on dissolving.
Sugar becomes a liquid in dissolving, and so weighs less. Dissolving is viewed as a process of a solid transforming into a liquid form.
Salt, sugar disappears in dissolving.
Dissolved sugar has no mass.
A high temperature or stirring are necessary for dissolving.
The everyday and scientific meaning of the word “particle” is not differentiated by students.
Sugar particles floated or sank at the bottom of the beaker instead of evenly mixing.
Water absorbed the sugar similar to the action of a sponge.
Students used the term “solute” and “solvent” interchangeably and students generally referred sugar as “sugar atoms”.
When sugar is dissolved in water it takes on properties of the water.
Salt is not hard (or dense) enough to resist dissolving.
9. Saturated solutions
Concentration of a saturated solution increases as water evaporates.
Concentration of a saturated solution decreases as water evaporates.
Diluting fruit juice by adding water is a chemical change.
Students believed that if the solute is broken in tiny pieces, it will dissolve in the solvent. Size of the solute is only the necessary thing to dissolve in a solvent.
A strong solution of a salt contains more of that salt than a weak solution, without regard to the quantity of solution.
Lowering melting (freezing) point
The weigh of the salt on the surface of the ice disrupts the lattice structure and the ice

melts.
The weigh of the salt on the ice surface generates heat to melt some of the ice.
When you put salt (or anything really) on the ice, it disrupts the crystal structure of the ice.

APPENDIX B

MADDENİN YOĞUN FAZLARI VE ÇÖZÜNÜRLÜK KAVRAM TESTİ

Soru 1

1. durum: Kapalı bir kap (1. kap) içerisinde bir miktar su ısıtılıyor ve suyun tamamen buhar haline geldiği gözleniyor.

2. durum: Kapalı bir kap (2. kap) içerisinde bir miktar su soğutularak buz haline getiriliyor.

1. ve 2. durumlarda kapların ağılıkları için ne söylenebilir?

	1. KAP	2. KAP
A	AZALIR	DEĞİŞMEZ
B	AZALIR	ARTAR
C	DEĞİŞMEZ	DEĞİŞMEZ
D	DEĞİŞMEZ	ARTAR

Neden?

Soru 2

Erzurum'da (yaklaşık rakım: 1500m) ve İzmir'de (deniz seviyesi) kaynatılan eşit miktar su hakkında aşağıda verilen yargılardan hangisi **doğrudur**?

A) Erzurum'da su daha yüksek sıcaklıkta kaynar.

B) Yemek Erzurum'da daha çabuk pişer.

C) İzmir'de su daha yüksek sıcaklıkta kaynar.

D) Su her iki ilimizde de aynı sıcaklıkta kaynar.

Neden?

Soru 3

Saf bir maddenin, hal değişimleri sırasında sıcaklık nasıl değişir?

A) Kaynama sırasında gittikçe yükselir ve donma sırasında gittikçe düşer.

B) Kaynama sırasında hafifçe düşer ve donma sırasında hafifçe yükselir.

C) Etrafın sıcaklığına göre düşer veya yükselir.

D) Çevresel basınca göre düşer veya yükselir.

E) Hal değişimi tamamlanana kadar değişmez.

Soru 4

Aşağıdakilerden hangisi bir sıvının kaynama noktasını etkilemez?

A) Atmosfer basıncı

B) Sıvının türü

C) Sıvının saflık derecesi

D) Yüzeye uygulanan basınç

E) Sıvının miktarı

Soru 5

Bir çaydanlıkta veya başka bir kapta kaynayan su izlendiğinde, suda büyük balonlar veya kabarcıklar görülür. Bu balonlar neden oluşmaktadır?

A) Hava

B) Isı

C) Buhar

D) Oksijen ve Hidrojen

E) Oksijen ve Karbondioksit

Soru 6

Sıcak bir yaz günü, bir pastanenin terasındaki kumaş gölgeliğin nemli tutulması,

A) Çok kötü bir fikir, çünkü ıslak kumaş daha fazla ısı çekeceğinden bir süre sonra, kumaş gölgelikteki ısınan suyun etkisi ile gölgeliğin altı daha fazla ısınacaktır.

B) Çok iyi bir fikir, çünkü suyun buharlaşması kumaşı soğutacak ve böylece kumaşın altı daha serin olacaktır.

C) İyi bir fikir değil, çünkü ısılatılan kumaşın sıcaklık değişimine etkisi olmayacaktır.

D) İyi bir fikir değil, kumaş değilde naylon bir gölgelik olsa etkili olabilirdi.

Soru 7

Dolaptan çıkan iyice soğumuş bir kola şişesinin dış yüzeyinde oluşan su damlacıklarının sebebi nedir?

A) İçecekteki su molekülleri şişenin yüzeyinden geçerek dışarı ulaşmıştır.

B) Şişenin dış yüzeyindeki su damlacıkları şişenin terlemesi sonucunda oluşmuştur.

C) Şişenin soğuk yüzeyi ve hava, oksijen ve hidrojeni birleştirmek için tepkimeye girerler.

D) Havada bulunan su buharı soğuk şişenin yüzeyinde yoğunlaşmıştır.

Soru 8

-10 ^{o}C de bir kabın içerisinde bir miktar buz ısıtılarak önce su haline getiriliyor ve daha sonra elde edilen bu suya ısı verilmeye devam edilerek kaynaması gözlemleniyor. Kaynayan su tamemen yok oluncaya kadar ısı verme işlemi devam ediyor. Bu süreç için aşağıda verilen yargılardan hangisi **doğrudur**?

A) Kaynayan su duman haline gelip yok olmuştur.

B) Başlangıçta buzun içersinde bulunan atomlarla sürecin sonunda oluşan su buharındaki atomlar birbirinden farklıdır.

C) Katının içerisinde bulunan atomlarla sıvının içerisinde bulunan atomlar birbirlerinin aynıdır.

D) Buzda bulunan moleküller sert ve donmuş bir haldedir.

Soru 9

Kapalı bir kaptaki sıvının buhar basıncını aşağıdakilerden hangisi etkiler?

A) Atmosfer basıncı

B) Kabın hacmi

C) Kabın şekli

D) Sistemin sıcaklığı

E) Kaptaki sıvı miktarı

Neden?

Soru 10

Bir kalorimetrenin içerisindeki suyun miktarı 100 ml ve sıcaklğı 48 ^{0}C dir. Bu kalorimetreye bir miktar buz atıldığında kalorimetredeki suyun sıcaklığı 4 ^{0}C ye düşüyor. Buzun erime ısısı 88 cal/g olduğuna göre kalorimetrenin içerisine kaç g buz atılmıştır? (C_{su}: 1 cal/g.C ve suyun kütlesi için **1ml = 1g** alınacak)

A) 25 B) 50 C) 75 D) 100 E) 125

Soru 11

Bir sınıfta öğretmen, bir beher içerisinde bir miktar tuzu bir miktar su içerisinde çözüyor ve doymamış tuzlu su çözeltisi elde ediyor. Bu çözelti hakkında öğrenciler bazı yorumlar yapıyorlar. Bu yorumlardan hangisi veya hangileri **doğrudur**?

I. Ahmet “Katı haldeki tuz çözününce sıvı olmuştur” diyor.

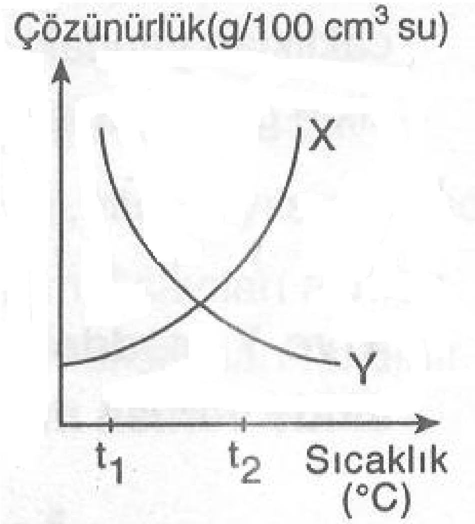
II. Pınar “Tuz erimiştir ve sıvı hale geçmiştir” diyor.

III. Ebru “Tuz yeterince sert ve yoğun bir madde olmadığından dolayı çözünme çabucak gerçekleşmiştir” diyor.

IV. Emre "Çözeltiye tuz ilave edilmeye devam edilirse belli miktar ilaveden sonra çözünme olmayacaktır"diyor.

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

Soru 12



Çözünürlük ve sıcaklık değişimi yukarıdaki şekilde verilen X ve Y maddelerinin, t_1 sıcaklığındaki **doymuş çözeltileri** t_2 sıcaklığına getirilirse, molar derişimler nasıl değişir (genleşme ihmal edilecek)?

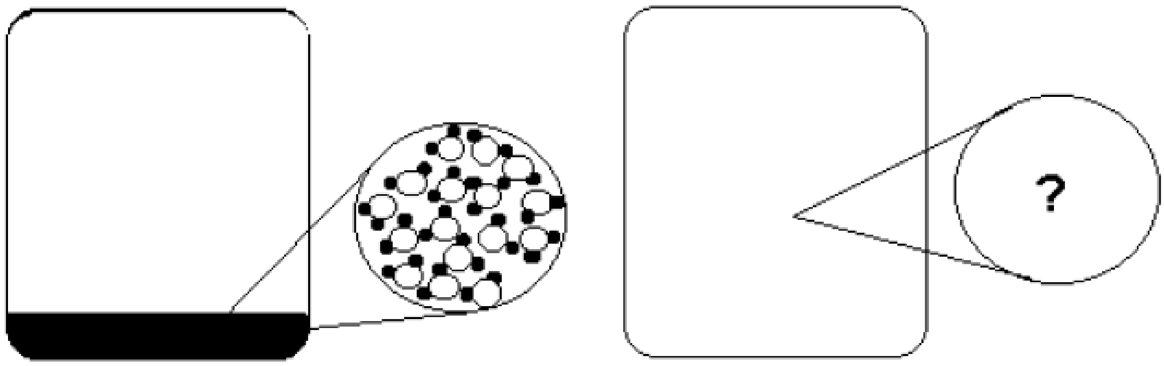
	X	Y
A	ARTAR	ARTAR
B	AZALIR	ARTAR
C	DEĞİŞMEZ	AZALIR
D	ARTAR	AZALIR
E	DEĞİŞMEZ	DEĞİŞMEZ

Soru 13

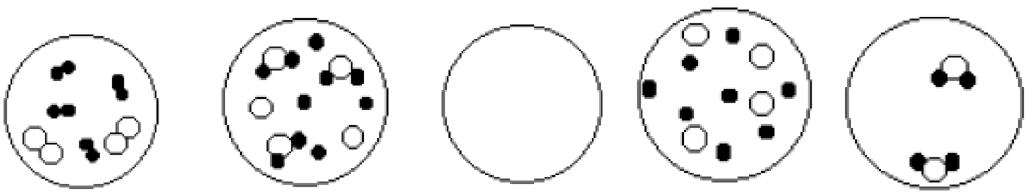
Şekil 1'deki dairede kapalı kapta bulunan suyun çok küçük bir kısmının büyütülmüş hali görülmektedir. Şekil 2'deki dairede su buharlaştıktan sonraki görünümü hangi seçenekte doğru verilmiştir?

Semboller: su Oksijen Hidrojen

Şekil 1 Şekil 2



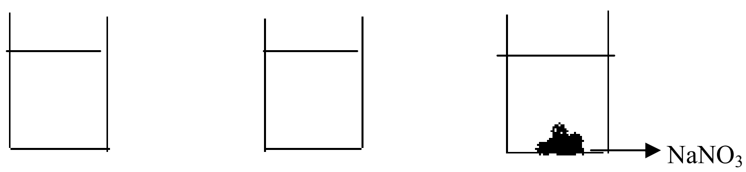
Su Su Buharı



A B C D E

Soru 14

I **II** **III**



Doymamış $NaNO_3$ çözeltisi Doymuş $NaNO_3$ çözeltisi Doymuş $NaNO_3$ çözeltisi

Yukarıdaki kaplarda aynı sıcaklıkta eşit hacimde $NaNO_3$ çözeltileri vardır. Bu çözeltiler için yapılan yorumlardan hangisi **yanlıştır**?

A) Çözünmüş madde miktarı en fazla olan III. çözeltidir

B) İyon derişimi en az olan I. çözeltidir.

C) III. çözeltinin sıcaklığını artırırsak, çokmüş olan $NaNO_3$ çözülebilir.

D) I. çözeltide bir miktar daha $NaNO_3$ çözülebilir.

Neden?

Soru 15

50 gr şeker 200 ml su içerisinde çözülerek, şekerli su çözeltisi elde ediliyor. Bu çözelti için aşağıdaki seçeneklerde verilenlerden hangisi veya hangileri **doğrudur**?

