FACILITATING CONCEPTUAL CHANGE IN LEARNING RATE OF REACTION CONCEPTS

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ABSTRACT

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The main aim of this study to investigate the effectiveness of conceptual change texts oriented instruction accompanied with analogies over traditionally designed chemistry instruction on overcoming 10th grade students' misconceptions, their understanding of rate of reaction concepts and attitude towards chemistry as a school subject.

56 tenth grade students from two classes of a chemistry course taught by the same teacher in the ATATÜRK Anatolian High school, participated in the study. This study was carried out in 2003-2004 spring semester.

There were two groups in the study. Experimental group was instructed with conceptual change texts oriented instruction accompanied with analogies and the control group was instructed by traditionally designed chemistry instruction over a period of four weeks.

To investigate the effect of treatment, Rate of Reaction Concepts Test and Attitude Scale Toward Chemistry as a school subject were administered to all students in both groups at the beginning and end of the treatment. To evaluate students' science process skills, Science Process Skills Test was administered before treatment.

To test the hypothesis of the study ANOVA and ANCOVA were used. The result of the study showed that students in conceptual change texts oriented instruction accompanied with analogies got higher average scores in Rate of Reaction Concepts Test than traditionally designed chemistry instruction. Also, students in experimental group indicated a higher positive attitude toward chemistry as a school subject. In addition, science process skill was a strong predictor for the achievement related to rate of reaction concepts.

Results and strategies that were developed for this study may be used by teachers to reduce and eliminate students' misconceptions about the rate of reaction concepts.

KEYWORDS: Conceptual Change Texts Oriented Instruction Accompanied with Analogies, Traditionally Designed Chemistry Instruction, Misconception, Attitude Scale Toward Chemistry as a school subject, Science Process Skills

ÖZ

REAKSİYON HIZLARIYLA İLGİLİ KAVRAMLARI ÖĞRENMEDE KAVRAMSAL DEĞİŞİMİN KOLAYLAŞTIRILMASI

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Bu araştırmanın amacı,benzetmelerle desteklenmiş kavramsal değişim metinlerine dayalı öğretimin lise 2.sınıf öğrencilerinin reaksiyon hızları konusunu anlamalarına,kavram yanılgılarını azaltmalarına ve kimya dersine olan tutumlarına etkisini incelemektir.

Çalışmada aynı kimya öğretmenin eğitim verdiği 56 lise ikinci sınıf öğrencisi yer almıştır.Çalışma ATATÜRK Anadolu Lisesinde 2003-2004 öğretim yılı bahar döneminde gerçekleştirilmiştir.

Çalışma için iki grup oluşturulmuştur.Deney grubunda,reaksiyon hızları konusu işlenirken benzetme destekli kavramsal değişim metinleri kullanılmıştır. Kontrol grubunda ise geleneksel kimya öğretim metodu kullanılmıştır.Öğrencilerin reaksiyon hızları konusundaki başarılarını belirlemek için reaksiyon hızı kavramları testi uygulanmıştır.Öğrencilerin kimya dersine olan tutumlarını belirlemek için kimya dersi tutum ölçeği kullanılmıştır.Öğrencilerin bilimsel işlem becerilerini ölçmek için ise bilimsel işlem beceri testi uygulanmıştır.

Çalışmanın hipotezlerini test etmek için Varyans analizi ve Ortak Değişkenli Varyans Analizi istatiksel analiz yöntemleri kullanılmıştır. Analiz sonuçları benzetme destekli kavramsal değişim metinlerini kullanan öğrencilerin reaksiyon hızları konusundaki başarılarının geleneksel kimya öğretim metodunu kullanan öğrencilere göre daha yüksek olduğunu göstermiştir.Ayrıca, benzetme destekli kavramsal değişim metinlerini kullanan öğrencilerin kimya dersine olan tutumlarının pozitif yönde değiştiği gözlenmiştir.Bilimsel işlem becerisi, öğrencilerin reaksiyon hızları ile ilgili kavramları anlamalarını etkileyen önemli bir faktördür.

Bu araştırma sonuçları ve geliştirilen yöntemler bakımından araştırmacılara ve kimya öğretmenlerine katkı sağlayabilir.

ANAHTAR SÖZCÜKLER: Benzetme Destekli Kavramsal Değişim Metinleri, Geleneksel Kimya Öğretim Metodu, Kavram Yanılgısı, Bilimsel İşlem Becerisi, Kimya Dersi Tutum Ölçeği

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t : statistic

p: Observed Significance Level

df: degrees of freedom

SS: Sum of squares

MS : Mean square

F : The ratio of two mean squares

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

n: number of sample observed

s: Standard deviation

LIST OF ABBREVIATIONS

ABBREVIATIONS

EG : Experimental group

CG : Control Group

RRCT : Rate of Reaction Concepts Test

ASTC : Attitude Scale Towards Chemistry as a school subject

SPST : Science Process Skills Test

CCTIA : Conceptual Change Texts Oriented Instruction Accompanied with Analogies

TDCI : Traditionally Designed Chemistry Instruction

CHAPTER 1

INTRODUCTION

Learning is viewed as a process of active construction which is shaped by the students' prior knowledge and conceptions. Ausubel (1968) stated that the most important single factor influencing learning is what the learner already knows. The current cognitive structure of the learners' influences the learning and retention of new material. Cognitive structure of the learner is composed of a set of abstract ideas, concepts and generalizations, built upon facts. It is the organization of the learners' present knowledge in a subject. During instruction learners generate their own meaning based on their experience and abilities (Nakhleh, 1992). Students who actively relate an incoming idea to previously acquired knowledge understand the meaning of the new information.

In learning process, learners' previously stored knowledge or ideas play an important role when teaching new concepts. (Goss, 1999; Dochy & Bouwens,1990). Ausubel(1968) emphasized this by distinguishing between meaningful learning and rote learning. For meaningful learning to occur, new knowledge must be related by the learner to relevant existing concepts in that learner's cognitive structure. West and Fensham (1974) suggested that meaningful learning occurs when the learner's appropriate existing knowledge interacts with the new learning and rote learning occurs when no such interaction takes place.

Teachers can be astonished to learn that despite their best efforts, students do not understand fundamental ideas covered in science class. Even, some of the students give the right answers but these are only correctly memorized words. Students are often able to use algorithms to solve numerical problems without completely understanding the scientific concepts.Mazur(1996) reported that students in his physics class had memorized equations and problem-solving skills, but performed poorly on tests of conceptual understanding. Nakhleh and Mitchell (1993) studied sixty students in an introductory course for chemistry majors. In an exam which paired an algorithmic problem with a conceptual question about the topic, only 49% of those students who classified as having high algorithmic ability were able to answer the parallel conceptual question.

Many science courses include abstract and complex concepts. Therefore, it is difficult for students to change their thinking. So, special instructional techniques are developed to assist and guide students in their learning. (Anderson&Roth, 1988; Posner, Strike, Hewson & Gertzog, 1982) Students' real world conceptions play a critical role in their view of the world. (Novick & Nussbaum,1982) Students are often faced with conflict in science lesson because their beliefs and conceptions about the world and natural phenomena don't meet with scientific understanding. Different researches have named these different ideas or beliefs as preconceptions or misconceptions (Driver and Easley, 1978), alternative frameworks. (Driver and Erickson, 1983) Several studies have found that students are often wrong ideas or misconceptions about the basic science concepts. (Anderson and Smith, 1987; Osborne and Wittrock, 1983) These misconceptions can function as a potential barrier to prevent the assimilation of new learning.

After 1980's science education constructivists and curriculum developers have been explored the role of students' prior alternative conceptions or misconceptions in learning natural science. After constructivism approach, many studies were done to identify and characterize the students' conceptions. During the past two decades, many researches were carried out related with the role of students' alternative conceptions and the result of these researches showed that these ideas limited students' understanding in science and mostly different form the commonly accepted scientific concepts.

Alternative conceptions have been identified in content areas such as, the particulate nature of matter (Novick& Nussbaum, 1978; Renstrom et. al., 1990; Haidar and Abraham, 1991; Lee, Eichinger et. al., 1993), mole concept (Stave and Lumpe, 1995; Yalçınalp, Geban, and Özkan,1995), chemical equilibrium (Gussarsky and Gorodetsky, 1988,1990; Banjeree, 1991; Camacho and Good, 1989; Pedrosa and Dias,2000), electrochemistry (Garnett and Treagust, 1992; Sanger and Greenbowe, 1999 ; Geban et. al.,2003), chemical bonding (Peterson,Treagust and Garnett, 1989; Boo,1998), chemical equations (Yarroch, 1985; Hines,1990).One of the important subjects in chemistry is the rate of reaction concepts. Rate of reaction concepts is an essential prerequisite for some chemistry concepts, especially chemical equilibrium concepts. Therefore, students' prior knowledge of rate of reaction is important for further understanding of the chemistry concepts. So, we can limit our study to rate of reaction concepts.

Many students come to class with their own conceptions of natural phenomena that are consistent with scientific explanation. Misconceptions or conceptual difficulties of students are potential barrier or risk to academic success of students in science. These misconceptions are resistant to change and form obstacle for students' learning. To overcome these difficulties new approach proposed by educational researchers, which is called conceptual change model.

A model of conceptual change was first proposed by Posner, Strike, Hewson and Gertzog (1982) and expanded by Posner (1982).According to conceptual change model, learning occurs when knowledge is constructed by students. And students create knowledge, if they are given opportunity, and if they find their preinstructional knowledge is useless.

Some conditions must be satisfied to promote conceptual change. (Posner, Strike, Hewson and Gertzog, 1982) These are:

a) Students must be dissatisfied with existing conception.

b) Students must find new conception intelligible

c) The new conception must be plausible

d) The new conception must be fruitful

Learning in science entails more than just adding new concepts to knowledge. Science learning often requires realignment in thinking and construction of new ideas that may be in conflict with earlier ideas. Piaget (1950) described such changes as accommodation: a learner's scheme does not fit with new information so the learner must adjust existing schemas and create new connections to make sense of the new information. Learners substitute old ways of thinking and construct new ways of thinking that are based in new information they find useful. Radical change in thinking, where students concepts, principles, theories change the organization of their schemas, are evidence of conceptual change(Posner,1982).When students accomplish conceptual change they demonstrate thinking that moves them toward accepted scientific understanding and ability to use those understanding to explain , describe , and predict real - world phenomena.

Conceptual change text is one of the techniques used for conceptual change. Simply having students read a scientific explanation does not modify students' misconceptions about a science topic. Conceptual change text which presents the scientific explanation and explicitly refutes the common misconceptions is effective in altering student science content misconceptions (Weber, 1994).

Use of analogy is another strategy identified as effective in changing science content misconceptions (Guzzetti, Snyder, Glass, & Gamas, 1993). An analogy is used as explanatory tool by putting new concepts and principle into familiar terms. Analogies are powerful tools to facilitate the learners' construction process on the grounds of concepts that are already available. (Duit, 1991)

This study compared the effect of conceptual change texts oriented instruction accompanied with analogies over traditionally designed chemistry instruction. In this study, the main aid of conceptual change based lesson was to activate the students' misconceptions related with the rate of reaction concepts.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Large empirical literatures exist on everyday conceptions or misconceptions in chemistry. A review of this literature shows a number of widespread conceptions which clearly stand in the way of understanding basic chemical concepts.

Because of abstract nature, understanding chemistry concepts is difficult for most students. So, most of the chemical concepts cannot be taught merely by showing an example. Meaningful learning is important for students to understand the chemical concepts. Learning new knowledge will be meaningful, if student can relate it to previous concept that they already understand. Therefore, learning in science can be seen as restructuring of existing ideas rather than merely adding information to existing knowledge (Hackling &Garnett, 1985). BonJaoude (1992) demonstrated that learners who relate new knowledge to relevant concepts and propositions they already know (meaningful learners) were able to use information they acquire in science classes to correct misunderstandings. By creating meaningful links with concepts acquired in a chemistry course, they reduce overload and increase their processing capacity. On the other hand, rote learners do not produce coherent understandings of scientific topics and elaborate cognitive structures to reason through science problems. He concluded that instructors should select a wide range of activities to give students diverse examples of scientific concepts.