I. Şeker eriyerek sıvı hale dönüştüğü için çözeltinin ağırlığı azalmıştır.

II. Çözünen şekerin kütlesi yoktur.

III. Şekerin su içerisisnde çözünmesi kimyasal bir değişimdir.

IV. Çözünmüş olan şekeri birtakım yöntemler ile çözeltiden ayırmak mümkündür.

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

Soru 16

Kütlece %2.4 lük sodyum asetat ($NaC_2H_3O_2$) içeren, 425 g sodyum asetat sulu çözeltisi hazırlamak için kaç g sodyum asetat, kaç g su içerisinde çözünmelidir?

Çözüm:

Soru 17

A **B**

250 ml
Doymuş tuzlu su çözeltisi

500 ml
Doymamış tuzlu su çözeltisi

Aynı sıcakılıktaki A ve B çözeltileri için yapılan aşağıdaki yorumlardan hangisi veya hangileri **yanlıştır**?

I. Aynı sıcaklıkta A çözeltisi içerisindeki suyun bir kısmı buharlaşırsa bu çözeltinin tuz konsantrasyonu artar.

II. A çözeltisi B çözeltisine göre daha güçlü bir tuzlu su çözeltisidir.

III. A çözeltisinin üzerine eklenecek bir miktar su ile doymamış tuzlu su çözeltisine dönüşmesi kimyasal bir değişimdir.

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

Soru 18

1 atm basınç altında 250 g suda 22,25 g $CaCl_2$ çözünüyor. Elde edilen sulu çözeltinin kaynama noktasını bulunuz ($CaCl_2$: 111 ve K_k(su) : 0,51).

Çözüm:

Soru 19

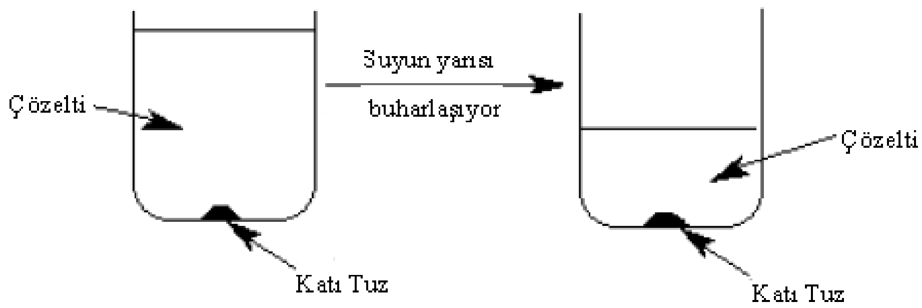
250 ml 0,1 molar $CuSO_4$ çözeltisi hazırlamak için 1 molarlık $CuSO_4$ çözeltisinden kaç ml almak gereklidir?

A) 2,5 ml B) 25 ml C) 5 ml D) 50 ml

Soru 20

Bir miktar tuz, suyun içerisine eklenerek karıştırılıyor.Tuz ekleme işlemine daha fazla tuz çözünmeyinceye ve biraz tuz çökene kadar devam ediliyor. Elde edilen çözeltinin hacminin yarısı kalana kadar su buharlaştığında çözeltideki tuz konsantrasyonu nasıl değişir? (Sıcaklık sabit)

1. Çözelti **2. Çözelti**



A) Artar B) Azalır C) Aynı kalır

Soru 21
Yukarıdaki soruya verdiğiniz yanıtın sebebi nedir?

A) 2. çözeltinin içerisinde 1. çözelti ile aynı miktarda tuz vardır.

B) 2. kapta daha fazla tuz çöker.

C) 2. kapta tuz buharlaşmaz ve çözelti içerisinde kalır.

D) 2. kapta daha az su vardır.

Soru 22

Bir beher içerisinde bir miktar tuz, bir miktar su içerisinde çözülüyor. Bu çözelti için aşağıdaki yargılardan hangisi veya hangileri **yanlıştır**?

I. Tuz ezilip karıştırılmadan suda bekletildiğinde çözünmez..

II. Su tuzu çözebilecek güce sahiptir ama tebeşiri çözebilecek gücü yoktur.

III. Çözeltide bulunan tuzu fiziksel yollarla sudan ayırmak mümkündür.

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

APPENDIX C

ÖĞRENMEDE GÜDÜSEL STRATEJİLER ANKETİ

Bu anket iki kısımdan oluşmaktadır. İlk kısımda kimya dersine karşı tutumunuzu, motivasyonunuzu, ikinci kısımda ise kimya dersinde kullandığınız öğrenme stratejileri ve çalışma becerilerini belirlemeye yönelik ifadeler yer almaktadır. Cevap verirken aşağıda verilen ölçeği gözönüne alınız. **Eğer ifadenin sizi tam olarak yansıttığını düşünüyorsanız, 7' yi yuvarlak içine alınız. Eğer ifadenin sizi hiç yansıtmadığını düşünüyorsanız, 1' yi yuvarlak içine alınız. Bu iki durum dışında ise 1 ve 7 arasında sizi en iyi tanımladığını düşündüğünüz numarayı yuvarlak içine alınız.** Unutmayın Doğru ya da Yanlış cevap yoktur yapmanız gereken sizi en iyi tanımlayacak numarayı yuvarlak içine almanızdır.

1 --- 2 --- 3 --- 4 --- 5 --- 6 -- 7
beni hiç yansıtmıyor — beni tam olarak yansıtıyor

A. Motivasyon (Güdülenme)

	beni hiç yansıtmıyor				olarak		beni tam yansıtıyor
1. Kimya dersinde yeni bilgiler öğrenebilmek için, büyük bir çaba gerektiren sınıf çalışmalarını tercih ederim.	1	2	3	4	5	6	7
2. Eğer uygun şekilde çalışırsam, kimya dersindeki konuları öğrenebilirim.	1	2	3	4	5	6	7
3. Kimya sınavları sırasında, diğer arkadaşlarıma göre soruları ne kadar iyi yanıtlayıp yanıtlayamadığımı düşünürüm	1	2	3	4	5	6	7
4. Kimya dersinde öğrendiklerimi başka derslerde de kullanabileceğimi düşünüyorum.	1	2	3	4	5	6	7
5. Kimya dersinden çok iyi bir not alacağımı düşünüyorum.	1	2	3	4	5	6	7
6. Kimya dersi ile ilgili okumalarda yer alan en zor konuyu bile anlayabileceğimden eminim.	1	2	3	4	5	6	7
7. Benim için şu an kimya dersi ile ilgili en tatmin edici şey iyi bir not getirmektir	1	2	3	4	5	6	7
8. Kimya sınavları sırasında bir soru üzerinde uğraşırken, aklım sınavın diğer kısımlarında yer alan cevaplayamadığım sorularda olur	1	2	3	4	5	6	7
9. Kimya dersindeki konuları **öğrenemezsem** bu benim hatamdır.	1	2	3	4	5	6	7
10.Kimya dersindeki konuları öğrenmek benim için önemlidir	1	2	3	4	5	6	7
11. Genel not ortalamamı yükseltmek şu an benim için en önemli şeydir, bu nedenle kimya dersindeki temel amacım iyi bir not getirmektir.	1	2	3	4	5	6	7
12. Kimya dersinde öğretilen temel kavramları öğrenebileceğimden eminim.	1	2	3	4	5	6	7
13. Eğer başarabilirsem, kimya dersinde sınıftaki pek çok öğrenciden daha iyi bir not getirmek isterim	1	2	3	4	5	6	7
14. Kimya sınavları sırasında bu dersten başarısız olmanın sonuçlarını aklımdan geçiririm	1	2	3	4	5	6	7
15. Kimya dersinde, öğretmenin anlattığı en karmaşık konuyu anlayabileceğimden eminim.	1	2	3	4	5	6	7
16. Kimya derslerinde öğrenmesi zor olsa bile, bende merak uyandıran sınıf çalışmalarını tercih ederim.	1	2	3	4	5	6	7
17. Kimya dersinin kapsamında yer alan konular çok ilgimi çekiyor.	1	2	3	4	5	6	7

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

B. Öğrenme Stratejileri

	beni hiç yansıtmıyor					olarak	beni tam yansıtıyor
32. Kimya dersi ile ilgili birşeyler okurken, düşüncelerimi organize etmek için konuların ana başlıklarını çıkarırım.	1	2	3	4	5	6	7
33. Kimya dersi sırasında başka şeyler düşündüğüm için önemli kısımları sıklıkla kaçırırım.	1	2	3	4	5	6	7
34. Kimya dersine çalışırken çoğu kez arkadaşlarıma konuları açıklamaya çalışırım.	1	2	3	4	5	6	7
35. Genelde, ödevlerime rahat konsantre olabileceğim bir yerde çalışırım.	1	2	3	4	5	6	7
36. Kimya dersi ile ilgili birşeyler okurken, okuduklarıma odaklanabilmek için sorular oluştururum.	1	2	3	4	5	6	7
37. Kimya dersine çalışırken kendimi çoğu zaman o kadar isteksiz ya da o kadar sıkılmış hissederim ki, planladıklarımı **tamamlamadan** çalışmaktan vazgeçerim.	1	2	3	4	5	6	7
38. Kimya dersiyle ilgili duyduklarımı ya da okuduklarımı ne kadar gerçekçi olduklarına karar vermek için sıklıkla sorgularım.	1	2	3	4	5	6	7
39. Kimya dersine çalışırken, önemli bilgileri içimden defalarca tekrar ederim	1	2	3	4	5	6	7

40. Kimya dersinde bir konuyu anlamakta zorluk çeksem bile hiç kimseden yardım almaksızın kendi kendime çalışırım.	1	2	3	4	5	6	7
41. Kimya dersi ile ilgili birşeyler okurken bir konuda kafam karışırsa, başa döner ve anlamak için çaba gösteririm.	1	2	3	4	5	6	7
42. Kimya dersine çalışırken, daha önce okuduklarımı ve aldığım notları gözden geçirir ve en önemli noktaları belirlemeye çalışırım.	1	2	3	4	5	6	7
43. Kimya dersine çalışmak için ayırdığım zamanı iyi değerlendirebiliyorum.	1	2	3	4	5	6	7
44.Eğer kimya dersi ile ilgili okumam gereken konuları anlamakta zorlanıyorsam, okuma stratejimi değiştiririm.	1	2	3	4	5	6	7
45. Kimya dersinde verilen ödevleri tamamlamak için sınıftaki diğer öğrencilerle çalışırım.	1	2	3	4	5	6	7
46. Kimya dersine çalışırken, dersle ilgili okumaları ve ders sırasında aldığım notları defalarca okurum	1	2	3	4	5	6	7
47. Ders sırasında veya ders için okuduğum bir kaynakta bir teori, yorum ya da sonuç ifade edilmiş ise, bunları destekleyen bir bulgunun var olup olmadığını sorgulamaya çalışırım.	1	2	3	4	5	6	7
48. Kimya dersinde yaptıklarımızdan **hoşlanmasam bile** başarılı olabilmek için sıkı çalışırım.	1	2	3	4	5	6	7
49. Dersle ilgili konuları organize etmek için basit grafik, şema ya da tablolar hazırlarım.	1	2	3	4	5	6	7
50. Kimya dersine çalışırken konuları sınıftaki arkadaşlarımla tartışmak için sıklıkla zaman ayırırım	1	2	3	4	5	6	7
51. Kimya dersinde işlenen konuları bir başlangıç noktası olarak görür ve ilgili konular üzerinde kendi fikirlerimi oluşturmaya çalışırım.	1	2	3	4	5	6	7
52. Çalışma planına bağlı kalmak benim için zordur.	1	2	3	4	5	6	7
53. Kimya dersine çalışırken, dersten, okuduklarımdan, sınıf içi tartışmalardan ve diğer kaynaklardan edindiğim bilgileri biraraya getiririm.	1	2	3	4	5	6	7
54. Yeni bir konuyu detaylı bir şekilde çalışmaya başlamadan önce çoğu kez konunun nasıl organize edildiğini anlamak için ilk olarak konuyu hızlıca gözden geçiririm.	1	2	3	4	5	6	7
55. Kimya dersinde işlenen konuları anladığımdan emin olabilmek için kendi kendime sorular sorarım.	1	2	3	4	5	6	7
56. Çalışma tarzımı, dersin gereklilikleri ve öğretmenin öğretme stiline uygun olacak tarzda değiştirmeye çalışırım.	1	2	3	4	5	6	7
57. Genelde derse gelmeden önce konuyla ilgili birşeyler okurum fakat okuduklarımı çoğunlukla **anlamam**	1	2	3	4	5	6	7
58. İyi anlamadığım bir konuyu öğretmenimden açıklamasını isterim.	1	2	3	4	5	6	7
59. Kimya dersindeki önemli kavramları hatırlamak için anahtar kelimeleri ezberlerim.	1	2	3	4	5	6	7
60. Eğer bir konu zorsa ya çalışmaktan vazgeçerim ya da yalnızca kolay kısımlarını çalışırım	1	2	3	4	5	6	7
61. Kimya dersine çalışırken, konuları sadece okuyup geçmek yerine ne öğrenmem gerektiği konusunda düşünmeye çalışırım.	1	2	3	4	5	6	7
62. Mümkün olduğunca kimya dersinde öğrendiklerimle diğer derslerde öğrendiklerim arasında bağlantı kurmaya çalışırım.	1	2	3	4	5	6	7
63. Kimya dersine çalışırken notlarımı gözden geçirir ve önemli kavramların bir listesini çıkarırım.	1	2	3	4	5	6	7