It has been found that major obstacles to solving especially conceptual problems in chemistry are the lack of understanding chemistry concepts. (Heuvelen 1991, Mcmillan and Swadners, 1991)

The study of the behavior of concepts related to rate of reaction has been fundamental part of high school chemistry courses. Because of abstract nature of this concept, students are faced with difficulties and trouble and also they have some misconceptions about the rate of reaction concept. For this reason, it is important to define and describe these misconceptions before instruction and also special instructional strategies has to be designed to show the students that scientific conception is more useful than the existing alternative conception. Therefore, this study is concerned with students' alternative conceptions about rate of reaction and the effect of conceptual change based instruction on understanding rate of reaction concept. On this ground, we examined the existing relevant literature dealing with the important variables. (e.g. misconceptions, conceptual change, analogy)

2.1 Misconception

An extensive body of research has shown that the knowledge that students bring to and bring away from the classroom is often incomplete, incorrect, and inconclusive (Driver, 1989; Osborne, 1983). Since students do build their own concepts; their constructions of a chemical concept sometimes differs from that of the science expert. In recent years, the science education literature has had many reports of studies relating to the identification, explanation, and improvement of student difficulties in understanding science concepts. Such difficulties have been characterized in various ways, for example, as misconceptions or preconceptions (Griffiths and Preston, 1992),

Misconceptions result from the interaction between learners and environments. Misconceptions are embedded in students' alternative belief system; therefore, most of misconceptions are difficult to change. Generally speaking, the possible sources of students' misconceptions are: 1. school teaching; 2. outside school teaching; 3. everyday experiences 4. social environment and 5. intuition. (Stepans, 1991; Herron, 1996).

Research on misconceptions covers virtually all grade and experience levels from pre-school age children to college students to pre-service teachers to university professors. Similarly, misconceptions occur in both science and non-science disciplines, because of the highly abstract nature of some science and non – science disciplines concepts.

Misconceptions are not easily replaced, even after students are exposed to correct mental models. Correcting misconceptions requires that learners be both aware of the misconception and dissatisfied with it and that a replacement concept be available that is intelligible, plausible, and applicable. Even though students are exposed to scientifically accurate mental models in a high school science classroom, many students tend to finish high school science courses with the same misconceptions with which they began.

Driver (1983) notes that the alternative conceptions that students have constructed to interpret their experiences have been developed over an extended period of time; one or two classroom activities are not going to change those ideas. She emphasizes that students must be provided time individually, in groups, and with the teacher to think and talk through the implications and possible explanations.

2.2 Misconceptions in Rate of Reaction

Understanding of chemistry concepts is very difficult for most students. Rate of reaction and the factors that affect them are important concepts in basic chemistry curriculum. (Cachapuz& Maskill, 1987; Ragsdale et al., 1998). In spite of its importance, it is surprising that the development of students' understanding and students' misconception about the rate of reaction has not been the focus of educational research over many years. This study may be starting point for further research in the area of rate of reaction misconceptions.

There is very little research about the students' understanding about the rate of reaction concepts. Chuephangam (2000) investigated the students misconception in rate of reaction concepts in Chemistry of Mathayom Suksa 5 students, Muang Chiang Mai District, Chiang Mai Province. The research instrument was the misconception test in Chemistry for Mathayom Suksa 5. It was found that students misconceived answers at 11.7 – 21.5 percent in the concept of the rate of reaction. The highest misconceptions in answer were 21.5 percent on the explanation of factors on the rate of chemistry reaction. The misconceptions in reasons were 6.2-18.9 percent. The highest rational misconceptions were 18.9 percent on the meaning of rate of reaction concepts.

Van Driel(2002) conducted a study related with chemical kinetics. In his research, he asked students to explain the effect of temperature on reaction rate, many students arrived at the wrong conclusion: they reasoned that collisions of fast moving particles would be less effective, because the particles would "bounce back". Some students added that the molecules would not have enough time to exchange atoms.

Kousathana and Tsaparlis (2002) in their research observed that many students in their Greek sample, of the early 80s, failed to grasp the fact that reaction yield and reaction rate are different concepts that are not directly related to each other.

Griffiths (1994) in his study reported that opinion of "Rate of reaction means the same as extent of reaction" was held by most of the secondary school students. In another research, misconception "increasing temperature increases amount of product" has been reported by Gorodetsky and Gussarksy (1986).

2.3 Conceptual Change and Conceptual Change Texts

Learning may involve changing a person's conceptions in addition to adding new knowledge to what is already there. This view was developed by conceptual change learning model.

Conceptual change model is composed of two major components. First one is the conditions that need to be meet for a person to experience conceptual change. The extent of conception that meets conditions is called as the status of a person's conception. The more conditions that a conception meets, the higher is its status. Second component is the person's conceptual ecology that provides the context for a conceptual change to occur, that influences the change and gives it meaning. According to conceptual change model, a person's conceptual ecology consists of different kind of knowledge which includes epistemological commitments to consistency and generalizability, metaphysical belief about the world and analogies and metaphors that serve to structure new information. Person's conceptual ecology plays a critical role in determining the status of the person's conception, since it influences his or her judgments whether the conditions for conceptual change have been met. (Hewson and Hewson, 1992)

In conceptual change model, learning is viewed as a conceptual change and the model distinguishes two patterns of change which are assimilation and accommodation. Assimilation is the use of existing concept to deal with new phenomena. Accommodation is the replacement or reorganization of the learner's central conceptions. Accommodation includes a permanent change that involves removing of the existing conceptions and accepting new conception.

Conceptual change is interpreted as a context-appropriate change to the chemical concept and a broadening of the learned chemical concept (Duit, 1996).Conceptual change is also described as a process of a change from the learner's prior conceptions to some intermediate conceptions then to scientific conceptions.

Dykstra, Boyle and Monarch (1992) claimed that conceptual change is a progressive process of refinement of students' conceptions and they define taxonomy of conceptual change as a differentiation, class extension and reconceptualization. Chi and Roscoe (2002) conceive of conceptual change as repair of misconceptions.

Starting with naive conceptions, students must identify their faulty conceptions and repair them. In this view, misconceptions are miscategorizations of concepts, so conceptual change is the reassignment of concepts to correct categories.

The model of learning a conceptual change suggest that there are conditions which a new conception has to satisfy before it can be integrated with existing knowledge . For a learners to undergo conceptual change , (Posner, Strike, Hewson and Gertzog, 1982)

1) They must be dissatisfied with the existing conception,

2) A new conception has to be intelligible. That is, the person considering it knows what it means and can construct a coherent representation of it. He or she can see that it is internally consistent without necessarily believing it to be true.

3) A new conception has to be plausible. A person who finds it so must find it intelligible and must also believe it to be true. This means that it can be reconciled with other existing conceptions.

4) A new conception has to be fruitful. It is so when it serves to resolve problems, to suggest new approaches. In other words, it provides explanatory and predictive power.

Cognitive conflict strategies, derived from a Piagetian constructivist view of learning, are effective in teaching for conceptual change (Duit & Wilbers, 1999). These strategies involve creating situations where learners' existing conceptions about a phenomenon or topic are made explicit and then directly challenged in order to create a state of cognitive conflict or disequilibrium. Cognitive conflict strategies are aligned with Posner theory of conceptual change in that their common goal is to create the four conditions necessary for conceptual change. Disequilibrium can occur when new information does not fit an existing schema. When this happens, the learner either assimilates in which the student adapts new information to preexisting schemes or accommodates in which the student creates new schemes to understand the new material.

Cognitive conflict has been used as the basis for number of models and strategies for teaching for conceptual change. Among these are the Generative Learning Model (Osborne&Cosgrove, 1983), the Ideational Confrontation Model (Champagne, Gunstone, & Klopfer, 1985), and an instructional strategy using anomalous data (Chinn & Brewer, 1993). Although these models suggest different methods and techniques, they all share a structure similar to the conceptual change teaching strategy proposed by Novick and Nussbaum (1982):

1. Reveal student preconceptions
2. Discuss and evaluate preconceptions
3. Create conceptual conflict with those preconceptions
4. Encourage and guide conceptual restructuring

Simple presentation of chemistry concepts is usually not sufficient for students to getting them to change their thinking about the how the world works. One of the more effective approaches is confronting students with discrepant events that contradict their existing conceptions to foster conceptual change. This is done with diequilibration techniques (Dykstra and Minstrell, 1988; Minstrell, 1989) or conceptual conflict that induces students to reflect their conceptions when trying to resolve the conflict. In other words, cognitive conflict forces students to construct new schemas.

Several researchers have suggested instructional strategies to bring about conceptual change. (Osborne and Cosgrove, 1983; Hewson and Hewson, 1988; Novick and Nussbaum,1982). Main points of these strategies include providing facilities for students to expose their conceptions, investigation of students' misconception to create cognitive conflict and application of new conception to experience its usefulness and facilitate accommodation.

A conceptual change text is the one of the techniques that address student misconceptions and foster conceptual change. Conceptual change text attempts to acknowledge the learners' existing conceptions and contrasts them with the more scientifically accepted conception, often through a historical progression. Conceptual change text is designed to at least partially meet Posner, Strike, Hewson, & Gertzog's (1982) conditions for conceptual change. Guzzetti, Snyder, Glass, and Gamas (1993) found in their research that conceptual change text was more effective than regular text at producing conceptual change in students. Conceptual change text is more successful than demonstration, or group discussion in producing long-term conceptual learning of counterintuitive information (Hynd & Alvermann, 1986; Hynd, Alvermann, & Qian, 1993).

Andre and Chambers (1997) investigated the use of conceptual change text on learning electric circuit concept. And they found that conceptual change text more effective than the traditional text in conceptual understanding of electric circuit concept.

Hynd et al. (1994) compared the effect of demonstration, discussion and conceptual change text on conceptual change in physics. Result of the study show that conceptual change text is more successful method than demonstration and discussion in changing students' naive ideas to scientific ones.

Uzuntiryaki (1998) investigated the effect of conceptual change texts accompanied with concept mapping instruction through the instructor lecture on 8th grade students' understanding of solution chemistry. Result of the study showed that the conceptual change text accompanied with concept mapping instruction caused a significantly better acquisition of scientific conceptions than the traditionally designed chemistry instruction.

Geban and Bayır (2000) conducted a research to investigate the effectiveness of conceptual change texts instruction over the traditionally designed chemistry instruction on 9th grade students' understanding of chemical change. The result of the study showed that students in conceptual change text instruction group had a significantly higher score with respect to achievement than the students in the traditionally designed instruction group.

Sungur et al. (2001) conducted a study to determine the results of promoting conceptual change through the use of conceptual change texts and concept mapping. The results of the study indicate support for facilitation of an environment consisting of debate, discussion, and increased participation. The students realized and became dissatisfied with their misconceptions and were receptive to the new, correct information. They realized the new concept was more meaningful through active involvement (Sungur, et al. 2001).

Çakır et al. (2001) compared the effectiveness of conceptual change text oriented instruction and traditional instruction on students` understanding of cellular respiration concepts and their attitudes toward biology as a school subject. Result of the study indicated that students exposed to conceptual change texts oriented instruction had better understanding of cellular respiration concepts than those exposed to traditional instruction.

2.4 ANALOGIES

By definition, an analogy refers to comparisons of structures between two domains. An analogy may be viewed as a statement of comparison on the basis of similarities between the structures of two domains. An analogy is used as explanatory tool by putting new concepts and principle into familiar terms. Analogy serves a creative function when it stimulates the solution of existing problems, the identification of new problem and the generation of hypothesis (Glynn et al, 1989). Analogical reasoning can be successful if students are familiar with the analog domain. Students must see the connection between the analog and target concept to achieve analogical reasoning. (Gabel & Samuel, 1986)

An analogy enables valid concepts from a familiar domain to be used to challenge the student's alternative conceptions with the result that the learner may be stimulated to reconstruct his or her knowledge.(Sutula & Krajcik , 1988) Successful use of analogies help students to modify their existing cognitive structure.(Shapiro,1985)

According to Gentner (1989), an analogy is a mapping of knowledge between two domains such that the system of relationships that holds among the objects in the analog domain also holds among the objects in the target domain. Thus, the purpose of an analogy is to transfer a system of relationships from a familiar domain to one that is less familiar (Mason & Sorzio, 1996).

Analogies can play several roles in promoting meaningful learning. They can help learners organize information or view information from a new perspective. Thiele & Treagust (1991) argue that analogies help to arrange existing memory and prepare it for new information.

Analogies are powerful tools to facilitate the learners' construction process on the grounds of concepts that are already available. (Duit, 1991) There are some advantages of analogies. These are:

1) They are valuable tools in conceptual change learning.

2) They may facilitate an understanding of the abstract concepts.

3) They may help students to visualize abstract.

4) They force the teacher to take students' prior knowledge into consideration.

Analogy plays a central role in conceptual change. Effective analogies can clarify thinking, help students overcome misconceptions, and give students ways to visualize abstract concepts. Misleading or confusing analogies, on the other hand, can be more than just a waste of class time.

Analogies can play an important role in promoting conceptual change by helping students overcome existing misconceptions (Dagher, 1994; Mason, 1994; Venville & Treagust, 1996; Gentner et al., 1997). Analogy allows the application of preexisting conceptual structure to new problems and domains, and hence supports the rapid learning of new systems. Ideally, analogies can help students recognize errors in conceptions they currently hold, reject those conceptions, and adopt new conceptions that are accepted by the scientific community. Analogies may make new ideas intelligible and initially plausible by relating them to already familiar information. If students can assimilate new information in terms of their existing knowledge, they are likely to be able to understand that information, relate it in their own words, and comprehend how that new information might be consistent with reality all necessary conditions for conceptual change. In his review, Duit (1991) shows that analogies are effective conceptual change agents because they enhance understanding by making connections between scientific concepts and the students' life-world experiences and by helping students visualize abstract ideas. He points out that analogies provoke students' interest and may therefore motivate them.

Many research reported the positive effects of analogy usage. (Harrison & Treagust, 1993; Treagust, Harrison, & Venville, 1996; Glynn & Takahashi, 1998).In their research, Black & Solomon (1987) investigated students' use of analogies in electric current concept. The result showed that analogies presented helped students to learn. And also they indicated that analogies were helpful since they allowed the students to construct their own knowledge by forcing them to view the new knowledge within the framework of the analogy.

Genther and Genther (1983) in their study indicated that analogies helped students in problem solving process of electric circuit concept. They also found that high school students who was applied " flowing fluid "or a " moving crowd" analogy are considerably different from other high school students who didn't show analogical reasoning in their learning process.

There has been little research about the usage of analogies in chemistry classes. Gabel and Samuel (1986) conducted a study to determine the effects of analogies when solving molarity problems. Results of the study indicated that students' achievement in certain molarity problems might be improve by using analogies if students saw the connection between analog and target concepts.

Gabel, Samuel and Friedel (1990) also investigated the usage of analogies in teaching stoichiometry concepts. At the end of the study, researchers found that analogies were not effective for teaching chemistry under the condition they were used in the study.

Although, analogies are commonplace in human communication, they are not as effective in the classroom as might be expected. (Duit, 1991) Uncritical use of analogies may generate misconceptions. (Champagne, Gunstone & Klopfer, 1985) and this is especially so when unshared attributes are treated as valid (Osborne&Cosgrove, 1983; Curtis & Reigeluth,1984) or when where the learners are unfamiliar with the analogy(Gentner & Gentner, 1983; Nagel,1961) So, analogy must be used with greater care and the analog must be true description of target concept.

It can be said that the main difference between current study and other studies is the treatment method on understanding of rate of reaction concepts. There were no studies that compare the effect of conceptual change texts oriented instruction accompanied with analogies over traditionally designed chemistry instruction related with rate of reaction concepts. Also, multiple choice test was developed to identify students' misconceptions about the rate of reaction concepts.

CHAPTER 3

PROBLEMS AND HYPOTHESIS

In this part, the main problems, sub-problems and hypotheses will be presented.

3.1 The Main Problems and the Sub-Problems

3.1.1. The Main Problem

The main aim of this study is to examine the effectiveness of conceptual change texts oriented instruction accompanied with analogies over traditionally designed chemistry instruction on 10^{th} grade students' understanding of rate of reaction concepts and attitudes towards chemistry as a school subject.

3.1.2 The Sub – Problems

1. Is there a significant difference between the effects of traditionally designed chemistry instruction (TDCI) and conceptual change texts oriented instruction accompanied with analogies (CCTIA) on students' understanding of rate of reaction concepts when the effect of students' science process skills are controlled as a covariate ?

2. Is there a significant difference between the girls and boys with respect to their understanding of rate of reaction concepts when the effects of students' science process skills are controlled as a covariate?

3. Is there a significant effect of interaction between gender and treatment on students' understanding of rate of reaction concepts when the effect of students' science process skills are controlled as a covariate?

4. What is the effect of students' science process skills on their understanding of rate of reaction concepts?

5. Is there a significant difference between the effects of TDCI and CCTIA on students' a ttitudes toward chemistry as a school subject?

6. Is there a significant difference between girls and boys with respect to their attitudes toward chemistry as a school subject?

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

3.2 Hypotheses

In this study, the following hypotheses were developed related with problems to find solution. All hypotheses were stated in null form at a significant level of 0.05.

H_o1: There is no significant difference between post-test mean scores of the students taught with TDCI and those taught with CCTIA with respect to their understanding of rate of reaction concepts when the students' science process skills are controlled.

H_o2: There is no significant difference between post-test mean scores of girls and boys with respect to their understanding of rate of reaction concepts when the students' science process skills are controlled.

H_o3: There is no significant effect of interaction between gender and treatment on students' understanding of rate of reaction concepts when the effect of students' science process skills is controlled.

H_o4: There is no significant contribution of students' science process skills to the variation on their understanding of rate of reaction concepts.

H_o5: There is no significant difference between post-test mean scores of the students taught with TDCI and those taught with CCTIA with respect to attitudes toward chemistry as a school subject.

H_o6: There is no significant difference between boys and girls with respect to their attitudes toward chemistry as a school subject.

H_o7: There is no significant effect of interaction between treatment and gender difference on students' attitudes toward chemistry as a school subject.

CHAPTER 4

DESIGN OF THE STUDY

4.1 The Experimental Design

In this study, Non-Equivalent Pretest-Posttest Control Group Design was used to evaluate students' development.

Table 4.1 Research Design of the Study

Groups	Pre-test	Treatment	Post-test
EG	RRCT,ASTC,SPST	CCTIA	RRCT, ASTC
CG	RRCT,ASTC,SPST	TDCI	RRCT, ASTC

In this table, EG represent the experimental group and CG is the control group. In this study, experimental group was instructed by conceptual change texts oriented instruction accompanied with analogies and control group was instructed with traditionally designed chemistry instruction. RRCT was the rate of reaction concepts test. ASTC was the attitude toward chemistry as a school subject. SPST was the science process skills test. CCTIA was the conceptual change texts oriented instruction accompanied with analogies and TDCI was the traditionally designed chemistry instruction.

RRCT, ASTC, SPST were given both groups before treatment as a pretest to investigate the effect of treatment on dependent variables and also to control students' understanding of rate of reaction concepts, attitudes towards chemistry and science process skills. RRCT, ASTC were administered to both groups at the end of the treatment to examine the effect of treatment.

4.2 Subjects of the Study

In this study 56 10^{th} grade students from the Atatürk Anatolian High School which was instructed by same chemistry teacher took part. This study was carried out during 2003-2004 spring semester.

In this study, two instructional methods were used and these methods were randomly assigned to each group. Experimental group was instructed with CCTIA while control group received TDCI. Both experimental group and control group was composed of 28 students.

4.3 Variables

In this study, there were two variables; independent and dependent variables.

4.3.1 Independent Variables

Treatment (CCTIA and TDCI), science process skills scores measured by SPST and genders are the independent variables in this study.

4.3.2. Dependent Variables

Students' understanding related with the rate of reaction concepts evaluated by RRCT and students' attitudes toward chemistry as a school subject evaluated by ASTC were the dependent variables in this study.(see table 4.2)

Table 4.2. Types of Variables

Variables	Type
RRCT Scores	Dependent
ASTC Scores	Dependent
Treatment (CCTIA and TDCI)	Independent
SPST Scores	Independent
Gender	Independent

4.4. Instruments

4.4.1 Rate of Reaction Concepts Test (RRCT)

Rate of reaction concepts test was developed by the researcher to measure the students' understanding of rate of reaction concepts. This test was composed of 24 multiple choice questions. There were four alternatives for each of the questions and distractors reflect the misconceptions. Rate of reaction concepts test was composed of concepts stated below to evaluate students' misconceptions and their conceptual misunderstandings.

1. Rate of reaction and its measurement
2. Collision theory
3. Activation Energy
4. Factors affecting reaction rate
    i. Effect of concentration
    ii. Effect of temperature
    iii. Effect of catalyst
    iv. Effect of surface area
5. Reaction mechanism, rate law, order of reaction

In Atatürk Anatolian high school, English is used as an educational language. So, English version of the rate of reaction concepts test was prepared. In the test, students' misunderstanding caused by complex vocabulary was diminished by using simple vocabulary. Test was composed of qualitative questions in which students make prediction about the phenomena and wrong responses reflect the students' misconceptions related with reaction rate concepts.

In construction period of the test, content of the rate of reaction concepts was examined and then instructional objectives were stated (See Appendix A). Students' misconceptions searched in the internet resources and also chemistry literature. Items of the test were prepared according to students' misconceptions and the instructiona l objectives.

Table 4.3. A classification of students' misconceptions

Misconceptions	**RRCAT Item**
I. Reaction rate and its measurement	
a. All chemical reactions are instantaneous or at least extremely fast.	21B*
b. Rate of reaction means the same as the extent of reaction.	12A,21C
II.Collision Theory	
a. All molecular collisions lead to a chemical reaction.	1A,5A
III. Activation Energy	
a. Activation energy does not affect the rate of reaction.	13 D
b.Activation energy is the highest point in number of molecules & kinetic energy graph.	13 B

* Alternative B of item 21 in RRCT

Table 4.3.continued

IV. Factors affecting reaction rate a. One can increase the rate of reaction by vigorous stirring, which results in more energetic collisions. b.The rate of reaction is constant throughout the reaction	 9B 14B,21D
i. Effect of Concentration a. Increasing the concentration of reactant always increases the rate of reaction.	 10C
ii.Effect of Temperature a. In exothermic reactions, reaction rate decrease when temperature increases. b. A faster rate of reaction means that more products are produced.	 6A,15C 3B,19B,23 A
iii.Effect of Surface Area a. To increase the rate of any reaction, you can increase the surface area of the reactants.	 4A,B,D, 10A
iv. Effect of Catalyst a. When catalyst is added to a reaction, only pathway with lower activation energy is available. b. A catalyst is a species that increase the rate of reaction but does not change or participate in the reaction. c. A catalyst produces higher yield of product. d. Catalyst cannot decrease the reaction rate. e. Catalyst is needed to initiate reaction.	 20B,22B 11A,20A 19A,20C 11C 22D
V.Reaction Mechanism, Rate laws and Order of reaction a. Students may have difficulty with the concept of slowest step determines the rate of reaction.	 16A

Table 4.3.continued

b. The exponents in the rate laws are the coefficient in the balanced equation for the reaction.	7B
c. Students confuse reaction intermediate and catalyst in reaction mechanism.	16B
d. The mechanism of a reaction can be deduced from the overall balanced chemical equation	12B,17A
e. Fast step determines the rate in reaction mechanism.	7A

To examine content validity and appropriateness, the items were evaluated by chemistry teachers and chemistry education expert. In addition, reliability of the test was found 0.64 after making reliability analysis.

Rate of reaction concepts test was administered before instruction as a pre-test to evaluate students' prior knowledge about the rate of reaction concepts. And it was also applied as a post-test to evaluate the effects of treatment on students' understanding of rate of reaction concepts. (See Appendix B)

4.4.2. Attitude Scale Toward Chemistry (ASTC)

This scale developed by Geban and Ertepınar consisted of 15 items in a point likert scale (fully agree, agree, undecided, partially agree, fully disagree) in Turkish (Geban et al., 1994). In this study this scale was applied as a pre-test and post-test to evaluate students' attitude. Reliability of the scale was found 0.83. (See Appendix E)

4.4.3. Science Process Skills Test (SPST)

Science process skills test originally developed by Okey, Wise and Burns (1982) and translated and adjusted into Turkish by Geban, Aşkar, Özkan (1991) contains 36 multiple choice questions. Each question contains four alternatives. This test was administered to both groups, experimental and control, at the beginning of the study. The reliability of the test was found 0.85. Science process skills test measures different objectives. These objectives are; identifying variables, identifying and stating hypothesis, operationally defining, designing investigation and graphing and interpreting data (See Appendix D).

4.5. Treatment (CCTAI vs. TDCI)

This research was carried about four weeks during the 2003-2004 spring semesters. 56 tenth grade students in two classes taught by the same chemistry teacher were participated in the study.

Two different instructional methods were applied to two groups, experimental and control. Experimental group was instructed by conceptual change texts oriented instruction accompanied with analogies and the control group received traditionally designed chemistry instruction. RRCT, ASTC and SPST were applied as pretests to both groups at the beginning of the research to determine whether these two groups were equivalent in those parameters.

Chemistry classroom instruction was three 45 minute period per week. And during the study rate of reaction concepts was covered as a regular chemistry classroom instruction. During the study each class received the same amount of teaching time. Students were engaged same materials and assignments except for conceptual change texts and analogies. Equal opportunities were supplied to students in each group to perform activities.