64. Kimya dersi için birşeyler okurken, o anda okuduklarımla daha önceki bilgilerim arasında bağlantı kurmaya çalışırım.	1	2	3	4	5	6	7
65. Ders çalışmak için devamlı kullandığım bir yer (oda vs.) vardır	1	2	3	4	5	6	7
66. Kimya dersinde öğrendiklerimle ilgili ortaya çıkan fikirlerimi sürekli olarak gözden geçiremeye çalışırım.	1	2	3	4	5	6	7
67. Kimya dersine çalışırken, dersle ilgili okuduklarımı ve derste aldığım notları inceleyerek önemli noktaların özetini çıkarırım.	1	2	3	4	5	6	7
68. Kimya dersinde bir konuyu anlayamazsam sınıftaki başka bir öğrenciden yardım isterim.	1	2	3	4	5	6	7
69. Kimya dersiyle ilgili konuları, ders sırasında öğrendiklerim ve okuduklarım arasında bağlantılar kurarak anlamaya çalışırım.	1	2	3	4	5	6	7
70. Kimya derslerinde verilen ödevleri ve derse ilgili okumaları zamanında yaparım.	1	2	3	4	5	6	7
71. Kimya dersindeki konularla ilgili bir iddia ya da varılan bir sonucu her okuduğumda veya duyduğumda olası alternatifler üzerinde düşünürüm	1	2	3	4	5	6	7
72. Kimya dersinde önemli kavramların listesini çıkarır ve bu listeyi ezberlerim.	1	2	3	4	5	6	7
73. Kimya derslerini düzenli olarak takip ederim	1	2	3	4	5	6	7
74. Konu çok sıkıcı olsa da, ilgimi **çekmese** de konuyu bitirene kadar çalışmaya devam ederim.	1	2	3	4	5	6	7
75. Gerektiğinde yardım isteyebileceğim arkadaşlarımı belirlemeye çalışırım.	1	2	3	4	5	6	7
76. Kimya dersine çalışırken iyi anlamadığım kavramları belirlemeye çalışırım.	1	2	3	4	5	6	7
77. Başka faaliyetlerle uğraştığım için çoğu zaman kimya dersine yeterince zaman ayıramıyorum	1	2	3	4	5	6	7
78. Kimya dersine çalışırken, çalışmalarımı yönlendirebilmek için kendime hedefler belirlerim.	1	2	3	4	5	6	7
79. Ders sırasında not alırken kafam karışırsa, notlarımı dersten sonra düzenlerim.	1	2	3	4	5	6	7
80. Kimya sınavından önce notlarımı ya da okuduklarımı gözden geçirmek için fazla zaman **bulamam**.	1	2	3	4	5	6	7
81. Kimya dersinde, okuduklarımdan edindiğim fikirleri sınıf içi tartışma gibi çeşitli faaliyetlerde kullanmaya çalışırım.	1	2	3	4	5	6	7

APPENDIX D

KİMYA DERSİ TUTUM ÖLÇEĞİ

AÇIKLAMA**:** Bu ölçekte, Kimya dersine ilişkin tutum cümleleri ile her cümlenin karşısında "Tamamen Katılıyorum", "Katılıyorum", "Kararsızım", "Katılmıyorum" ve "Hiç Katılmıyorum" olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

			Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1.	Kimya çok sevdiğim bir alandır	......	○	○	○	○	○
2.	Kimya ile ilgili kitapları okumaktan hoşlanırım	......	○	○	○	○	○
3.	Kimyanın günlük yaşantıda çok önemli yeri yoktur	......	○	○	○	○	○
4.	Kimya ile ilgili ders problemlerini çözmekten hoşlanırım	......	○	○	○	○	○
5.	Kimya konularıyla ilgili daha çok şey öğrenmek isterim	......	○	○	○	○	○
6.	Kimya dersine girerken sıkıntı duyarım	......	○	○	○	○	○
7.	Kimya derslerine zevkle girerim	......	○	○	○	○	○
8.	Kimya derslerine ayrılan ders saatinin daha fazla olmasını isterim	......	○	○	○	○	○
9.	Kimya dersini çalışırken canım sıkılır	......	○	○	○	○	○
10.	Kimya konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim	......	○	○	○	○	○

			Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
11.	Düşünce sistemimizi geliştirmede Kimya öğrenimi önemlidir	......	◯	◯	◯	◯	◯
12.	Kimya, çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir	......	◯	◯	◯	◯	◯
13.	Dersler içinde Kimya dersi sevimsiz gelir	......	◯	◯	◯	◯	◯
14.	Kimya konularıyla ilgili tartışmaya katılmak bana cazip gelmez	......	◯	◯	◯	◯	◯
15.	Çalışma zamanımın önemli bir kısmını Kimya dersine ayırmak isterim	......	◯	◯	◯	◯	◯

APPENDIX E

BİLİMSEL İŞLEM BECERİ TESTİ

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

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

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

a. Her oyuncunun almış olduğu günlük vitamin miktarını.

b. Günlük ağırlık kaldırma çalışmalarının miktarını.

c. Günlük antrenman süresini.

d. Yukarıdakilerin hepsini.

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

a. Arabaların benzinleri bitinceye kadar geçen süre ile.

b. Her arabanın gittiği mesafe ile.

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

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

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

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

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

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

c. Büyük evlerin ısınma giderleri fazladır.

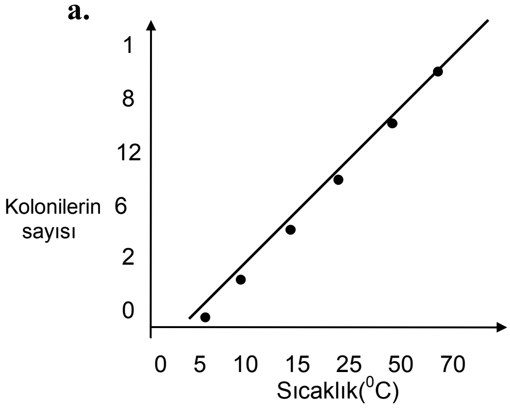
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

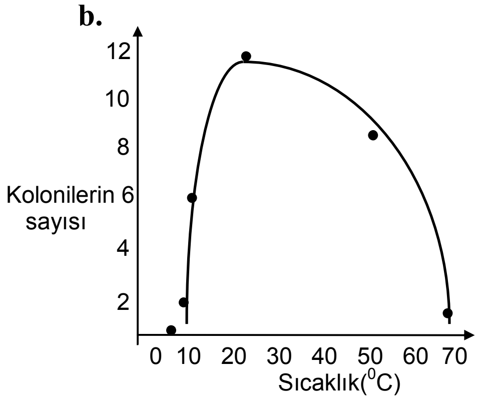
Deney odasının sıcaklığı (^0C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

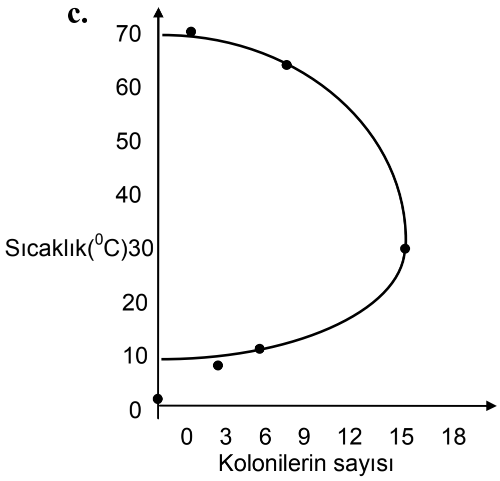
a.



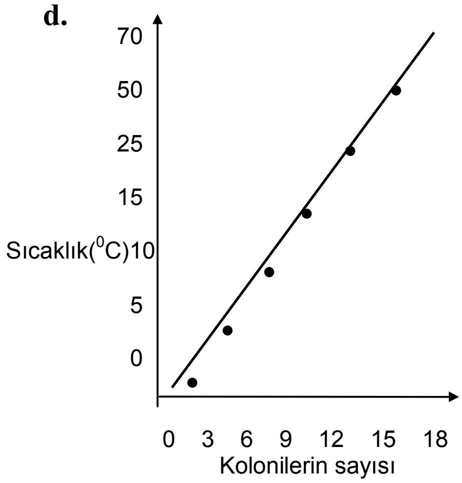
b.



c.



d.



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

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

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

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

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

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

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

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

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

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

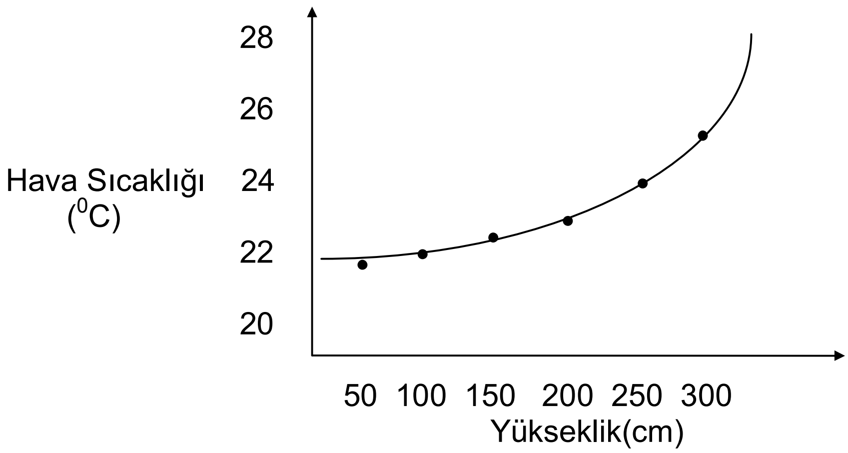
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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

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

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

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



a. Yükseklik arttıkça sıcaklık azalır.

b. Yükseklik arttıkça sıcaklık artar.

c. Sıcaklık arttıkça yükseklik azalır.

d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

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

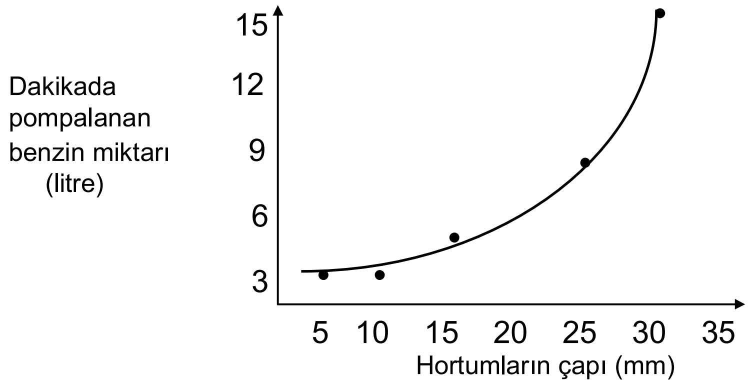
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

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

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

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

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

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

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

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

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

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

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

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

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

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

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

c. Güneş farklı maddeleri farklı derecelerde ısıtır.

d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

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

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gübrenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

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

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

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

17. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

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

a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.

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

c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.

d. Her alana ektiği tohum sayısına bakar.

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

a. Kullanılan toz ya da spreyin miktarı ölçülür.

b. Toz ya da spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.

c. Her fidede oluşan kabağın ağırlığı ölçülür.

d. Bitkilerin üzerinde kalan bitler sayılır.

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

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

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

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

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

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

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

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

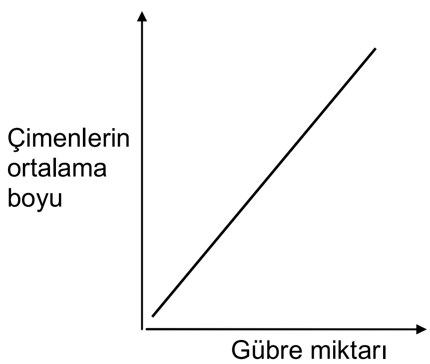
d. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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

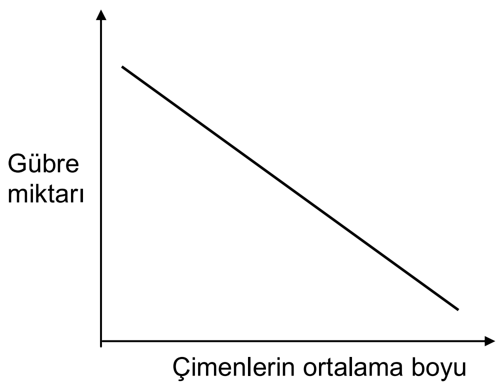
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

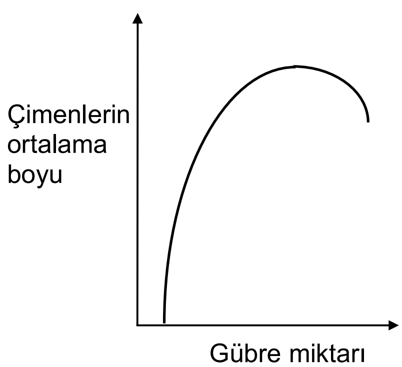
a.



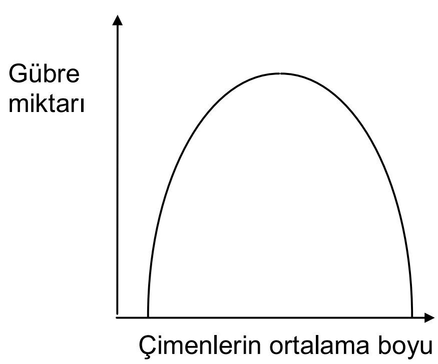
b.



c.



d.



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

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Hergün fareleri tartar.

d. Hergün farelerin yiyeceği vitaminleri tartar.

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

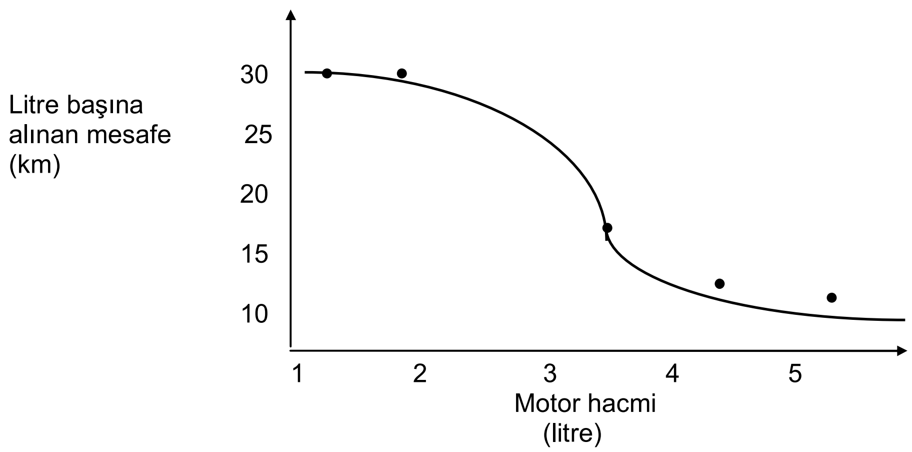
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

b. Su soğudukça, şekeri çözebilmek için daha fazla karıştırmak gerekir.

c. Su ne kadar sıcaksa, o kadar çok şeker çözünecektir.

d. Su ısındıkça şeker daha uzun sürede çözünür.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

a. Motor ne kadar büyükse, bir litre benzinle gidilen mesafe de o kadar uzun olur.

b. Bir litre benzinle gidilen mesafe ne kadar az olursa, arabanın motoru o kadar küçük demektir.

c. Motor küçüldükçe, arabanın bir litre benzinle gidilen mesafe artar.

d. Bir litre benzinle gidilen mesafe ne kadar uzun olursa, arabanın motoru o kadar büyük demektir.

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

Toprağa karıştırılan yaprakların domates üretimine etkisi araştırılmaktadır. Araştırmada dört büyük saksıya aynı miktarda ve tipte toprak konulmuştur. Fakat birinci saksıdaki torağa 15 kg., ikinciye 10 kg., üçüncüye ise 5 kg. çürümüş yaprak karıştırılmıştır. Dördüncü saksıdaki toprağa ise hiç çürümüş yaprak karıştırılmamıştır.

Daha sonra bu saksılara domates ekilmiştir. Bütün saksılar güneşe konmuş ve aynı miktarda sulanmıştır. Her saksıdan eled edilen domates tartılmış ve kaydedilmiştir.

29. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı.

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı.

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

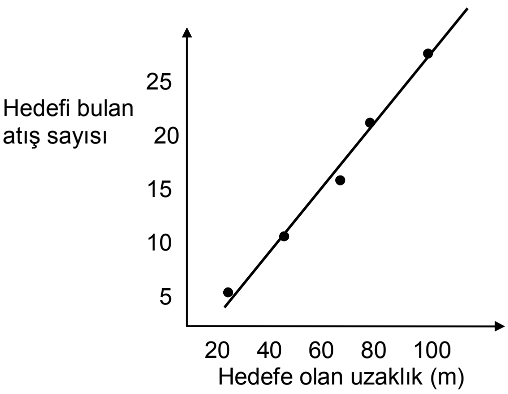
d. Çekilen demir tozlarının ağırlığı ile.

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

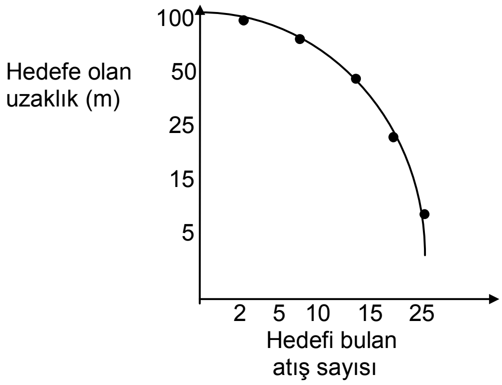
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

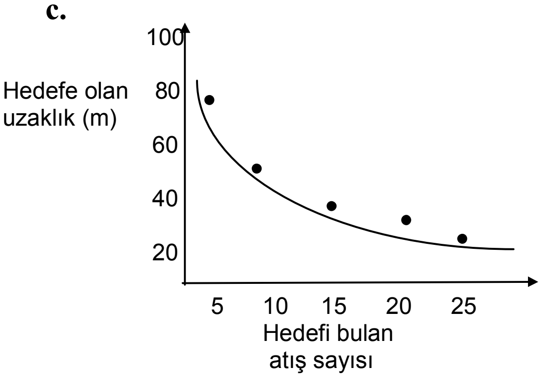
a.



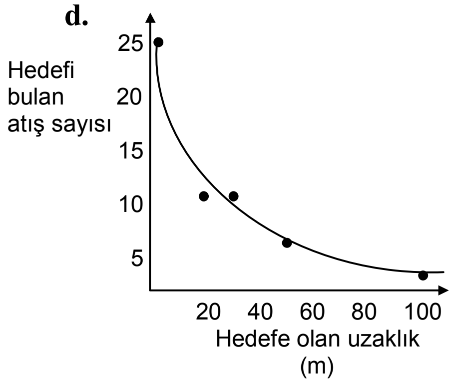
b.



c.



d.



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

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

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

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

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

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

a. TV'nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c.

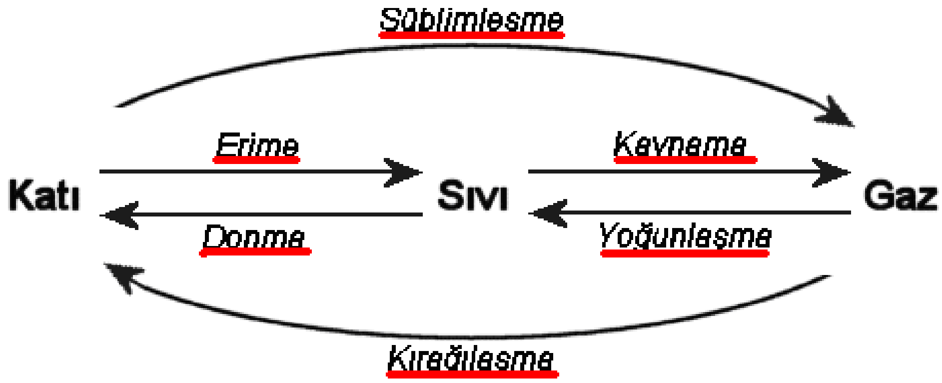
APPENDIX F

ACTIVITY 1

ERİME, ERİME ISISI - BUHARLAŞMA, BUHARLAŞMA ISISI

1. Girme Aşaması (Engagement):

Öğretmen konuya başlamadan önce öğrencilere aşağıdaki şekli vererek, oklar üzerindeki boşluklara (kırmızı ile altı çizili olan yerler) gelmesi gereken kavramları yazmalarını ister. Bunu yapmaktaki amaç öğrencilerin ön bilgilerini ortaya çıkarmaktır.



Öğretmen daha sonra günlük yaşamdan sorular sorarak öğrencilerin ilgisini konuya çekmeye çalışır.

Faz değişimi

- ✓ Erime, buharlaşma, yoğunlaşma ve donma olaylarına çevrenizden örnekler veriniz?
- ✓ Yapraklar üzerinde meydana gelen çiy ve kırağı nasıl oluşur? Kar atmosferde nasıl meydana gelir?

- ✓ Aynı miktarda katı ve sıvı yağı (aynı yağın katısı ve sıvısı) ayrı ayrı tavalarda özdeş iki ocakta yumurta pişirmek üzere ısıtttığımızı düşünelim. Hangi tavadaki yağ yumurtayı pişirmeye daha önce hazır olur? Neden?
- ✓ Kapalı bir kapta bir miktar buzu eritip su haline getirdiğimizde elde edilen suyun kütlesi ile buzun kütlesi arasında bir fark olur mu? Bu suya ısı verilip kapalı kapta tamemen gaz haline getirilirse kütlesi değişir mi?

Buhar basıncı ve kaynama noktası

- ✓ Kaynayan bir sıvının sıcaklığı ona ısı vermeye devam ettiğimiz halde neden hep aynı kalır?
- ✓ Normal bir tencerede mi yemek daha çabuk pişer, düdüklü tencerede mi daha çabuk pişer? Neden?
- ✓ İstanbul'da ve Van'da suyun kaynama sıcaklığı aynı mıdır? Neden?
- ✓ Bulaşıkları yıkadıktan sonra, bulaşıkların üzerindeki su damlacıklarının birkaç saat sonra yok olduğu görülmektedir? Bunun sebebi nedir?

Erime Isısı

- ✓ Kış günlerinde çatılardan sarkan buzların erimesi ısı alan (ekzotermik) yoksa ısı veren (endotermik) bir olay mıdır?
- ✓ Soğuk kış günlerinde kar yağdığı zaman havanın ısınmasının sebebi nedir?

2. Keşfetme aşaması (Exploration)

Buhar basıncı (gösteri)

1. İçi civa ile dolu olan bir kolona, bir damlatıcı ile alt taraftan birkaç damla su ilave edelim. Su damlacıkları, yoğunluğu civadan az olduğu için yukarı doğru hareket edeceklerdir ve cıvanın üzerinde su toplanacaktır. Başlangıçta civa kolonun üst seviyelerindeyken üzerine gelen bir miktar su ile h kadar aşağıya düşmüştür. Suyun üst tarafında meydana gelen boşluk neden kaynaklanmaktadır?

2. Bir erlenin içerisine 200 ml su konur ve bu erlenin ağzı hava almayacak şekilde plastik ve esnek bir balonla kapatılır. Erlen alt taraftan yavaş yavaş ısıtılır ve balonun şiştiği gözlemlenir. Balonun şişmesinin sebebi öğrenciler ile tartışılır.

Kaynama noktası ve Erime Noktası

-10 ^oC de bulanan bir miktar buz ile 5 ^oC de bulunan asetik asidin öğrenciler tarafından erime ve kaynama noktalarının tespit edilmesi istenir. Bu sırada öğrencilere sorular yöneltilir.

- ✓ Erime ve kaynama sırasında sıcaklık değişimi meydana geldi mi? Neden?
- ✓ İki maddenin erime ve kaynama sıcaklıkları aynı mı? Aynı olmamasının sebebi nedir?