In traditionally designed chemistry instruction, lecture method was used by teacher. Teaching methods was mainly based on teacher explanation and textbooks. So, students' misconceptions were not considered. Teacher presented topic on the blackboard by giving definition of the concepts. And also during instruction, quantitative problems related with rate of reaction concepts were solved by teacher to teach concepts. Students' involvement to lecture was limited during instruction. Questioning method was also used by teacher.

In conceptual change texts oriented instruction accompanied with analogies, conceptual change text was given students in experimental group during class hours. Before treatment, teacher was trained about conceptual change texts and their usage. Conceptual change texts were prepared by the researcher in the light of the information gained by literature review and internet resources. Conceptual change texts were designed to address students' misconceptions about the rate of reaction concepts. Conceptual change texts presented the information that illustrated inconsistencies between common misconceptions about the rate of reaction concepts and scientific knowledge. Conceptual change texts also included examples, figures to activate students' misconceptions about the rate of reaction concepts. And also scientifically correct explanations which were plausible and intelligible were presented in the texts.

Conceptual change text was composed of five main parts.

1. Rate of reaction and its measurement
2. Collision theory
3. Activation Energy
4. Factors affecting reaction rate
   i. Effect of concentration
   ii. Effect of temperature
   iii. Effect of catalyst

iv. Effect of surface area

5. Reaction mechanism, rate law, order of reaction

In conceptual change texts, students misconceptions in rate of reaction identified and correct scientific explanation of the phenomena presented with example and also analogies.(See Appendix C) Some of the concepts that students held misconceptions and confronted with difficulties were taught with analogies by presenting in conceptual change texts. In this way, students were expected to dissatisfy with their current conceptions. During construction of analogies, analog and target concepts about the rate of reaction concepts were carefully examined. And then analogies were produced in the light of the target concepts. Some analogies were taken directly by internet resources and adapted into the rate of reaction concepts. Before study, teacher was instructed about the usage of analogies and also their limitations.

During the study, researcher met with teacher to follow that she was carrying treatment both groups appropriately. Researcher contacted with teacher in many times, to answer the questions and solve the problems that teacher faced during the study. Also, experimental and control group class were visited randomly during the treatment to confirm that the rate of reaction topics were covered perfectly.

Each part of conceptual change texts were given to students to read in 2 or 3 days before the regular chemistry class hours. When the rate of reaction concept was covered in class, students were directed to read the text by the teacher. Texts presented the proof that why students' intuitive ideas was incorrect and also gave the scientifically correct explanation of the phenomena. After reading the texts, teacher asked to students if there were any points in the texts that contradict with their ideas. Teacher also asked to students about their opinion related with the explanation which was presented in the texts. In each part of the rate of reaction concepts, conceptual change texts were provided for students. And after reading text, students and teacher discussed the conceptual change texts. In addition, teacher revealed students' misconceptions by asking questions and explaining correct scientific explanation of the phenomena.

4.6 Analysis of Data

ANCOVA statistical method was used to compare the effectiveness of instructional methods and also gender differences on students' understanding of rate of reaction concepts while effect of students' science process skills were controlled as a covariate. ANCOVA was also used to determine the contribution of science process skills on students' understanding of rate of reaction concepts. To examine the difference of post-test mean scores of both groups, CCTIA and TDCI, with respect to attitudes toward chemistry as a school subject, ANOVA statistical method was used. ANOVA statistical method was also used to investigate effect of gender differences on students' attitude toward chemistry as a school subject.

4.7. Assumptions and Limitations

4.7.1. Assumptions

1) Experimental and control group students did not interact during treatment.

2. Students in both groups were sincere and accurate in answering questions in the instruments used in the study.

3. Teacher was not biased during study.

4. Besides conceptual change text, other methods that modify the post-test results of the students were not used in the experimental group.

4.7.2 Limitations

1. The study was limited to rate of reaction concepts.

2. The subjects of the study were limited to 56 tenth grade students from Atatürk Anatolian high school.

CHAPTER 5

RESULTS AND CONCLUSION

In this chapter, the results of the hypotheses were presented. To test the hypotheses ANCOVA and ANOVA models were used at a significant level of 0, 05. Statistical analyses were carried out by using the SPSS/PC (Statistical Package for social sciences for personal computers.)

5.1 Results

In order to identify students' previous knowledge about the rate of reaction concepts, prior attitudes toward chemistry as a school subject and their science process skills, RRCT, ASTC and SPST were administered before treatment as pretests.

The results of the analysis showed that there was no significant difference between CCTIA and TDCI group in terms of rate of reaction concepts achievement ($t = 0,48$, $p > 0,05$) ; attitudes toward science as a school subject ($t = 1,18$, $p > 0,05$) ; and science process skill ($t = 1,58$, $p > 0,05$).

Hypothesis 1:

Analysis of covariance was used to test questions stated by hypothesis 1 that there is no significant difference between post-test mean scores of the students taught with TDCI and those taught with CCTIA with respect to their understanding of rate of reaction concept when the students' science process skills are controlled. The results of the analysis were presented in table 5.1.

Table 5.1 ANCOVA Summary (Achievement)

Source	df	SS	MS	F	P
Covariate (Science Process Skills)	1	34,897	34,897	6,571	0,013
Treatment	1	196,279	196,279	36,862	0,000
Gender	1	0,700	0,700	0,132	0,718
Gender*Treatment	1	0,529	0,529	0,099	0,754
Error	51	271,558	5,325		

The result of the analysis showed that there was a significant difference between post-test mean scores of the students taught with TDCI and those taught with CCTIA with respect to their understanding of rate of reaction concepts. The score of the CCTIA group is significantly higher than the TDCI group. ($\overline{X}$(CCTIA) = 20.61, $\overline{X}$ (TDCI) = 17.00) Figure 5.1 showed proportions of the correct responses to the questions in the post-test.

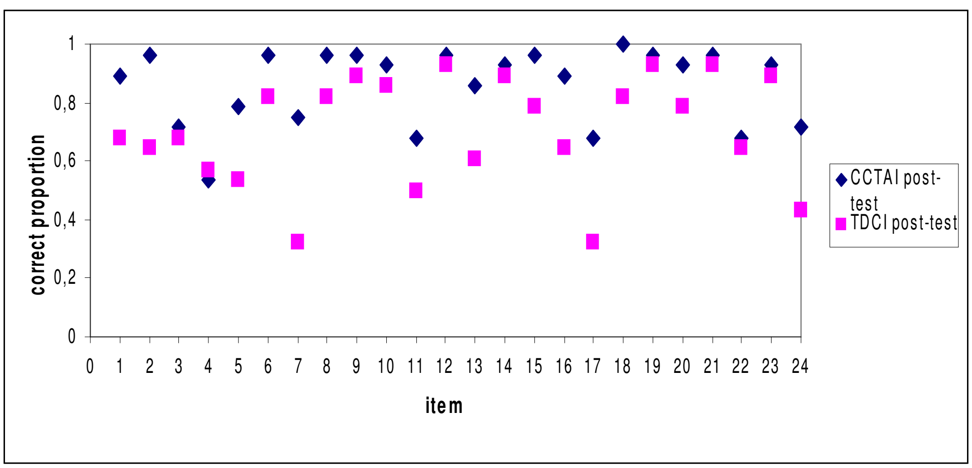

Figure 5.1. Comparison between post-test scores of CCTAI and TDCI

It can be seen from the figure that there is a difference in response to RRCT items between CCTIA group students and TDCI group students. Lower proportion of students in TDCI group answered correctly question 7,11,17,14. In question 7, rate equation (rate law) of the reaction was asked to students. Common misconception among the students related with the rate of reaction is that rate equation is written according to fast step or net reaction equation. % 32 of students in the TDCI group did correctly question 7, while % 75 of students in CCTIA group answered this question correctly. This result showed that higher proportion of the students in the TDCI group still has misconception about writing of rate equation (law). Many students confuse the function of the catalyst. Alternative conception held by students was that catalyst does not participate in to reaction and catalyst only affects reaction by increasing rate. Question 11 was related catalyst. After treatment, % 50 of the students in TDCI group answered correctly question 1, while % 67.9 of the students in CCTIA group did it correctly. Most of the students confuse reaction intermediate and catalyst in the reaction mechanism. Question 16 was asked students to examine this fact. Proportion of the students' correct response in qu estion 16 in TDCI group was %64.3, while in CCTIA group it was %89.3. Question 1 and 5 were related to collision theory. For both questions, correct response rate was higher in CCTIA group students then the TDCI group students. Question 4 was asked students to inspect their ideas about the surface area effect on rate of reaction. Common misconception held by students that to increase the rate of any reaction, you can increase the surface area of the reactants. After treatment, almost equal proportion of the students in both group answered correctly question 4. Question 6 and 15 were related with the effect of temperature on rate of reaction. Both groups showed improvement after treatment. But correct response rate is higher in CCTIA group then the TDCI group. After treatment the average correct response percent was %71 for TDCI group and %86 for CCTIA group. So, we can conclude that students in CCTIA group understood rate of reaction concept better than the TDCI group students.

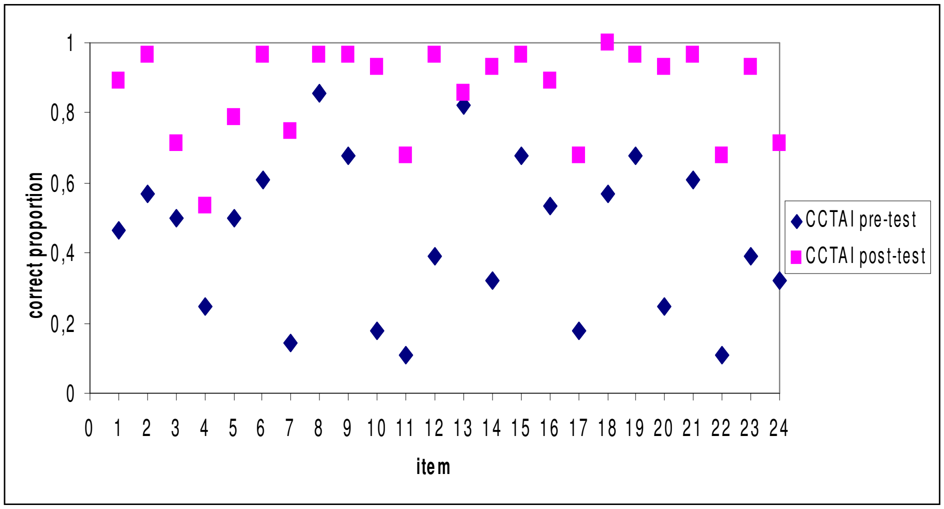

Figure 5.2. Comparison between pre-test and post-test scores of students in CCTIA group.

The average correct response percent was %45 before treatment, and after treatment this percent raised to %86. Students made a greater improvement in questions 1, 7,11,12,14,20,22,23. For example, in question 20, %75 of the students held misconception about the properties of catalyst. But after treatment only %7.1 of the students held this misconception.

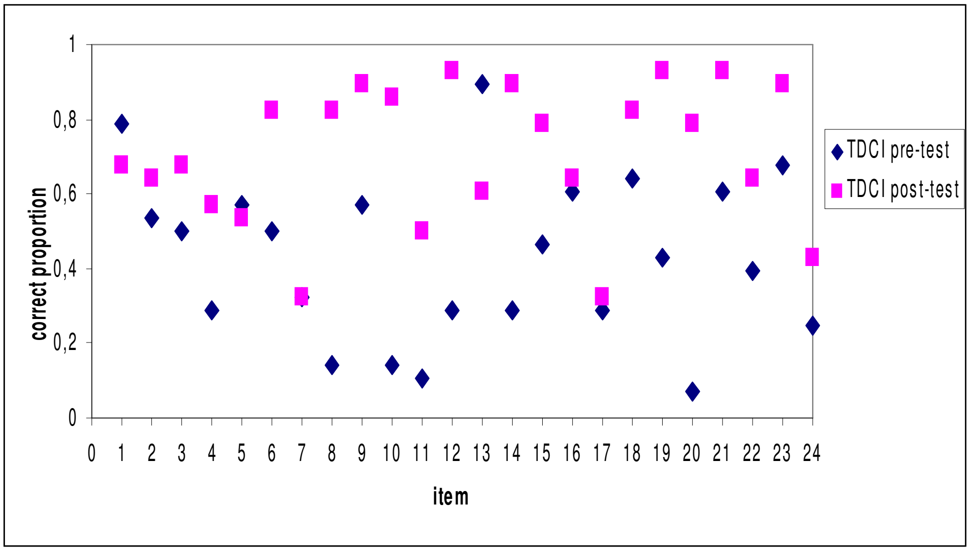

Figure 5.3. Comparison between pre-test and post-test scores of students in TDCI group.