Bir miktar buz dibi düz cam bir balon içerisine konularak ağzı tamamen kapatılır. İçerisinde buz olan bu balon tartılır ve kaç gr olduğu bir kenera yazılır. Sonra bu cam balona yavaş yavaş ısı verilerek beherin içerisindeki buz tamamen su haline getirilir. İçerisinde tamamen su oluşmuş cam balon tartılır ve bir kenara not edilir. Daha sonra içerisinde su olan cam balona ısı verilmeye devam ederek su tamamen gaz haline getirilir. İçerisinde su buharı olan cam balon tartılır ve elde edilen değer bir kenara yazılır.

Bu deney, küçük gruplar halinde öğrenciler tarafından gerçekleştirilir, deney sırasında öğrencilerden buzun ve suyun ağırlıklarının değişip değişmeyeceğini tahmin etmeleri istenir.

Erime ısısı

Her grupta 5 kişi olacak şekilde toplam 6 grup oluşturulur. Kalorimetrenin ne işe yaradığı öğrencilere anlatılır. Laboratuvarda yapılan basit kalorimetre öğrencilere tanıtılır. Her grupdaki öğrenciye bir adet basit kalorimetre verilir.

Kolorimetre deneyi

Kalorimetre: fiziksel ve kimyasal değişim sırasında emilen (absorbe edilen) veya açığa çıkan (salınan) ısı miktarını tespit etmek için kullandığımız bir araçtır.

Deney sırasında kolorimetredeki suyun sıcaklığının değişiminin kaydedilmesi ve gözlenmesi öğrencilerden istenir. Ve herbir gruba şu malzemeler dağıtılır.

1. 400 ml lik beher
2. 100 ml lik mezur (graduated cylinders)
3. termometre
4. kalorimetre (cofee-cup)
5. su ısıtıcısı (kettle)
6. karıştırıcı (termometre bu amaçlada kullanılabilir)

Deneye başlamadan önce öğrencilerden kolarimetre içerisinde ne kadar su kullanacakları, suyun başlangıç ve son sıcaklıklarının ne olacağını, kullanacakları buz miktarını belirlemeleri istenir.

Bir miktar su kettle ın içerisinde ısıtılarak kolrimetrenin içerisindeki behere konur ve kolarimetrede bu suyun miktarı ve sıcaklığı tespit edilir.

Kalorimetredeki suyun miktarı: 100 ml
Kalorimetredeki suyun sıcaklığı: 48 ^{o}C
Kalorimetredeki suyun kütlesi: 100 g

Bir miktar buz kalorimetrenin içerisine atılır ve yavaş yavaş karıştırılır. Buz tamamen eridikten sonra suyun son sıcaklığı ve kalorimetredeki suyun miktarı ölçülür.

Kalorimetredeki suyun son miktarı: 150 ml
Kolorimetredeki son sıcaklık: 4 ^{o}C
Daha sonra şu sorular gruplara verilir:

- ✓ 1 g buzu eritebilmek için gerekli olan ısı miktarını bu deneyde elde ettiğimiz verilerle bulabilirmiyiz?
- ✓ Erime sıcaklığı ve Erime ısısı aynı şeyi mi ifade eder?

3. Açıklama Aşaması (Explanation)

Öğrencilerden hal değişimi, erime, erime ısısı, buharlaşma, buharlaşma ısısı hakkında bildiklerini açıklamaları istenir. Bu açıklamaların ilk ve ikinci aşamada yapılan etkinliklerin temel alınarak yapılması öğrencilerden istenir. Öğretmen aşağıda anlatılan kavramların öğrenciler tarafından tam olarak bilinip bilinmediğini, öğrencilerin açıklamalarını irdeleyerek anlar. Eğer anlaşılmayan veya yanlış anlaşılan kavramlar varsa doğrudan anlatım yolu ile bunu gidermeye çalışır.

a. Faz değişimi

Bir madenin bir fazdan başka bir faza geçmesine hal değimi adı verilir.

Erime, bir maddenin katı halden sıvı hale geçmesidir. Örneğin; buz veya karın suya dönüşmesi:

H_2O (k) ⟶ H_2O (s)

Donma, sıvı haldeki bir maddenin katı hale dönüşmesidir. Örneğin: Suyun buz hale geçmesi.

H_2O (s) ⟶ H_2O (k)

Buharlaşma, sıvı haldeki bir maddenin gaz haline dönüşmesidir. Örneğin; suyun buharlaşması.

H_2O (s) ⟶ H_2O (g)

Katı haldeki bir maddenin doğrudan gaz haline dönüşmesi süblimleşme olarak adlandırılır. Örneğin; kışın kar yığınlarını erimesini sağlayacak sıcaklık olmadığında bile kar yığınlarının yavaş yavaş gözden kaybolduğu gözlemlenir. Kar doğrudan su buharına dönüşmüştür.

H_2O (k) ⟶ H_2O (g)

Yoğunlaşma, gaz halindeki maddenin sıvı veya katı hale geçmesidir. Örneğin; yapraklar üzerinde oluşan çiy atmosferdeki su buharının yoğunlaşması ile meydana gelir.

H_2O (g) ⟶ H_2O (s)

Kırağı atmosferdeki su buharının sıvı hale geçmeden doğrudan katı hale geçmesi ile oluşur. Kar da atmosferde benzer şekilde meydana gelir.

Öğrencilere faz değişimini moloküler boyutta anlatan animasyon sessiz bir biçimde izlettirilir *(faz değişimi ile ilgili animasyon)***.** Bu animasyonda bir katı ısıya maruz bırakıldığında bu katının sıcaklığının nasıl değiştiği yandaki termometrede verilmektedir. Katı tanecikli yapı halinde gösterilmektedir. Katıda bulunan moleküllerin kinetik enerjilerinin sıcaklık artışı ile arttığı yine moleküler boyutta net bir şekilde verilmektedir. Erime noktasına gelindiğinde sıcaklığın erime tamamlanıncaya kadar sabit kaldığı net bir şekilde animasyonda belirtilmektedir. Aynı durum kaynama noktası içinde geçerlidir. Sıcaklık ve zaman grafiği (hal değişim grafiği) ayrıca bu animasyonun ikinci kısmında gösterilmektedir.

Öğrencilere bu animasyonla ilgili sorular sorulur:

- ✓ Katıya ısı verildiğinde sıcaklık belli bir noktaya kadar yükselir. Belli bir noktada ısı verilmeye devam edilse de sıcaklık yükselmesi bir süreliğine durur? Bunun sebebi nedir?
- ✓ Taneciklerin ısı verildikçe daha hızlı hareket etmelerinin sebebi nedir?
- ✓ Sıcaklık zaman grafiğinde düz çizgiler neyi ifade etmektedir?

Faz değişimi sırasında maddelerin kütlelerinin değişmeyeceği yukarıda yapılan deney ile öğrencilere ıspatlanır.

b. Buhar basıncı

Bir sıvı üzerindeki buhardan kaynaklanan basınca o sıvının buhar basıncı denir. İçi civa dolu olan kolonun içine damlalık ile su damlatılması sonucunda meydana gelen gözlemler irdelenir. Her sıvının hatta her katının belli bir buhar basıncının olduğu vurguanır.

Sıvıları oluşturan moleküllerin bir kinetik enejileri vardır. Sıvının yüzeyinde bulunan moleküller belli bir kinetik enerjiye ulaşınca kolonun üstündeki boşluğa yayılır. Zamanla daha fazla su molekülü bu boşlukta oluşur. Daha fazla molekül oluşunca, belli kinetik enerjiye sahip olan bu moleküller suyun yüzeyine çarparlar ve su yüzeyine bir basınç uygularlar. Buharlaşma olayı devam ettikçe cıva aşağıya doğru itilir.

Buhar fazına geçmiş olan su molekülleri su yüzeyine çarparlar ve su yüzeyine tutunup kalırlar. Yani su buharı yoğunlaşarak suya dönüşür. Buhar artmaya devam ettikçe, yoğunlaşma da buna paralel olarak artar. Bu süreç bir dengede son bulur. Bu denge anında su buharının su yüzeyine yapmış olduğu basınç suyun o sıcaklıktaki buhar basıncı olarak tanımlanır.

$$H_2O\ (s) \rightleftarrows H_2O\ (g)$$

Sıcaklık arttıkça moleküllerin kinetik enerjileri ve buhar fazındakiş moleküllerin sayısı artacak dolayısı ile buhar basınçlarıda artacaktır. Ağzı bir balonla kapatılmış içinde su olan erlen ısıtılınca balonun şişmesinin sebebi suyun buhar basıncının artmasından kaynaklanmaktadır.

- ✓ Suyu kaynarken izlediğinizde birçok büyük baloncuk görürsünüz. Baloncukların içinde ne vardır?

Öğrenciler genellikle, kaynama sırasında gördüğümüz baloncukların ısıdan oluştuğunu düşünmektedirler.

c. Kaynama Noktası ve Erime Noktası

Sıvının buhar basıncının sıvının üzerine uygulanan basınca (eğer sıvı bir kap içerisinde basınca maruz değilse, bu açık hava basıncıdır) eşit olduğu sıcaklık o sıvının kaynama noktasıdır.

Bildiğimiz gibi sıvının sıcaklığı artınca, sıvıyı oluşturan moleküllerin kinetik enerjileri artar, bununla beraber sıvının buhar basıncıda artar. Bu buhar basıncı açık hava basıncına ulaştığı anda sıvının içerisinde baloncuklar oluşur. Buna kaynama adı verilir. Kaynama başladığı anda sıvının sıcaklığı aynı kalır.

Bir sıvının üzerine uygulanan basınç değişirse, o sıvının kaynama noktasıda değişir. Mesela, su 1 atm basınçda (deniz seviyesinde, istanbul) 100 C de kaynar. Fakat açık hava basıncının 0.83 atm olduğu Van'da su 95 C de kaynar. Bunun nedenleri derinlemesine sınıfda tartışılır, öğrencilerden açıklama yapmaları beklenir. Düdüklü tencerede yemeklerin daha çabuk pişmesinin sebepleri bu bağlamda sınıfda tartışılır.

Sıvıların üzerindeki basınç düşdükçe kaynama noktası düşer.

Gösteri

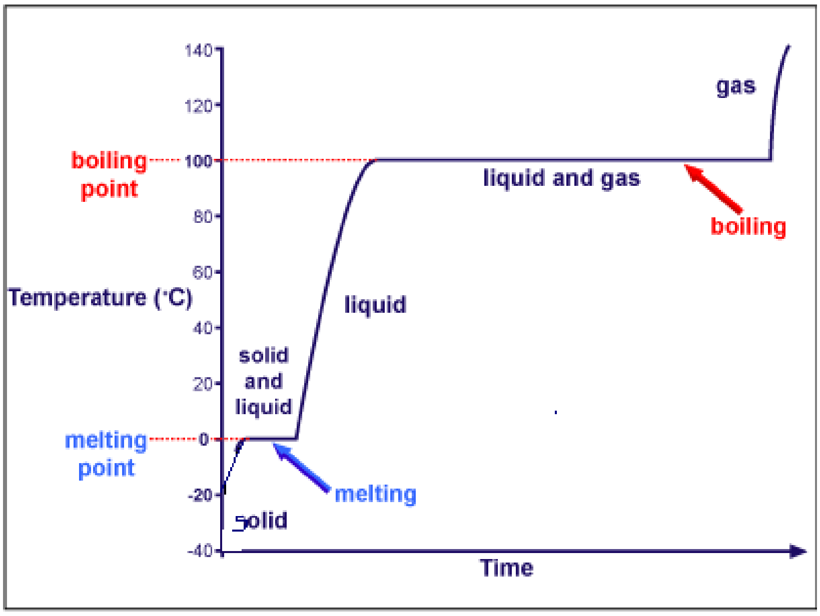
Bir cam balon alınır, yarısı su ile doldurulur. Su kaynatılır. Kaynama başladıkdan sonra ateş söndürülür ve balonun ağzı mantar ile kapatılır. Eline aldığın sıcak su dolu balon ters çevrilerek soğuk ıslak bezle balonun yukarı gelen kısmı soğutulursa, suyun yeniden fakurdayıp kaynadığı görülür. Bunun sebebi, soğutulduğunda üstte bulunan buharın bir kısmının yoğunlaşması suyun yüzeyine etki eden basıcın azalmasıdır. Üzerindeki basınç azaldığı içinde kaynama noktasının altında olduğu halde su yeniden kaynamaktadır .

Saf bir sıvının kristallenerek katılaştığı, donduğu sıcaklığa donma noktası adı verilir. Kristal haldeki katının sıvıya dönüştüğü, eridiği sıcaklığa erime noktası adı verilir. Bir madde için erime ve donama noktası aynıdır. Kaynama noktasının tersine erime noktası ancak çok yüksek basınç değişimlerinden etkilenir.