In TDCI group, average correct response percent was %43 before treatment, and after treatment this percent raised to %71. The difference between pretest and posttest scores was greater in CCTIA than the TDCI group. This result showed that TDCI group showed progress but not as much as CCTIA group. Students in TDCI group made greater improvement in question 1,5,13. But treatment made a negative effect for questions 1,5,13. The number of students' misconceptio n increased in question 1, 5 which were related to collision theory. This result showed that instruction sometimes may generate misconceptions. Treatment made a little difference in questions 2, 3, 7,16,17,24. For example, question 7 was related to writing of rate equation or rate law. And after treatment % 68 of the TDCI group students held misconception that the fast step determines the rate law or rate law is written according to net reaction equation.

In the light of the result, we may say that students in CCTIA group understood rate of reaction concepts better than the students in TDCI group.

Hypotheses 2:

To test the hypotheses in which there is no significant difference between post-test mean scores of girls and boys with respect to their understanding of rate of reaction concepts, ANCOVA was used by controlling the effect of students' science process skills. The result of the analysis showed that there was no significant difference between the performance of boys and girls with respect to their understanding of rate of reaction concepts. ($F = 0{,}132$, $p = 0{,}718$) Boys and girls were equivalent in terms of their understanding of rate of reaction concepts

Hypotheses 3:

To answer the question posed by hypotheses 3 in which there is no significant effect of interaction between gender and treatment on students' understanding of rate of reaction concept, ANCOVA was used by controlling the effect of students' science process skills. The results showed that there was no significant effect of interaction between gender and treatment on students' understanding of rate of reaction concepts. ($F = 0{,}099$ $p = 0{,}754$)

Hypotheses 4:

Analysis of covariance was used to test question stated by hypotheses 4 there is no significant contribution of students' scien ce process skills to the variation on their understanding of rate of reaction concept. Results showed that science process skills made a significant contribution to the variation on students' understanding of rate of reaction concepts ($F = 6{,}571$, $p = 0{,}013$).

Hypotheses 5:

ANOVA was used to test question stated by hypotheses 2 that there is no significant difference between post-test mean scores of the students taught with TDCI and those taught with CCTIA with respect to attitudes toward chemistry as a school subject. The result of the analysis was given in table 5.2.

Table 5.2. ANOVA Summary (Attitude)

Source	df	SS	MS	F	P
Gender	1	92,192	92,192	0,858	0,359
Treatment	1	481,906	481,906	4,483	0,039
Gender*Treatment	1	22,478	22,478	0,209	0,649
Error	52	5590,044	107,501		

The result of the analysis showed that there was a significant difference between post-test mean scores of the students taught with TDCI and those taught with CCTIA with respect to attitudes toward chemistry as a school subject. CCTIA group showed more positive attitudes than TDCI group after treatment. ($\bar{X}$(CCTIA) = 57.43 , $\bar{X}$(TDCI) = 50.93)

Hypotheses 6:

ANOVA was used to test the hypotheses 6 in which there is no significant difference between boys and girls with respect to their attitudes toward chemistry as a school subject. Result of the analysis showed that there was no significant difference between boys and girls with respect to their attitudes toward chemistry as a school subject ($F = 0{,}858$, $p = 0{,}359$). In both groups, boys and girls were equal after treatment with respect to their attitude toward chemistry as a school subject.

Hypotheses 7:

To answer question posed by hypotheses 7 in which there is no significant effect of interaction between treatment and gender difference on students' attitudes toward chemistry as a school subject, ANOVA was used. Result of the analysis showed that there was no significant effect of interaction between treatment and gender difference on students' attitudes toward chemistry as a school subject. ($F = 0,209$, $p = 0,649$)

5.2. Conclusions

The following conclusion can be derived from the results:

1. The CCTIA caused significantly better acquisitions of scientific conceptions related to rate of reaction concept and elimination of alternative conceptions than TDCI.

2. The CCTIA produced significantly higher positive attitudes toward chemistry as a school subject than TDCI.

3. Both CCTIA and TDCI groups improved their understanding. So, it can be drawn that the growth in understanding of rate of reaction concepts is statistically significant, but the growth was higher in CCTIA group.

4. Students' science process skills were a strong predictor for the understanding of rate of reaction concepts.

5. Boys and girls were equivalent in terms of their understanding of rate of reaction concepts.

6. There was no significant effect of interaction between gender and treatment in students' achievement related to rate of reaction concepts

7. In both groups, boys and girls were equal after treatment with respect to their attitude toward chemistry as a school subject.

8. There was no significant effect of interaction between treatment and gender difference on students' attitude s toward chemistry as a school subject.

CHAPTER 6

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

In this chapter result of the analysis presented in previous chapter will be discussed and also implications and recommendation for further research will be presented.

6.1 Discussion

The main purpose of this study was to compare effectiveness of the conceptual change texts oriented instruction accompanied with analogies and traditionally designed chemistry instruction on 10^{th} grade students' understanding of rate of reaction concepts. Students' misconception in rate of reaction concepts was also investigated.

As mentioned earlier, rate of reaction concepts test was administered to both groups before treatment as a pretest. Pretest result indicated that there was no significant differences between the pretest mean scores of two groups. Therefore, it can be said that both groups were equivalent with respect to their understanding of rate of reaction concepts before treatment. After treatment, same test was given to all students in both groups to examine the effects of two different instructional methods on understanding of rate of reaction concepts. RRCT post-test result showed that students in the CCTIA group got higher scores than the students in TDCI group. In the light of the result of the analysis, it may be concluded that conceptual change texts oriented instruction accompanied with analogies was more effective in elimination of misconceptions and better acquisition of scientific conceptions than traditionally designed chemistry instruction. If the results of RRCT post-test scores were compared, average correct response of CCTIA group was % 86 and the TDCI group was %71.The differences in RRCT post-test scores may be result of the treatment. This findings is supported by findings of Beeth (1997), Andre and Chamber (1997), Hynd et al.(1994), that conceptual change instruction was more effective method when compared to other instructional methods. There may be some reasons why experimental group students got higher scores than the control group. Students in the experimental group were engaged conceptual change texts which helped students to think about their prior knowledge and also these texts emphasized the students' misconceptions about the rate of reaction concepts. But in control group, students were instructed with traditional texts and teacher explanations. And traditional texts did not consider students' misconceptions. So, while students in experimental group became dissatisfied with their existing conceptions and thought about their prior knowledge and willing to accept scientifically correct explanation of the phenomena, students in the control group showed a little improvement about clarifying misconceptions related with rate of reaction concepts.

When conducting study, CCTIA group was instructed with conceptual change text oriented instruction accompanied with analogies. In this study, conceptual change texts were prepared to indicate the differences between students' intuitive ideas and correct scientific knowledge. Rate of reaction conceptual change texts created conceptual conflict by explaining why students' intuitive ideas were incorrect and also scientifically correct explanation of the phenomena was presented in the texts. These texts activated students' misconception and provided opportunity for students to revise and reconstruct their ideas about the scientific phenomena by refuting the alternative conceptions. Conceptual change texts were also powered with analogies. Because of the abstract nature of the science concepts, most of the students cannot relate their previous knowledge to new knowledge during instruction. Analogies provide special learning environment by presenting target concepts with the help of the analogs that are known. During treatment, students in CCTIA group actively participated into the instruction and there was a strong interaction between teacher and students. After students read the texts, students discussed their ideas about the rate of reaction concepts with teacher. And the students were willing to enrolled these discussion sessions. Therefore, discussion of the rate of reaction concepts could facilitate conceptual understanding of the students. In that way, students that were dissatisfied with the existing knowledge became persuaded to accept scientifically correct explanation of the phenomena. When conceptual change texts were used as a teaching strategy it is important to give enough time for students to think about their prior conceptions. Teacher also provided feedback to students while students were engaged with conceptual change text by stating common students' misconception about the rate of reaction concepts. However, in traditionally designed chemistry instruction, students' prior knowledge was not taken into account and rate of reaction concepts was presented by using traditional chemistry text and also algorithmic problems was solved by teacher during instruction. Students' participation was limited dur ing instruction. In other words, they were passive listeners during study. This may be the one reason why students in the TDCI group got poor result in RRCT. Consequently, Students' conceptual understanding was weaker in TDCI group than the CCTIA group students. RRCT was composed of qualitative questions which required conceptual understanding of the phenomena. Items in the RRCT were prepared for students to make prediction about the natural phenomena. But traditionally designed chemistry instruction did not make any contribution to students' conceptual understanding.

Science process skills test was administered to both groups of students to examine its effect on their understanding of rate of reaction concepts. The result of the analysis indicated that science process skills accounted for significant portions of variation on understanding of rate of reaction concepts. In order to solve abstract and complex chemistry problems, students should be able to use suitable conceptual framework. Conceptual qualitative problems in science and especially chemistry require students to identify variables, state hypothesis, define operation, design investigation, graph and interpret data. In the light of the result, it may be concluded that science process skills is a significant predictor of the chemistry achievement. There was a significant relationship between science process skills and students' understanding of the rate of reaction concepts. This finding was supported by literature. (Sungur et al,2001; Preece and Brothertan,1997)

As stated before, attitude toward chemistry as a school subject was applied to all students in both groups before treatment as a pretest. ASTC pretest result showed that there was no significant difference between the mean scores of CCTIA group and TDCI group in terms of attitude toward chemistry as a school subject. After treatment, ASTC was administered to both groups as a post-test. And ASTC post-test result indicated that there was a significant difference between the post-test mean scored of CCTIA group and TDCI group. In other words, experimental group have shown more positive attitude after treatment. One of the reasons may be the status of the students in the treatment. Students in the CCTIA group were active in the lesson. They participated into instructional process and follow their learning by discussing teacher whether their ideas or beliefs correct or not. Whereas, TDCI group students were the passive listeners. There was a limited interaction between teacher and students. Another reason may be the usage of interesting analogies. Analogies are helpful to teach abstract and complex science concepts that students often face difficulties. With the help of the analogies, students in CCTIA group understood abstract rate of reaction concepts better. These were the some reason why students in CCTIA changed their attitude positively.

The result of the analysis indicated that there was no significant difference between girl and boys with respect to their understanding of rate of reaction concepts. Reason of this result may be that girl and boys in both groups engaged same teaching material and all the condition was the same for girls and boys.

This study was led to determination and identification of students' misconceptions about the rate of reaction concepts. The results of the study provided further proof about the literature related with students' misconceptions in chemistry.

In summary, this study showed that conceptual change texts oriented instruction accompanied with analogies led to better understanding of rate of reaction concepts, and also better in elimination of students' misconceptions than the traditional chemistry instruction through cognitive disequilibrium. This research also indicated that conceptual change texts and discussion about the texts address the students' misconceptions. Conceptual change texts oriented instruction accompanied with analogies provides alternative strategy to clarify students' misconceptions in chemistry concepts.

6.2 Implications

The findings of the study have the following implications.

1. Most of the students have misconceptions about the rate of reaction. Especially, students held many misconceptions about the factors that affect the reaction rate. So, teachers identify and examine these misconceptions and take them into consideration before regular chemistry instruction.

2. Conceptual change texts can cause better understanding of the scientific phenomena.

3. Traditionally designed chemistry instruction is not enough in elimination of students' misconceptions.

4. Students' misconceptions or alternative conceptions can form a barrier for scientific understanding of the concept. Therefore, teacher must realize students' misconceptions.

5. Teacher must be informed about the usage of conceptual change texts and also encouraged to use the conceptual change texts in instructional activities.

6. Conceptual change text should produce disequilibrium in which students to reconstruct or revise their previous knowledge for further learning.

7. Teacher should ask questions that evolve students' misconceptions in instruction and also in examination.

8. Teacher should recognize that traditional instruction will not lead to substantial conceptual change.

9. Teacher should pay attention on the use of textbooks and languages in instruction.

10. Science process skill is a strong determinant for chemistry achievement. So, teacher should develop alternative instructional strategies to improve students' science process skills.

11. Teacher should provide opportunity for students to think about their intuitive ideas.

10. Teacher should use alternative teaching methods to attract students' interest and also eliminate students' misconceptions.

6.3. Recommendations

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

1. Similar studies may be conducted for different grade levels, and different courses.

2. In this study, sample is small. To obtain more accurate result, sample size should be increased for further research.

3. For further research, conceptual change text instruction may be compared with

other instructional strategies such as computer assisted instruction, demonstration.