Erime noktası ve kaynama noktası maddeleri tanımlamamızda bize yardımcı olan fiziksel özelliklerdir.

d. Erime ve Buharlaşma Isısı

-20 ^{o}C deki buzun buharlaşıncaya kadar olan sıcaklık zaman grafiğinin öğrenciler tarafından açıklanması istenir.



Erime sıcaklığında bulunan bir katıyı eritmek için gerekli olan ısı miktarına erime ısısı adı verilir. Örneğin, buzun erime ısısı, bir mole için 6.01 kj dur.

H_2O (k) ⟶ H_2O (s) $\Delta H_{erime} = 6.01$ kj/mol

Kaynama sıcaklığında bulunan bir sıvıyı buharlaştırmak için gerekli olan ısıya buharlaşma ısısı adı verilir. Örneğin, suyun buharlaşma ısısı, bir mol için 40.7 kj dir.

H_2O (s) ⟶ H_2O (g) $\Delta H_{erime} = 40.7$ kj/mol

Bir maddenin erime ısını hesaplamız için yaptığımız kalorimetre deneyindeki kaydettiğimiz verileri hatırlayalım:

Kalorimetredeki suyun miktarı: 100 ml

Kalorimetredeki suyun sıcaklığı: 48 ^oC

Kalorimetredeki suyun kütlesi: 100 g

Kalorimetredeki suyun son miktarı: 150 ml

Kolorimetredeki son sıcaklık: 4 ^oC

C_{su}: 1 cal/g.^oC

Kalorimetreye atılan buz belli bir miktar ısı emerek suyun sıcaklığını son sıcaklığa düşürmüşdür. Buzun absorbe ettiği ısı miktarı suyun kaybettiğ ısı miktarına eşittir.

Kolorimetredeki suyun kaybettiği ısı miktarı (ΔH) = ΔT x M x c

44.0 C x 100 g x 1.00 cal/g.^oC

4.4 x 10^3 cal

Kolorimetredeki suyun kaybettiği ısı miktarı buzun absorbe ettiği ısı mikrtarına eşittir.Eriyen buzun kütlesi, kalorimetredeki suyun hacminin değişimine eşittir ve buda 50 g dır.

Kalorimetreye koyduğumuz buzun ilk sıcaklığının 0 ^oC olduğunu ve kalorimetre kabının bu işlemler sırasında ısı alıp vermediğini kabul edersek, suyun verdiği ısının bir kısmı buzun eriyip 0 ^oC de su haline gelmesini sağlarken bir kısmına da 0 ^oC deki suyu (buzun erimesi sonucu oluşan su) 4 ^oC ye kadar ısıtmak için harcanmıştır.

O halde;

Kalorimetredeki suyun verdiği ısı = buzun erimesi için aldığı ısı + oluşan 0 ^oC deki suyun 4 ^oC ye kadar ısınması için gerekli ısı

$4{,}4 \times 10^3$ cal = Q_{buz} + 50 x 1 x 4

= Qbuz + 200 cal

Q_{buz} = 4400 – 200 ise Q_{buz} = 4200 cal

Buzun tamamı 50 gr ise Q_{buz} = 4200 / 50 = 84 cal /gr olur. Elde edilen veriler doğrultusunda buzun erime ısısı 84 cal/g dır.

4. Derinleşme Aşaması

Buhar Basıncı

(Laboratuvar)

Sıvıların buhar basıncının sıcaklık ile arttığını gösteren bir deney yapmaları sağlanır. Yarıya kadar su ile dolu olan beher ısıtılır. Isıtılırken beherin ağzına hava kaçırmayacak şekilde balon bağlanır. Sıcaklık arttıkça balonun şişmesi gözlenir. Balon şişme sebebi öğrenciler ile tartışılır.

Erime Isısı

- ✓ Öğrencilerin daha önce yapmış oldukları deney doğrultusunda (buzun erime ısısının 84 cal/g olduğu biliniyor) bir miktar buz verilerek bu buzun miktarının kalorimetre kullanılarak hesaplanması istenir.

- ✓ Buzun erime ısısı 6.01 kj/mol dür. Suyun buharlaşma ısısı 40.7 kj/mol dür. Bu iki değer arasında bu kadar fark olmasının sebebi öğrencilere sorulur.

Erime ve Kaynama Noktası

Öğrencilere 3 madde verilir. Bu maddelerin erime ve kaynama noktalarını tespit ederek bu maddlerin ne olduğunu öğrenciler bulmaya çalışır.

5. Değerlendirme Aşaması

Öğrencilere konu ile ilgili sorular verilir. Bu soruların cevapları doğrultusunda öğrecilere dönütler verilir.

ACTIVITY 2

ÇÖZELTİLER-1

Çözeltiler, Çözelti çeşitleri (doymuş, doymamış, aşırı doymuş çözeltiler)

1.Girme Aşaması (Engagement)

Öğrencilere çözelti deyince ne anladıkları, günlük yaşamda karşılaştıkları çözeltilerden bahsetmeleri istenir. Herhangi bir çözeltiyi oluşturan bileşenler neler olabileceği öğrencilere sorulur. Öğrenciler şekerli su deneyini yaparlarken onlara, oluşturdukları şekerli suyun bir çözelti olup olmadığı sorulur. Bu şekerli suda neyin çözünen ve neyin çözücü olduğu sorulur. Çözeltilerin sadece katının sıvı içerisinde çözünmesi ile oluşan karışımlar mı olduğu, yoksa sıvı-sıvı, katı- katı, gaz-gaz çözeltilerinde olup olmadığı eğer varsa günlük yaşamdan bu çözelti çeşitlerine örnek vermeleri istenir. Günlük yaşamdan şu sorular sorularak çözeltilerin günlük yaşamımızdaki önemi vurgulanır.

- ✓ Tuz suda çözünmeseydi tuzun yemeğe kazandırdığı tat oluşabilir miydi? Böyle bir durumda tuzu yemeğe katmamızın bir anlamı olacak mıydı?
- ✓ Bitkilerin kökleriyle topraktan gerekli mineralleri almaları ile çözünme arasında nasıl bir ilişiki var? Bu mineraller sude çözünmese bitkiler beslenebilir miydi?
- ✓ Günlük yaşamızda karşımıza çıkan çözeltilere örnekler veriniz?
- ✓ Erime ve çözünme aynı şey midir?

Cevaplar

Gündelik yaşamımızda karşılaşılan bazı maddelerin birbiri içerisine dağılarak homojen karışımlar oluşturduklarını bazılarının ise karışmayıp ayrı fazlar halinde kaldığını gözlemlemekteyiz. Tuz suda çözünmeseydi tuzun yemeğe kazandırdığı tat oluşmayacaktı ve bundan böyle yemeğe tuz katmanın bir anlamı olmayacaktı. Bitkilerin kökleriyle topraktan gerekli mineralleri almaları da çözünmeyle mümkün olabilmektedir.

Çözeltiler yaşamımızda önemli bir yere sahiptir. Başlıca azot ve oksijen elementlerinden oluşan soluduğumuz hava, çeşitli mineralleri ve çözünmüş gazları içeren içme suyu, sodyum klorür ve diğer bileşikleri içeren deniz suyu, yaklaşık yüzde beş oranında asetik asit içeren sirke, çözünmüş karbondioksit ve birçok başka madde içeren soda, onlarca karbonlu bileşik içeren benzin, başlıca metan olmak üzere diğer yanıcı gazları içeren doğal gaz, bakır ve çinkodan oluşan sarı pirinç, su ve sodyum hipoklorit'ten oluşan çamaşır suyu, su ve hidroklorik asitten oluşan tuz ruhu, su, etil alkol ve koku verici maddeden oluşan kolonya, otomobillerde donmayı önleyen sıvı olarak kullanılan antifriz (Etilen glikol, CH_2OHCH_2OH)-su karışımı ve şekerli su çözeltileri gündelik hayatta karşılaştığımız veya farklı amaçlarla kullandığımız çözelti örnekleridir. Balıklar suda çözünmüş olan oksijeni alarak yaşamlarını sürdürürler.

Öğrenciler küçük (5 kişilik 6 grup) gruplara ayrılır. Her gruba içinde 100 ml su bulunan cam kap ve bir miktar kesme şeker verilir. Öğrencilere "Verilen kesme şekerlerin hepsinin suda çözündü mü?" "Çözünmenin belli bir sınırı var mı?" soruları sorulur ve gruplar bu probleme çözüm bulmaya yönlendirilirler. Gruplardaki öğrenciler tartışarak, problemin çözümüne yönelik fikirler ve hipotezler ileri sürerler. Öğrencilerin kesme şekerleri tek tek suya atarak bir karıştırıcıyla karıştırmalarının sonuca daha doğru bir şekilde ulaşabilecekleri bir yol olduğu vurgulanır ve deney sonucunu arkadaşlarıyla tartışmaları istenir. İlk başta şekerin suda çabuk bir şekilde çözündüğü, belli bir miktar şeker atılıncaya kadar çözünmenin devam ettiği fakat belirli bir noktadan sonra şeker atılmaya devam edildiğinde karıştırıldıktan sonra bile bir miktar şekerin çöktüğünün gözlemlenmesi beklenir. Gözlem sonucunun grup içinde tartışılarak maddelerin çoğunun belirli bir çözücü içinde çözünürlüklerinin bir sınırı olduğu sonucuna varmaları beklenir.

Öğrencilerin sıcaklık artışının çözünürlüğü arttırdığına dair günlük yaşamdan örnekler verilir. Öğrencilere şekerin sıcak su içerisinde soğuk suya oranla eden daha çabuk çözündüğü sorulur. Sıcak suda mı çökmeden daha fazla şeker çözebiliriz oksa soğuk suda sorusu öğrencilere sorulur. Günlük yaşamda çokça kullanılan pekmez kıvamındaki tatlı sıvı veya şurupların nasıl hazırlandığı sorusu sorulabilir. Sıcaklık artışının bütün maddelerin çözünürlüğünü artırmayabileceği istisnası belirtilir.

2. Keşfetme Aşaması (Exploration)

Öğrencilerin çözünürlük kavramını daha iyi anlayabilmeleri için NaCl ün suda çözünmesi öğrenciler tarafından gerçekleştirilir.

Laboratuvar (1)

20 C de, 30 g NaCl 100 ml su içerinde yavaş yavaş karıştırılarak çözünür. Belli bir süre sonra 30 g NaCl in suda tamamen yok olduğu gözlemlenir (1. çözelti). Başka bir kapta oluşturulan aynı çözeltinin üzerine 10 g daha NaCl ilave edilirse ve karıştırılmaya devam edilirse, ilave edilen NaCl in bir kısmının daha çözündüğü, ama bir kısmının ne kadar karıştırılırsa karıştırılsın, kabın dibine çöktüğü gözlemlenir (2. çözelti).

- ✓ NaCl ün tamemen çözündüğü 1. çözelti nasıl bir çözeltidir?
- ✓ 30 g NaCl ü 100 ml suda çözdükten sonra, bu çözeltinin üzerine 10 g daha NaCl ilave etmemiz durumunda 10 g NaCl ün tamamen çözünmemesinin sebebi nedir?
- ✓ Oluşturduğumuz 2. çözelti nasıl bir çözeltidir?
- ✓ Şekerin suda çözünme miktarı ile NaCl suda çözünme miktarı eşit mi? Neden?

Laboratuvar (2)

100 C (kaynayan su), 100 ml su içerisinde $Na_2S_2O_3$ (sodyum tiyosülfat) ın çözünürlüğü 231 g dır. Oda sıcaklığında çözünürlük 50 g düşer. 100 C de, 100 ml suda

231 g $Na_2S_2O_3$ çözünür (3. çözelti). Ve bu çözelti yavaş yavaş soğumaya bırakılır. Soğumaya bırakılan bu çözelti kristallenme olmadan soğur. Fakat bu çözeltinin içerisine çok az $Na_2S_2O_3$ ilave ettiğimizde kristallenme meydana gelir ve bu kristallenme gitgide büyür.

- ✓ Oluşturulan 3. çözelti nasıl bir çözetidir.
- ✓ Neden birdenbire çok yüksek düzeyde krsitallenme meydana gelmiştir.

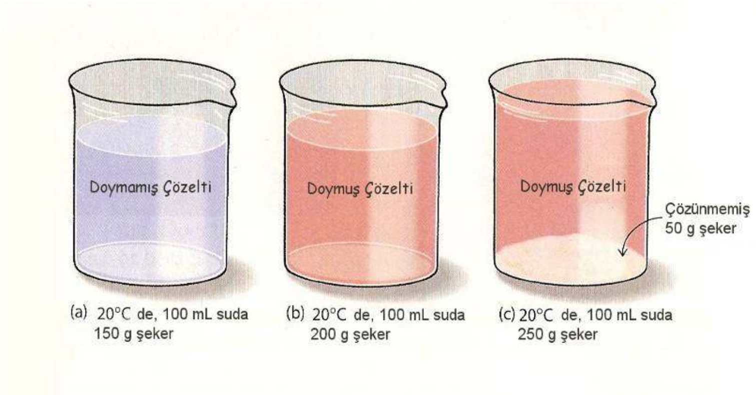
Öğrenciler laboratuvarda küçük gruplara ayrılarak suda çözünebilen katıların çözünürlüklerine sıcaklığın etkisi nedir sorusuna cevap bulmaları istenebilir. Öğrenciler sıcaklığın çözünürlüğe etkisinin nasıl olabileceğiyle ilgili hipotezler kurarlar ve deney tasarlarlar.

Grupların bir kısmı örneğin çözünen olarak sodyumnitrat bir kısmı şeker kullanabilir. Deney sonucunda öğrencilerin suda çözünebilen katıların sıcak suda soğuk suya göre daha hızlı ve daha fazla miktarda çözündüğü, yani genel olarak sıcaklık artışının çözünürlüğü artırdığı sonucuna varmaları beklenir.

Öğrencilere, yüksek sıcaklıkta hazırlatılan çözünürlüğü artmış böyle çözeltiler soğutulursa yani tekrar oda sıcaklığına gelmesi beklenirse neyin olacağı sorusu sorulur. Öğrenciler yüksek sıcaklıkta doygun hale getirdikleri çözeltileri soğumaya bıraktıklarında çözünen maddenin bir kısmının kabın dibine çöktüğünü gözlemlerler. Sonuç olarak şeker veya sodyumnitrat çözeltisinin çözünürlüğünün sıcaklık azaldıkça azaldığı sonucuna varmaları beklenir.

Çözünürlüğü yüksek bir çözelti hazırlamak için ne yapılmalı sorusuna, öğrencilerin oldukça yüksek derişime (konsantrasyon) sahip şeker çözeltileri oluşturulması gerekir cevabını vermeleri beklenir. Çözeltinin sıcaklığının artırılması çözünürlüğü neden artırır? şeklindeki yönlendirici sorularla öğrencinin sıcaklığın etkisini olayıyla ilşkilendirmesi sağlanır.

3. Açıklama Aşaması (Explanation)



Öğrencilere şekillerin neyi ifade ettiği sorulur. Öğrencilerin Şekil- a da şekerin suda çözündüğünü, çözünme olayının 200 gr. şeker ilave edene kadar süreceğini belirtmeleri beklenir. Şekil-b de suyun şekere doyduğu yani suyun daha fazla şekeri homojen bir karışım oluşturmak için kabul edemeyeceği nokta olduğunu ifade etmeleri beklenir. Bu tür bir durum oluşmuşsa elde edilen çözeltiye doymuş çözelti denildiği, şekil a da ise henüz suyun şekeri homojen bir karışım oluşturmak için kabul edebileceği, bu durumdaki çözeltiye de doymamış çözelti denildiğini öğretmen tarafından açıklanır. Şekil- c de ise 50 gr şekerin çözünmeden dibe çöktüğünün öğrenciler tarafından belirtilmesi beklenir.

Öğrencilere animasyon izlettirilerek şekerin su içerisinde moleküler düzeyde nasıl çözündüğü gösterilir *(NaCl çözünmesi ile ilgili animasyon)*.

Doymuş, doymamış ve aşırı doymuş çözelti kavramları tanecik boyutuna indirgenerek oluşum şartları anlaşılır hale getirilebilir. Çözünürlük konusunu daha iyi anlayabilmek için NaCl in su içerisinde çözünmesini inceleyelim. NaCl iyonik bir maddedir ve su içerinde Na^+ ve Cl^- iyonlarına ayrışarak çöznür. NaCl ün çözünmesini makroskopik yolla incelersek, dinamik bir sürecin meydana geldiği gözlemlenir. Mesela, 40 g NaCl kristallerini 20 C de 100 ml suda karıştıralım. Na^+ ve Cl^- iyonları kristalin yüzeyinden çözeltiye doğru ayrılırlar. Bu iyonlar özeliti içerisinde rastgele hareket ederler ve şans eseri birbirleri ile çarpışarak tutunurlar ve kristal duruma yine dönüşürler. NaCl çözünmeye devam ederse, daha fazla iyon çözeltiye karışacak ve iyonların çözelti içerisinde çarpışarak kristalize olma oranı artacaktır. Ve sonuç olarak kristalden ayrılan iyonlar ile iyonların çarpışarak kristal meydana getirme oranı dinamik bir dengeye ulaşacaktır. Bu denge şu şekilde ifade edilir.

$$NaCl\ (k) \rightleftharpoons Na^{+}\ (suda) + Cl^{-}\ (suda)$$

İşte bu dengede bulunan çözültilere doymuş çözeltiler, bu dengeye henüz ulaşamamış, çözünmenin devam ettiği çözeltilere de doymamış çözeltiler adı verilir.

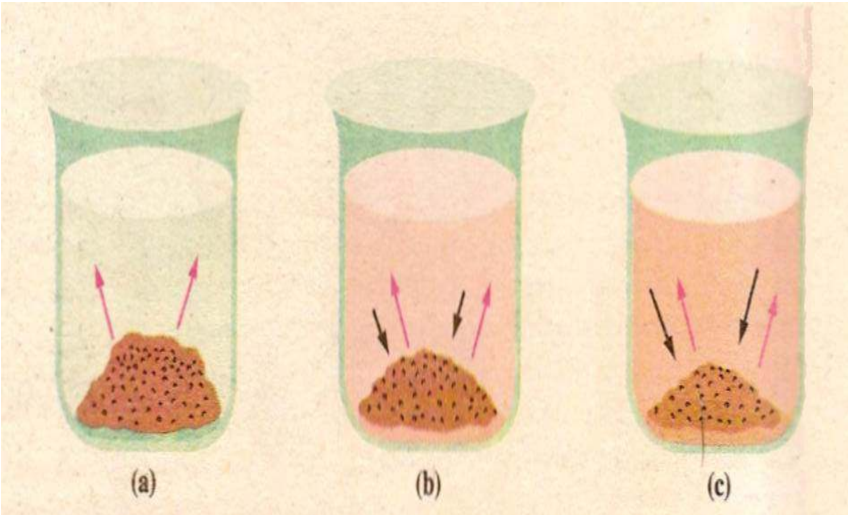
Bir çözücü ile bir çözünen karıştırıldığında (kapta belli miktardaki suya çözünen ilave edildiğinde) doymuş bir çözelti konumu oluşana kadar nasıl bir olayın meydana geldiği aşağıda resmedilmiştir.

Öğretmen doygun çözeltinin derişimini, verilen çözücü içindeki çözünenin çözünürlüğü (konsantrasyonu) olduğunu ifade eder. Doygun çözeltinin belli bir sıcaklıkta oluştuğu (oda sıcaklığı) öğrencilere hatırlatılıp, böyle bir çözeltinin sıcaklığını, çözünürlüğün daha az olduğu bir dereceye getirdiğimizi varsayarsak çözeltiye ne olur sorusu sorulur. Sıcaklığın düşürüldüğü yeni ortamda çözünürlük azaldığına göre çözünenin fazlasının çökeceği cevabına ulaşılması beklenir. Öğretmen bu durumda bazen hiç çökelme olmayabileceğini söyler ve öğrencilerden açıklama bekler. Öğrencilerin farklı sıcaklıklarda çözünen madde miktarının farklı olabileceği çıkarımını yapıp, çözeltideki çözünmüş madde miktarının, o sıcaklıkta çözünmesi gerekenden fazla olduğu sonucuna varmaları beklenir. Öğretmen böyle çözeltilere aşırı doygun çözelti dendiğini belirtir.

Öğrencilerden sıcaklığı artırmanın çözünürlüğü artıracağı, çözücünün yani su moleküllerinin sıcaklık artırımıyla daha hızlı hareket edecekleri (kinetik enerjilerinin yükseleceği) ve katı çözünenle daha etkili çarpışmaya gireceklerini söylemeleri beklenir.

Bu durumda çözücü molekülleri çözünen maddenin moleküllerini daha kısa zamanda saracağından çözücü- çözünen arasındaki etkileşim kuvvetinin çözücü-çözücü arasındaki etkileşim kuvvetini zayıflatacağı çıkarımını yapmaları beklenir.

4. Derinleşme Aşaması

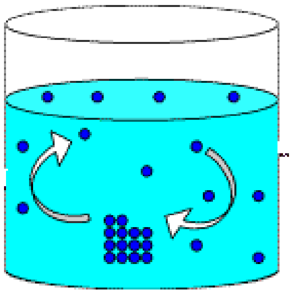


Şekil: Doygun çözeltinin oluşması
Okların uzunluğu çözünme ve çökelme hızlarını göstermektedir.

Yukarıdaki şekil doymuş bir çözelti gösterimi için uygundur. Küçük gruplar oluşturularak öğrencilerin şekilleri tartışmaları istenebilir. Öğretmen bazı sorularla tartışmayı yönlendirir. Doymamış çözelti ve doygun bir çözelti oluşması için gerekli şartların neler olduğu sorusu sorulur ve olayın çözünenin çözünme ve çökelme hızları ile açıklanması beklenir. Öğrencilerin önce yalnızca çözünmenin meydana geleceği, hemen ardından çökelme olayının başlayacağı ve çökelmenin gittikçe artacağını ifade etmeleri beklenir. Öğrencilere çökelmenin neden belli bir noktadan sonra arttığı sorusu sorulur. Öğencilerin saf çözünenden çözeltiye geçen molekül veya iyonlarının çözeltide hareket ettikleri, çözeltiye geçen iyon veya moleküllerin sayıları arttıkça bunların saf çözünen ile çarpışma ve tekrar saf çözünene geçme olasılığının artığı sonucuna varmaları sağlanır. Yani çözünmüş iyon veya moleküllerin bir kısmının yeniden çözünmemiş hale döndüklerini ifade etmeleri beklenir. Bir süre sonra çözünme hızı ile çökelme hızının eşit hale gelmesinin ne anlam ifade ettiği ve çözeltinin derişimini bu durumun nasıl etkilediği sorusu sorulur. Öğrencilerin bu durumda çözünenin çözeltideki derişiminin artık değişmeyip sabit kaldığı ve çözeltinin bu halinin ise doygun çözeltiyi yansıttığını fark etmesi beklenir.

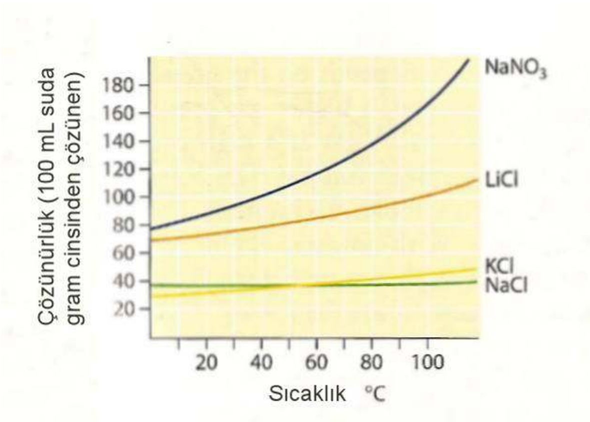
Öğrencilere animasyon izlettirilerek $KmnO_4$ ün su içerisinde moleküler düzeyde nasıl çözündüğü gösterilir *($KMnO_4$ ün çözünmesi ile ilgili animasyon).*

Bu animsayon üzerine çeşitli tartışmalar gerçekleştirilir.



Öğrencilerden nasıl bir çözelti olduğunu yorumlamaları istenir. Çözünme hızı ile çökelme hızının eşit hale gelmesinin çözünenin çözeltideki derişiminin artık değişmeyip sabit kaldığı ve çözeltinin bu halininde doygun çözeltiyi yansıttığınının ifade edilmesi beklenir. Yani bir miktar katı çözünenle dengede bulunan bir doymuş çözelti beherin içinde bulunmaktadır.

Sulu çözeltideki çözünürlüğün sıcaklık artışıyla ilişkisini gösteren grafik öğrencilerin göreceği bir şekilde duvara yansıtılır.



Öğrencilerin bu grafiği yorumlamalarına yardımcı olabilecek sorular sorulur. Örneğin, NaCl nin çözünürlüğünün sıcaklıktan neden ötekilere göre daha az etkilenmiş olabilir? sorusuna yaratılan tartışma ortamında cevap aranmaya çalışılır. Çözünen moleküllerin kendiiyonları aralarındaki kimyasal bağların kuvvetliliği ve bu moleküllerin örgün yapıda bir arada olmalarının buna neden olabileceği sonucunun çıkması sağlanabilir.