4. For further research, different chemistry subject may be selected to examine the effect of conceptual change text.

5. Further research, students' attitude toward effect of conceptual change text may be investigated.

6. Further research may be done to examine the effect of conceptual change text on the students' logical thinkin g ability.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

1. To understand the rate of reaction concepts

2. To define reaction rate.

3. To discriminate the condition for successful collision.

4. To understand the collision theory.

5. To define the activation energies.

6. To find rate law for given reaction mechanism.

7. To find order of reaction.

8. To know the factors that affect the reaction rate.

9. To comprehend the effect of concentration on rate of reaction.

10. To comprehend the effect of temperature on rate of reaction

11. To understand the effect of surface area on rate of reaction

12. To know the function of catalyst.

13. To understand the reactions that have mechanism.

14. To discriminate the step that determines the reaction rate.

15. To discriminate reaction intermediate and catalyst in a given reaction mechanism.

APPENDIX B

RATE OF REACTION CONCEPTS TEST

This test was designed to measure and evaluate your learning of rate of reaction in chemistry course. It consists of 24 multiple choice questions.

1. Related with collision theory which one of the following statements is correct?
a) All molecular collisions lead to chemical reaction.
b) Collision theory is valid only in gas phase's collisions.
c) Rate of reaction is equal to number of collisions per unit time.
*d) Some of the collisions which have higher energy than certain level lead to chemical reactions.

2) 2X (g) + Y (g) -------> 2Z (g) reaction is given. Rate equation of this reaction is equal to rate = $k[X]^2$ .According to this
I. Reaction occurs in more than one step
II.Reaction is a second order
III.If Y gases added, rate of reaction increases. Which one(s) of the above statements is (are) correct?
a) Only I b) Only II *c) I, II d) I, II, III

3. A (g) + 2B (g) ----------> 2C (g) + 3D (g) reaction is given. During this reaction, the reaction vessel is heated. According to this, which one of the following statement(s) is (are) correct?
I. Reaction rate increases
II. Heat of reaction increases
III.Amount of product increases

*a) Only I b) Only III c) I, II d) I, II, III

4. Which one of the following reaction rate cannot be increased by increasing the surface area?

a) $Fe_2O_3(s) + 3CO(g)$ ---------> $2Fe(s) + 3CO_2(g)$

*b) $N_2(g) + 3H_2(g)$ ----------> $2NH_3(g)$

c) $SO_2(g) + H_2O(l)$ ----------> $H^+(aq) + HSO_3^-(aq)$

d) $SiO_2(l) + CaO(s)$ ----------> $CaSiO_3(l)$

5. I. $CH_3CHO(g)$ ----------> $CH_4(g) + CO(g)$ Ea1

II. $H_2(g) + I_2(g)$ ----------> $2HI(g)$ Ea2

It is known that second reaction occurs faster than the first reaction (All conditions are the same for both reactions). According to this, which one(s) of the following statements is (are) correct?

I. In second reaction, all molecular collision resulted with reaction.

II.Activation energy of a first reaction (Ea1) is greater than the activation energy of the second reaction (Ea2).

III.Rate of second reaction is greater than the first reaction.

a) Only I b) I, II *c) II, III d) I, II, III

6) Which one of the following statements is correct related with the effect of temperature on reaction rate?

a) Rate of exothermic reactions decreases when temperature increases.

b) Temperature increases the reaction rate by lowering the activation energy.

c) Temperature increases the reaction rate by giving heat.

*d) Temperature increases the reaction rate by increasing the kinetic energy of the molecules.

7. $2XY_2(g) + Z_2(g)$ ----------> $2XY_2Z(g)$ reaction occurs in two steps. If fast step of this reaction is $XY_2(g) + Z(g)$ ----------> $XY_2Z(g)$ what is rate equation (law) of the reaction?

a) $k[XY_2]$ [Z]

b) $k[XY_2]^2 [Z_2]$

*c) $k[XY_2]$ [Z_2]

d) $k[XY_2Z]$[Z]

8. For endothermic and exothermic reactions which one of the following statements is correct?

a) All endothermic reactions occur very slowly.

b) All exothermic reactions occur rapidly.

c) It is very difficult to initiate endothermic reactions.

*d) Rate of exothermic reactions increase when temperature increases.

9. If we mix reaction vessel, the reaction occurs rapidly. What is the reality behind this fact?

a) The activation energy decreases

b) Average kinetic energy of the molecules increase.

c) Molecules are broken.

*d) Number of fruitful collisions increase.

10. 2A(s) + B (s) ----------> 3C(s) + 2D(g)

It is known that the reaction above occurs in more than one step. Which one of the following changes below increase absolutely the reaction rate?

I. Increasing the surface area of reactant

II. Increasing temperature

III. Increasing the concentration of B liquid.

a) Only I *b) only II c) I,III d) I,II,III

11. I. Catalyst doesn't participate into the reaction

II. Catalyst only affects reaction by increasing the rate.

III. Catalyst changes the value of activation energy.

Which one(s) of the statements above is (are) correct?

a) Only I *b) Only III c) I, II d) I, II, III

12. $2NO + Cl_2$ --------> $2NOCl$ net reaction is given. It is known that above reaction occurs more than one step. According to this which one of the following statements s absolutely correct?

a) Reaction rate is equal to time that NOCl is formed.

b) This information is enough to write reaction mechanism.

c) If concentration of Cl_2 increases, reaction rate also increases.

*d) If temperature increases, reaction rate also increases.

13. Which one of the following statements is correct related with the activation energy?

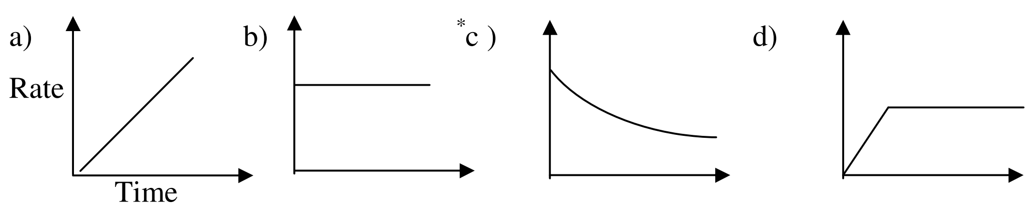
a) It is a kind of heat energy.

b) It is the top point in number of molecules & kinetic energy graph.

*c) It is a kind of kinetic energy for reactant to form product.

d) It doesn't affect reaction rate.

14. 14) X + Y -------> Z reaction is given. Which one of the following graphs shows the changes of reaction rate with time?



15. CH_4 (g) +$2O_2$ (g) ---------> CO_2 (g) + $2H_2O$ $\Delta H < 0$ When the reaction is going on, temperature is increased. According to this, which one(s) of the following statements is (are) correct?

I. Reaction rate decreases

II.Kinetic energy of the molecule decreases.

III.Amount of product increases.

*a) Only II b) I, II c) I, III d) I, II, III

16) Mechanism of the reaction which occurs in aqueous phases is given below.

Ce^{+4} + Mn^{+2} --------> Ce^{+3} + Mn^{+3} (slow)

Ce^{+4} + Mn^{+3} --------> Mn^{+4} + Ce^{+3} (fast)

Mn^{+4} + Tl^{+} --------> Tl^{+3} + Mn^{+2} (fast)

Which one of the following statements is correct?

a) Rate equation of the reaction Rate = k[Ce^{+4}] [Mn^{+3}]

b) Mn^{+2} is the reaction intermediate and Mn^{+3} is catalyst.

c) If volume of the solution doubled by adding water, reaction rate is halved.

*d) Net reaction equation is Tl^{+} + 2 Ce^{+4} --------> 2Ce^{+3} + Tl^{+3}

17) 3A (g) + 2C (g) --------> 3D (g) reaction occurs in two steps. If the fast step is A (g) + C (g) +E (g) --------> D (g) + B (g) which one of the following statements is correct?

a) Reaction mechanism can be written by looking the net reaction equation.

*b) If concentration of C is halved, reaction rate is also halved.

c) Rate equation is equal to Rate = k[A]

d) B is the catalyst of the reaction.

18. A(g) + B (g) $\xrightarrow{C}$ D(g) + E(g) If C is the catalyst of the reaction. What is the function of C in the reaction?

a) Speeding up the molecules

*b) Decreasing the activation energy

c) Facilitating molecules to react

d) Increasing the amount of product.

19. When lemon juice reacts with baking powder carbondioxide gases evolve. To increase the reaction rate and also amount of CO_2 produced which one of the

following process must be made?

a) Catalyst must be added

b) Temperature must be increased

*c) Concentration of both reactants increased

d) The surface area must be increased

20) $2H_2O_2(aq) \xrightarrow{HBr(aq)} 2H_2O\ (s) + O_2(g)$ In this reaction, HBr is used as a catalyst. According to this which one of the following statements is correct?

a) HBr doesn't participate into the reaction.

b) Pathway which has higher activation energy disappears.

c) Catalytic reaction produces more product than the uncatalytic reactions.

*d) In catalytic reactions H_2O_2 is decomposed more rapidly than the uncatalytic reactions.

21. Related with reaction rate which one of the following statements is correct?

*a) Reaction rate is equal to changes of concentration of reactant (or product) per unit time.

b) All the chemical reactions occur vigorously.

c) Reaction rate is equal to time period between reaction starts and ends.

d) Reactions go on with their initial rate.

22. Related with catalyst which one of the following statements is correct?

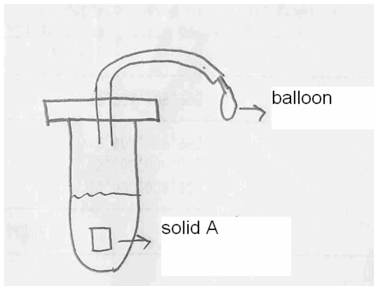
a) If catalyst is used, more substances give a reaction.

b) If catalyst is used, pathway with a higher activation energy is disappear

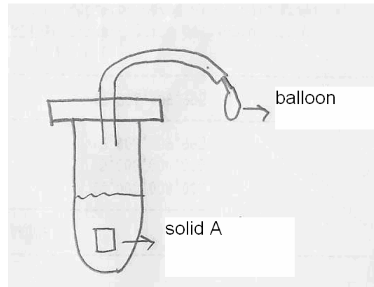
*c) Catalyst does not change the heat of reaction.

d) Catalyst is needed to initiate the reaction.

23.



Vessel 1



Vessel 2

A(k) + 2B(s) -------> 2C(s) + D(g) This reaction is carried in both vessels and vessel 1 is heated during reaction. If amount of substances are the same for both vessel, which one of the following statements is correct?

a) Balloon in the vessel 1 gets bigger than the vessel 2.

b) Balloon in the vessel 2 gets bigger than the vessel 1.

*c) Balloon in the vessel 1 swells more rapidly than the vessel 2.

d) Both balloons in the vessels swell same speed.

24. Related with activated complex which one of the following statements is wrong?

a) It is the state of highest potential energy.

*b) All the molecules in the state of activated complex turn into product.

c) It is a necessary energy to move up energy of activated complex.

d) Molecules in the state of activated complex are rearranged to form product molecules.

APPENDIX C

A CONCEPTUAL CHANGE TEXT SAMPLE

A common misconception among students is that all chemical reactions are extremely fast. Most of the reactions which students see in laboratory and also natural environments occur rapidly such as natural gases explosion, burning of coal. But all the chemical reactions do not happen rapidly. For example, decomposition of hydrogen peroxide and rusting of iron occur slowly.

Most of the students think that rate of reaction means the same as the extent of reaction. But, rate of reaction is described as amount of reactants that give reaction per unit time or the amount of product formed per unit time throughout the reaction. For the reaction,

$2NO_2(g) + F_2(g)$ --------> $2\ NO_2F(g)$

$$Rate = \frac{1}{2}\frac{\Delta[NO_2F]}{\Delta t} = -\frac{\Delta F_2}{\Delta t}$$

Students know from the physics lesson that velocity is equal to average distance taken per unit time ($v = \frac{\Delta x}{\Delta t}$).

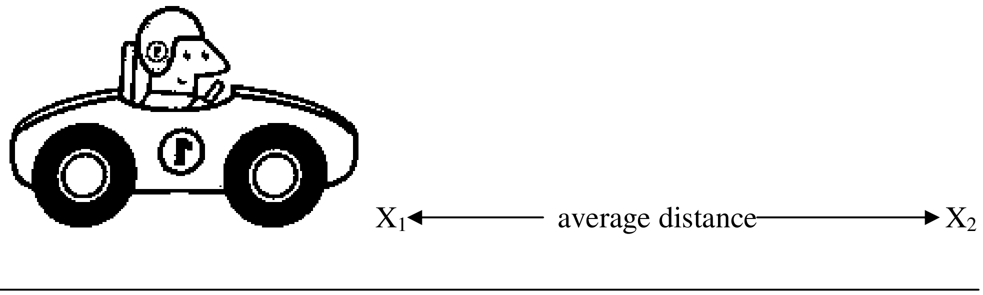


Figure A1. Reaction rate analogy

Reaction rate is also like that. Rate is equal to average changes of reactant or the product concentration. For example,

$H_2(g) + I_2(g)$ -------> $2HI(g)$

$$Rate = \frac{1}{2}\frac{\Delta[HI]}{\Delta t} = -\frac{\Delta H_2}{\Delta t}$$

A chemical reaction can be imagined as analogous to an automobile manufacturing plant. Raw materials like iron, plastic and glass are the reactants and cars are the finished product. To measure the rate of this reaction, you could measure the rate at which a product is produced (e.g. #cars/day) or measure the rate at which a single reactant is used up (e.g. #tons of iron used up/day). This is the same idea as measuring the rate of a chemical reaction.

Most of the students think that reaction rate is constant throughout the reaction. This misinterpretation may be may be caused by invisibility of reactions. Most reactions occur at macroscopic levels. So, students cannot see and also cannot follow the reactions and also their rates. Concentration is important factor that affect the reaction rate. If concentration of reactants is high and also rate of reaction is high. But, when reactants concentration decrease, rate of reaction also decrease. In other words, reaction rate is not constant throughout the reaction.

Another common misconception among students is that all molecular collisions lead to chemical reactions. Collisions are necessary condition for reaction but it is not sufficient. Just because two molecules collide does not necessarily mean that they will react with each other. A successful collision may require that the two molecules or species must collide with the correct collision geometry, that is, be oriented in just the correct fashion so that certain atoms will encounter each other during the collision. It is similar to saying that when putting a piece into a jigsaw puzzle, you can't just put it in any way you want .The piece will only fit successfully if it is the right side up and is turned with the correct orientation so that the projections and indentations match up. That is, it must have the correct "collision geometry". Secondly, colliding molecules must have sufficient kinetic energy to exceed activation energy barrier. The most basic statement of the collision theory is that molecules must collide with each other in order to react. This is similar to saying that wrestlers must actually contact one another in order to wrestle.

Activation energy is another topic in the rate of reaction concepts that students have difficulties. Most students think that activation energy is heat energy. This confusion may be the students' misunderstanding about heat and temperature. Activation energy is the minimum kinetic energy that reactants must go through to form product .Activation energy can be thought as a barrier that reactants must overcome in order to reach the transition state. Activation energy Think a girl who ride a bicycle and she meet with a hill. (Figure 2)

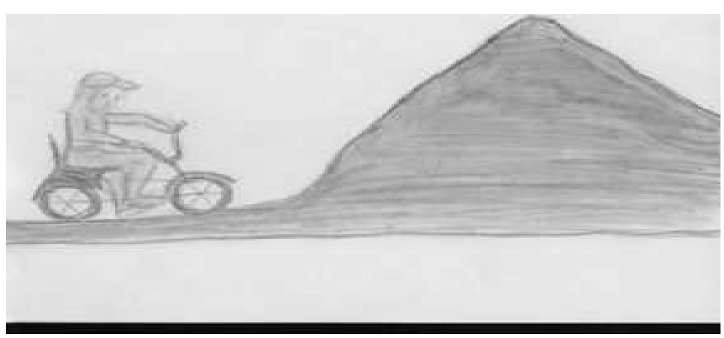


Figure A2. Activation energy analogy

This hill forms a barrier for this girl. There are two choices. Whether girl pass the hill to go their road or turn back. In chemical reactions, molecules which have high energy exceed the activation energy barrier. But molecules with a lower energy go back without reacting.

Also, think a boy who wants to overcome the wall. How can this boy overcome the barrier? Possible answer may be;

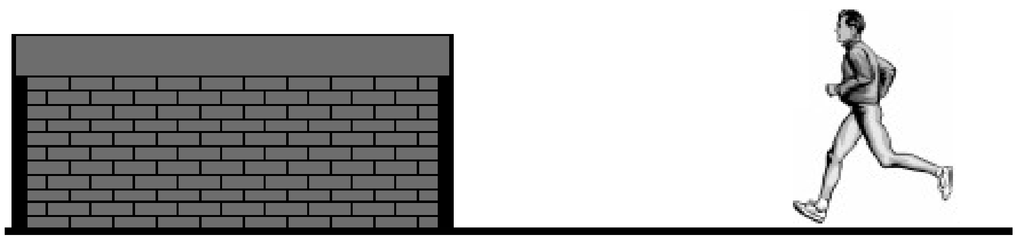


Figure A3. Overcoming activation energy

- ✓ By jumping over
- ✓ Using a ladder
- ✓ Breaking down the wall

If a boy has sufficient energy, he jumps over the wall. (This look likes molecules having sufficient energies overcome activation energy barrier to react.)
If a boy cannot pass other side with his effort, he may overcome the wall by using a ladder. (In chemical reactions, molecules with lower energy cannot overcome activation energy barrier. But, if we increase temperature energy of the molecules also increase and they overcome activation energy barrier.)

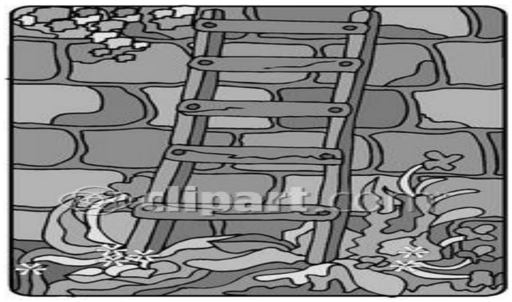


Figure A4. Overcoming activation energy analogy

Or he breaks the wall (This looks like a catalyst effect, catalyst decrease the activation energy. In this way, molecules with lower energy surpass activation energy barrier.)

Figure A5. Effect of catalyst on activation energy

Most students think that the mechanism of a reaction can be deduced from the overall (net) balanced chemical equation. Actually, the overall equation rarely relates to the mechanism, which usually is a series of unimolecular and/or bimolecular steps. If the reaction occurs in one step, then the mechanism can be deduced from the balanced chemical equation.

Another common misconception among students is that exponents in the rate equation (law) are the coefficients of overall (net) reaction equation. Actually, the exponents in a rate law expression are experimentally determined and no way related to coefficients in the balanced equation in reaction mechanism. In other words, rate equation is written according to slowest step in reaction mechanism. For example, look at the overall (balanced) equation.

$4 HBr (g) + O_2 (g)$ ------>$2Br_2 (g) + 2 H_2O (g)$

Experimentally determined rate low for this reaction is $v = k [HBr][O_2]$. If we look at more closely, we can see that exponents in the rate law are not the coefficients in balanced chemical equation.

Most of the students think that one can increase the rate of reaction by vigorous stirring which results more energetic collisions. Actually, stirring or shaking is needed for homogeneous distribution of reactant species not to increase the average energy of the molecules.

Another common misconception among the students is that a faster rate of reaction means that more products are produced. Increasing temperature of the reaction medium or adding a catalyst increases the reaction rate. But this change doesn't affect the amount of product obtained. A catalyst may produce product faster, but the theoretical amount will be the same. A faster rate of reaction only means that we get the products faster, not produce more product.

Most students think that to increase the rate of any reaction, you can increase the surface area of reactants. Increasing the surface area only increase the rate of heterogeneous reactions (solid + liquid, solid + gas, liquid + gas)You cannot increase the surface area , and increase the amount of contact between two liquids or gases.

Another common misconception among the students is that a catalyst is a species that increase the rate of reactions but it does not change or participate in to the reaction. The catalyst is directly involved in the reaction, often being used up and then regenerated at the end of the reaction. A catalyst appears in a reaction mechanism first in one step as a reactant and later step, as a product. Look at the reaction mechanism below.

1) H_2O_2 (aq) + I^{1-}(aq) → H_2O(l) + IO^{1-}(aq)
2) IO^{1-}(aq) + H_2O_2 (aq) → H_2O (l) + O_2 (g) + I^{1-}(aq)

2 H_2O_2 (aq) → 2 H_2O(l) + O_2(g)

I^{1-} is a catalyst in the reaction. It is present throughout the reaction, being used up reproduced at the end.

A catalyst is like a minister at a wedding ceremony. The minister causes the ceremony to take place, plays a role in determining how fast the ceremony takes place, and is not himself permanently changed as a result of the ceremony. Unlike the couple getting married, who are permanently changed as result of the ceremony.

Most students think that when a catalyst is added to a reaction, only pathway with lower activation energy is available. Adding a catalyst does provide a new pathway with lower activation energy but the old path with its higher activation energy is also still remains.

In rate of reaction concepts most students face conceptual conflict, because they don't understand why slowest step determines the rate of reaction. Look at the funnels in the figure 6. If we pour the colored liquid in to funnels which are different bore diameter, flow rate is different for different funnel. Flow rate is high in large diameter's funnel while it is low in the small diameter's funnel. Overall rate depends on small diameter funnel. Because, whatever the flow rate of fast step, without finishing the slow step, overall process cannot be finished. In other words, slow step (slow flowing liquid) determines the flow rate of overall process. If we turn back our issue, whatever the rate of fastest, without finish the slow step of the reaction, overall reaction cannot be finished.

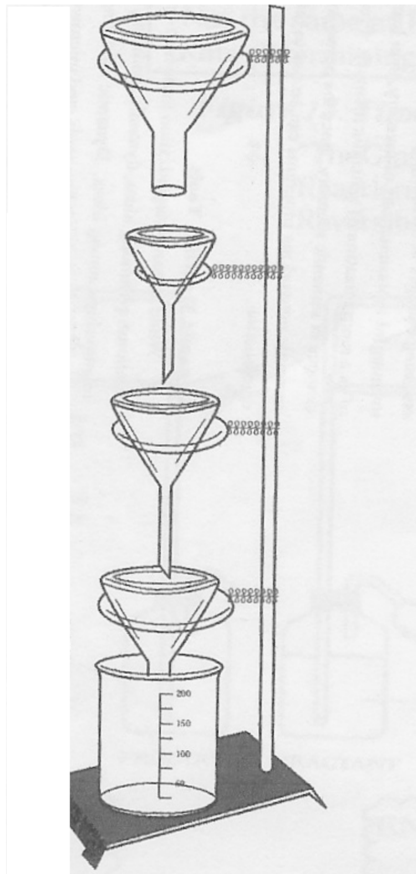


Figure A6. Determination of rate of reaction

APPENDIX D

BİLİMSEL İŞLEM BECERİ TESTİ

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

Bu testin orijinali James R. Okey, Kevin C. Wise ve Joseph C. Burns tarafından geliştirilmiştir. Türkçe'ye çevrisi ve uyarlaması ise Prof. Dr. İlker Özkan, Prof. Dr. Petek Aşkar ve Doç. 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.

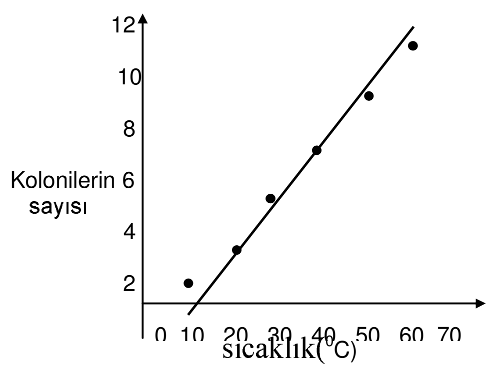
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

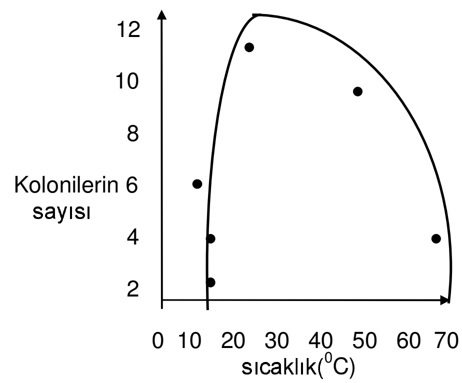
Deney odasının sıcaklığı (^{0}C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

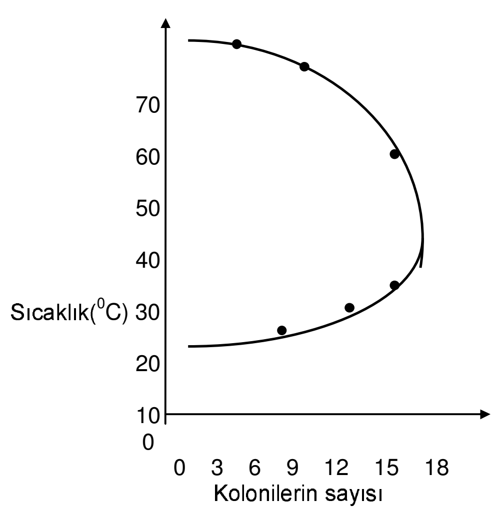
a.