5. Değerlendirme Aşaması

Öğrencilere konu ile ilgili sorular verilir. Bu soruların cevapları doğrultusunda öğrecilere dönütler verilir.

ACTIVITY 3

ÇÖZELTİLER 2

Çözeltilerin Derişimleri

1.Girme Aşaması (Engagement)

Öğretmen öğrencilere kolonyanın üzerinde yazan 80^{o} veya 90^{o} yazılarının ne anlama geldiğini sorar. Bununla beraber içkilerin üzerinde yazan %45 (rakı), veya %5 (bira) ne anlam ifade ettiği öğrencilere sorulur.

80^{o} veya 90^{o} lik kolanyalar arasında ne gibi farklar vardır. Bira ile rakı arasıda alkol oranı olarak ne gibi farklılıklar bulunmaktadır. Günlük yaşamımızda karşımıza çıkan yiyecek ve içeceklerde bilgi verilen ifadeler ne anlama gelmektedir? Şeklinde sorular sorulur.

Bir çözeltinin içerisinde çözünen madde miktarını hangi ölçülerle vurgularız. Mesela, kütlece % 3,5 lik NaCl çözültesi dendiğinde ne anlıyoruz? 1 molar $CuSO_4$ çözeltisi dediğinde ne anlıyoruz? 1 molal $CuSO_4$ çözeltisi dendiğinde ne anlıyoruz?

2. Keşfetme Aşaması (Exploration)

Laboratuvar

1. deney: Öğrencilere %3.5 lik NaCl çözeltisi hazırlatılır. Bu çözelti, 3,5 g NaCl nin 96,5 g suyun içerisinde çözünmesi ile hazırlanır. Öğrencilere bu çözelti hazırlanırken bunun günlük yaşamlarında karşılarına çıkan kolonya ve içkilerdeki örneklerle bir ilgisinin olup olmadığı sorularak tartışılır. Kütlece yüzde derişim dendiğinde öğrencilerin ne anladığı öğrencilere sorulur. Not: Günlük yaşamda karşımıza çıkan çözeltiler sıvı-sıvı karışımı çözeltiler olduğu için yüzdeler hacim olarak verilmiştir.

2. deney: Öğrencilere 1 Molar NaCl çözeltisi hazırlatılır. 1 mol (Cl:35,5 ve Na: 23) NaCl alınır 58,5 g NaCl) ve bir miktar suda çözünür ve bu su ile 1 litreye tamamlanır. 1 M 1 lt NaCl çözeltisi elde edilmiş olur. NaCl yi bir miktar suda çözüp

bunu 1 lt ye tamamlamamızın sebebi öğrencilere sorulur. Çözeltinin hazırlama basamaklarından öğrencilerden molarite nin ne olduğunu tartışmaları istenir.

3. deney: Öğrencilere 1 Molal NaCl çözeltisi hazırlatılır. 1 mol (Cl:35,5 ve Na: 23) NaCl alınır (58,5 g NaCl) 1 kg su içerisinde çözülür ve oluşan çözeltinin 1 molal olduğu öğrencilere söylenir. (Çözücü su olduğu için (yoğunluğu 1 gr/cm^3) 1 kg su yerine 1 litre su alınabilir. Ama çözücü değişik ise bu 1kg 1 litre den az veya çok olabilir) 1 lt yerine 1 kg su kullanmamızın sebebi öğrencilere sorulur. Molalite ve molarite arasındaki farklar öğrencilere sorulur.

3. Açıklama Aşaması (Explanation)

Kütlece yüzde derişim: Çözeltinin 100 gramında çözünmü olarak bulunan maddenin gram cinsinden miktarına, kütlece yüzde derişim denir.

Kütlece yüzde derişim = çözünenin kütlesi / çözeltinin kütlesi X 100

Örnek: 425 g %2.40 lık sodyum asetat çözeltisi nasıl hazırlanır?
2.4 = çözünenin kütlesi / 425 g X 100
Çözünenin kütlesi = 10.2 g
10.2 g sodyum asetat 425 – 10.2 = 414,8 g su içerisnde çözülür.

MOLARİTE: Bir litre çözeltide çözünen maddenin mol sayısına molarite denir. Birimi mol/lt dr.

Molarite = çözünenin mol sayısı / çözeltinin hacmi (lt)

Öğrencilere 250 ml 1M $CuSO_4$ ün nasıl hazırlanacağının anlatıldığı animasyon seyrettirilir *(1 molar $CuSO_4$ ün hazırlanması).*

Öğrencilerden 500 ml 1M NaCl çzöeltisi hazırlamaları istenir.

Öğrencilere, konsantrasyanu bilinen bir çözeltiden istenilen konsantrasyonda çözelti elde edilmesini anlatan animasyon gösterilir ve bu animasyon üzerinde tartışılır. (1 molar NaCl hazırlanması).

Bu animasyonda öğrencilerin durumu daha iyi anlamalrı için $M_1V_1 = M_2V_2$ formulün nasıl kullanıldığı anlatılır.

MOLALİTE: 1 kg çözücü içerisinde çözünen maddenin mol sayısına molalite denir.

Örnek: 0.2 mol etilen 2 kg su içerisinde çözünmesi ile oluşan çözelti kaç molaldir.

0.1 molaldir.

4. Derinleşme Aşaması

Öğrencilere kütlece yüzde derişimleri, molariteleri ve molaliteleri belli olan çözeltiler hazırlatılır.

5. Değerlendirme Aşaması

Öğrencilere konu ile ilgili sorular verilir. Bu soruların cevapları doğrultusunda öğrecilere dönütler verilir.

ACTIVITY 4

ÇÖZELTİLER 3

Donma Noktası Düşmesi ve Kaynama Noktası Yükselmesi

1.Girme Aşaması (Engagement)

Kışın kar yağınca belediye ekiplerinin yollara tuz atmasının sebebi öğrencilere sorularak bunun nedenleri tartışılır. Ayrıca arabaların motorlarına antifriz koyulmasının nedenleride tartışılır.

Öğrencilere annelerinin yemek yaparken neden tuzu su kaynadıktan suyun içine attıkları sorulur. Madem suyun kaynama sıcaklığını içinde bazı maddeleri çözerek yükseltebiliyorsak düdüklü tencere neden ihtiyaç duyulmaktadır. Öğrencilere bu sorular sorularak onların dikkati çekilmeye çalışılır.

İki farklı dösteri yapılır.

Birinci gösteri: Birincisinde iki kap su vardır. İlki saf su ikincisi tuzlu su olmak üzere aynı miktarda iki kap su vardır. ikiside ısıtılır ve kaynamaya başladıkları sıcaklıklar kaydedilir ve kıyaslanır.

İkinci gösteri: iki kase buz vardır. Birinci kasedeki buz sudan elde edilmiştir. İkinci kasedeki buz tuzlu sudan elde edilmiştir. İkiside -10 C dedir. İkisine birden ısı vermeye başlanır ve ikisininde erime sıcaklıkları not edilir.

Birinci gösteride iki kabın içinde bulunan suyun kaynama noktalarının neden farklı olduğu öğrencilere sorulur.İkinci gösteride buzların erime noktaları neden farklıdır sorusu öğrencilere sorulur.

2. Keşfetme Aşaması

Öğrencilerin donma noktası düşmesi ve kaynama noktası yükselmesi kavramlarını daha iyi anlamaları için aşağıdaki deneyler öğrencilere yaptırılır.

Laboratuvar

1 mol NaCl 1000 g suda çözülür ve ısıtılarak kaynama noktası tespit edilir.

1 mol $CaCl_2$ 1000 g suda çözülüyor ve ısıtılarak kaynama noktası tespit edilir.

İki çözeltinin kaynama noktalarının farklı oluşunun sebebi öğrencilere sorulur? Bu iki çözeltinin donma noktası aynı mıdır? Hangisinin donma noktasının daha düşük olması beklenir? Neden?

3. Açıklama Aşaması (Explanation)

Bir sıvının buhar basıncının açık hava basıncına (1atm) eşit olduğu sıcaklık o sıvının kaynama sıcaklığıdır. Katının sıvı içerisinde çözünmesi o sıvının buhar basıncını düşüreceğinden, çözeltinin buhar basıncının açık hava basıncına (1atm) ulaşması normal kaynama noktasından daha yüksek sıcaklıklarda olacaktır. Buda kaynama noktasının yükseleceği anlamını taşır. Aynı şekilde buhar basıncının düşmesi donma noktasının düşmesine neden olacaktır.

Çözelti içersisindeki tanecek sayısı arttıkça kaynama noktası yükselir.

$NaCl (k) \longrightarrow Na^{+}(aq) + Cl^{-} (aq)$

1 mol 1 mol 1 mol

Tepkimesinde göre, toplam 2 mol iyon oluşur. Diğer taraftan;

$CaCl_2 (k) \longrightarrow Ca^{2+} (aq) + 2Cl^{-}$

1 mol 1 mol 2 mol

Tepkimesinde, toplam 3 mol iyon oluşur. O halde, $CaCl_2$ çözetisinin donma noktası NaCl çözeltisinden düşük, kaynama noktası ise yüksek olur.

Öğrencilere molalite kavramı verildikten sonra (veya bunu daha önce öğrendilerse sorun yok) kaynama noktası yükselmesi ve donma noktası alçalması şu şekilde anlatılabilir:

Kaynama noktası yükselmesi (ΔT_k), çözeltinin kaynama noktasından, saf çözücünün kaynama noktası arasındaki farktır. Kaynama noktası yükselmesi çözeltinin molal konsantrasyonu ile (molalite) doğru orantılıdır. Kaynama noktası yükselmesi sabiti her çözücünün kendine has özelliğidir. Bu durumda;

$\Delta T_k = i\ K_k \times M$ olacaktır. Bazı çözücülerin K_k ları aşağıdaki gibidir.

Maddeler	K_k
benzene	2.53
camphor	5.95
carbon tetrachloride	5.03
ethyl ether	2.02
water	0.52

Donma noktası alçalması (ΔT_d), saf çözücünün donma noktasından, çözeltinin donma noktasının çıkarılması ile bulunur. Donma noktası alçalması, çözeltinin molal konsantrasyonu ile doğru orantılıdır. Donma noktası alçalması sabiti her çözücünün kendine has özelliğidir. Bu durumda;

$\Delta T_d = i\ K_d \times M$ olacaktır. Bazı çözücülerin K_d ları aşağıdaki gibidir.

Maddeler	K_d
benzene	5.12
camphor	40.
carbon tetrachloride	30.
ethyl ether	1.79
water	1.86

4. Derinleşme Aşaması

Laboratuvar

55,5 g $CaCl_2$, 250 g suda çözünür ve öğrencilerden hazırlanan bu çözeltinin kaynama noktasını tespit etmeleri istenir. Bunu tespit etmeden önce hesaplama yoluyla (2 yoldanda) öngörülen sıcaklığın ne olacağı bulunur ve deney yoluyla elde ettikleri sıcaklıkla bu değer karşılaştırılıp tartışılır ($CaCl_2$: 111 ve K_k(su) : 0,51).

Hesaplamalar:

1. Yol:

N = m / Ma ise n = 55,5 / 111 ise n = 0,5 mol

250 g suda 0.5 mol $CaCl_2$ çözünürse

1000 g suda X

X = 2 mol $CaCl_2$ çözünür.

C_aCl_2 (k) ⟶ Ca^{+2} (suda) + $2Cl^-$ (suda)

2 mol 2 mol 4 mol

Bu durumda 1000 g suda toplam 6 mol iyon oluşur.

1 mol iyon kaynama noktasını 0.51 C arttırırsa

6 mol iyon kaynama noktasını X artırır.

X = 3,06 C olur. Kaynama noktası 100 + 3, 06 = 103, 06 C olur.

2. Yol:

ΔT_k = i K_k x M formulünden yola çıkacak olursak;

Molalite = Çözünenin mol sayısı / çözücünün miktarı (kg)

Molalite = 0.5 / 0.25

Molalite = 2

C_aCl_2 (k) ⟶ Ca^{+2} (suda) + $2Cl^-$ (suda)

1 mol 1 mol 2mol

Toplam 3 mol iyonlaşır . i = 3

$\Delta T_k = i\ K_k \times M$

$\Delta T_k = (3) \times 0.51 \times 2$

$\Delta T_k = 3{,}06$

Kaynama noktası 100 + 3, 06 = 103, 06 C olur.

5. Değerlendirme Aşaması

Öğrencilere konu ile ilgili sorular verilir. Bu soruların cevapları doğrultusunda öğrecilere dönütler verilir.

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