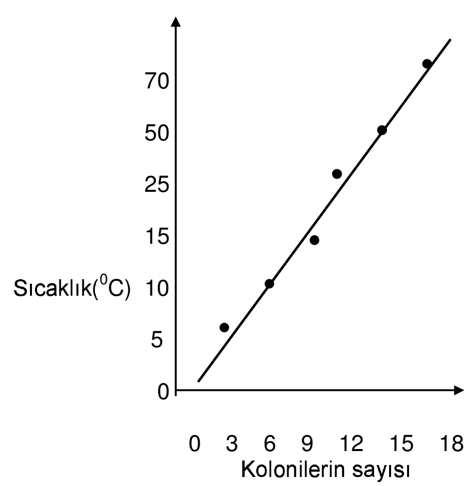
b.



c.



d.



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

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

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

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

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

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

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

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

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

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

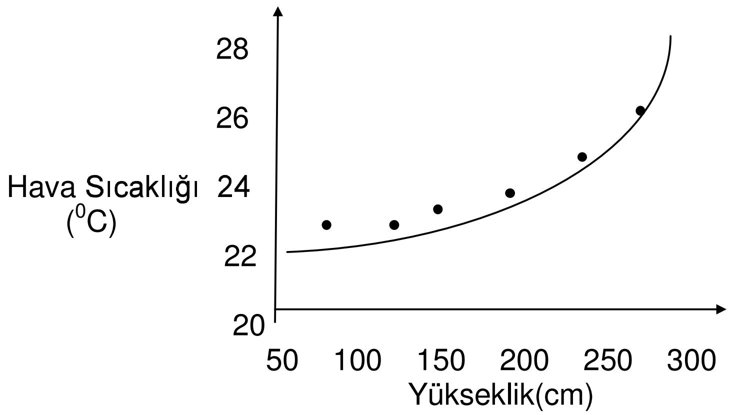
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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

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

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

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



a. Yükseklik arttıkça sıcaklık azalır.

b. Yükseklik arttıkça sıcaklık artar.

c. Sıcaklık arttıkça yükseklik azalır.

d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

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

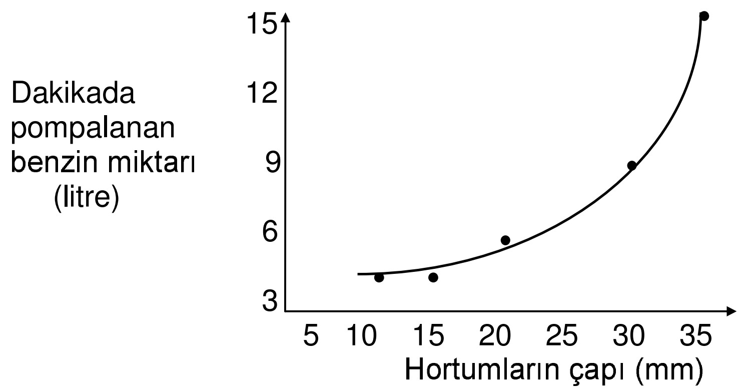
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

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

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

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

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

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

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

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

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

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

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

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

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

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

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

c. Güneş farklı maddeleri farklı derecelerde ısıtır.

d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

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

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gürenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

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

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

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

17. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?
a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

21. Bir bahçıvan domates üretimini artırmak istemektedir. Değişik birkaç alana domates tohumu eker. Hipotezi, tohumlar ne kadar çok sulanırsa, o kadar çabuk filizleneceğidir. Bu hipotezi nasıl sınar?
a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.
b. Her sulamadan bir gün sonra domates bitkisinin boyunu ölçer.
c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.
d. Her alana ektiği tohum sayısına bakar.

22. Bir bahçıvan tarlasındaki kabaklarda yaprak bitleri görür. Bu bitleri yok etmek gereklidir. Kardeşi "Kling" adlı tozun en iyi böcek ilacı olduğunu söyler. Tarım uzmanları ise "Acar" adlı spreyin daha etkili olduğunu söylemektedir. Bahçıvan altı tane kabak bitkisi seçer. Üç tanesini tozla, üç tanesini de spreyle ilaçlar. Bir hafta sonra her bitkinin üzerinde kalan canlı bitleri sayar. Bu çalışmada böcek ilaçlarının etkinliği nasıl ölçülür?
a. Kullanılan toz yada spreyin miktarı ölçülür.
b. Toz yada spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.
c. Her fidede oluşan kabağın ağırlığı ölçülür.
d. Bitkilerin üzerinde kalan bitler sayılır.

23. Ebru, bir alevin belli bir zaman süresi içinde meydana getireceği ısı enerjisi miktarını ölçmek ister. Bir kabın içine bir litre soğuk su koyar ve 10 dakika süreyle ısıtır. Ebru, alevin meydana getirdiği ısı enerjisini nasıl ölçer?
a. 10 dakika sonra suyun sıcaklığında meydana gelen değişmeyi kaydeder.
b. 10 dakika sonra suyun hacminde meydana gelen değişmeyi ölçer.

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

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

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

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

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

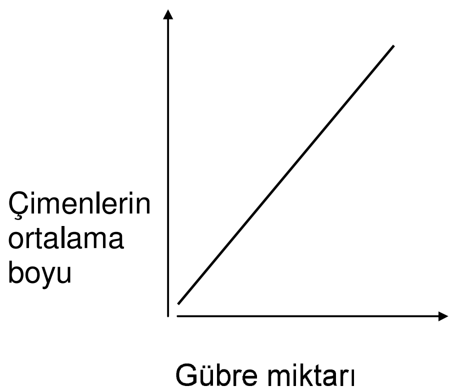
d. Her biri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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

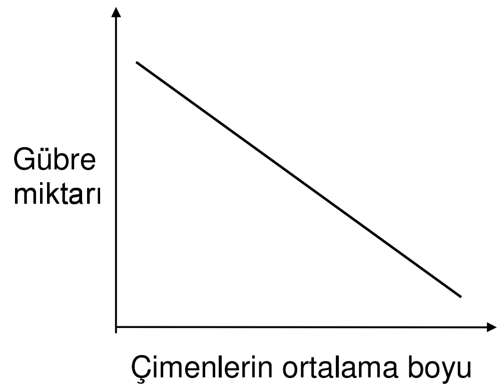
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

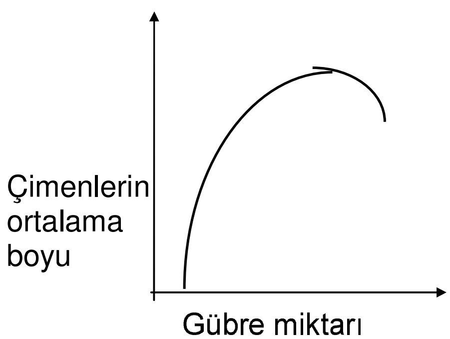
a.



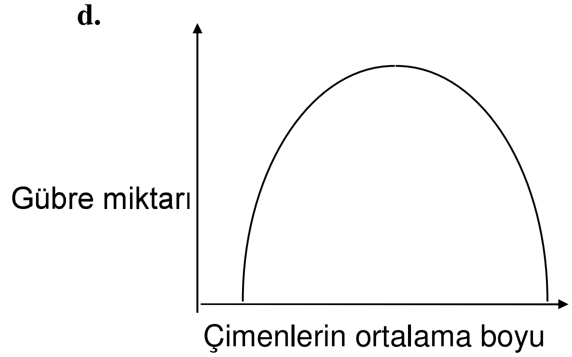
b.



c.



d.



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

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Her gün fareleri tartar.

d. Her gün farelerin yiyeceği vitaminleri tartar.

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

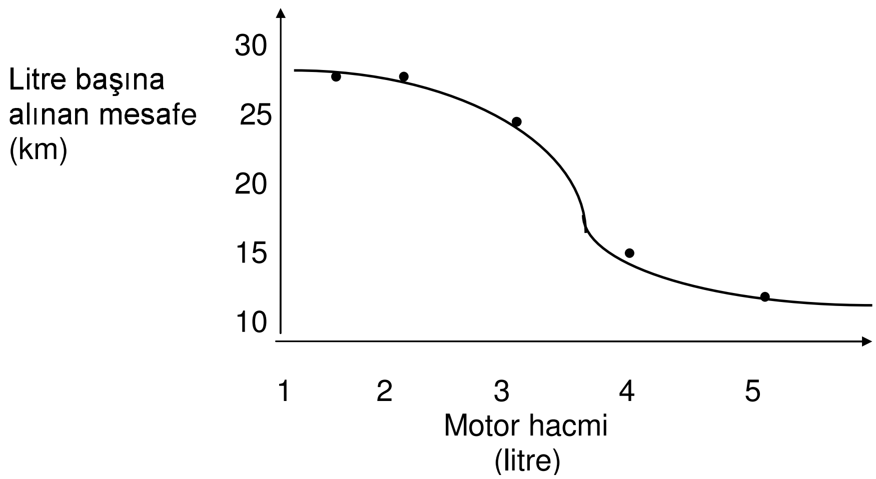
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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

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

d. Su ısındıkça şeker daha uzun sürede çözünür.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

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

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

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

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

29. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

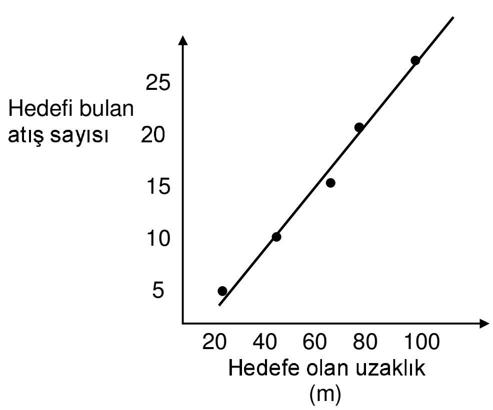
d. Çekilen demir tozlarının ağırlığı ile.

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

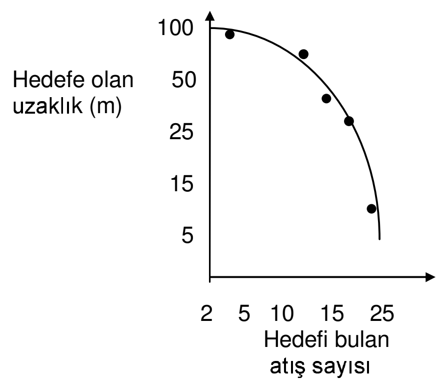
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

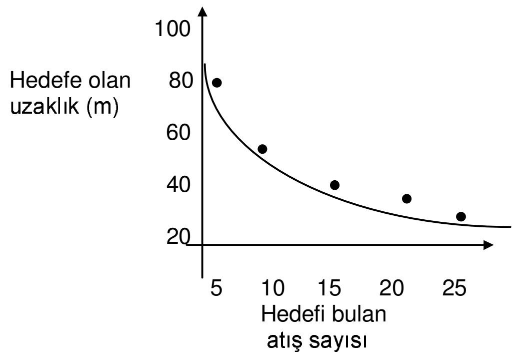
a.



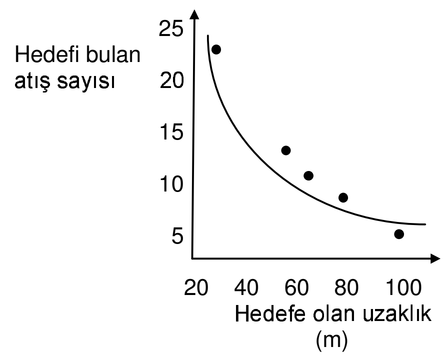
b.



c.



d.



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

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

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

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

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

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

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c.

APPENDIX E

KİMYA DERSİ TUTUM ÖLÇEĞİ

Açıklama:Bu ölçek, Kimya dersine ilişkin cümleleri ile her cümlenin karşısında Tamamen Katılıyorum,Katılıyorum,Kararsızım,Katılmıyorum ve Hiç Katılmıyor-um olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonar kendinize uygun seçeneği işaretleyiniz.

	Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1)Kimya çok sevdiğim bir alandır.					
2) Kimya ile ilgili kitapları okumaktan çok 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 büyük sıkıntı duyarım.					
7) Kimya derslerine zevkle girerim.					
8) Kimya dersine ayrılan ders saatinin daha fazla olmasını isterim.					
9) Kimya dersine çalışırken canım sıkılır.					
10)Kimya konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim.					
11)Düşünce sisteminizi geliştirmede kimya öğrenimi önemlidir.					
12)Kimya çevremizdeki doğal olayların daha iyi anlaşılmasında yardımcı olur.					
13)Dersler içinde Kimya dersi bana sevimsiz gelir.					
14)Kimya konuları ile ilgili tartışmaya katılmak bana cazip gelmez.					
15)Çalışma zamanının önemli bir kısmını kimyaya ayırmak isterim.					