EFFECT OF CONCEPTUAL CHANGE ORIENTED INSTRUCTION ON REMOVING MISCONCEPTIONS ABOUT PHASE CHANGES

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ABSTRACT

EFFECT OF CONCEPTUAL CHANGE ORIENTED INSTRUCTION ON REMOVING MISCONCEPTIONS ABOUT PHASE CHANGES

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In this study, a comparison of the effectiveness of conceptual change oriented instruction with traditionally designed chemistry instruction and an investigation of the effect of gender difference were made on ninth grade students' understanding of phases and phase changes concepts. In addition, the effects of these instructional methods on students' attitudes toward chemistry as a school subject were compared.

In this study 56 ninth grade students from two classes of a chemistry course instructed by the same teacher from Ankara Atatürk Anatolian Lycee in 2003-2004 educational year's first semester took part. The classes were randomly assigned as control and experimental groups. The experimental group was instructed by conceptual change oriented method with conceptual change texts supported by demonstration, whereas the control group was instructed by traditionally designed method over a period of three weeks. Both groups were administered to Phases and Phase Changes Achievement Test as pretest and posttest in order to assess students' understanding of phases and phase changes concepts. Additionally, Science Process Skills Test was given before the treatment to measure students' science process skills and Attitude Scale toward Chemistry as a School Subject was given after the treatment to determine their attitudes.

The hypotheses were tested using analysis of covariance (ANCOVA), paired samples t-test, and analysis of variance (ANOVA). Results of this study indicated that conceptual change oriented instruction caused a significantly better understanding of phases and phase changes concepts; that males had fewer alternative conceptions than females on phases and phase changes; and that science process skills were strong predictors of understanding in phases and phase changes concepts. On the other hand, no significant difference between conceptual change oriented instruction and traditionally designed chemistry instruction; and no effect of gender difference on students' attitudes toward chemistry as a school subject were found.

Keywords: Misconception, Conceptual Change, Phase Changes, Science Process Skills, Attitude toward Chemistry

ÖZ

KAVRAMSAL DEĞİŞİM YAKLAŞIMINA DAYALI ÖĞRETİMİN HAL DEĞİŞİKLİKLERİYLE İLGİLİ KAVRAM YANILGILARININ GİDERİLMESİNE ETKİSİ

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Bu çalışmada dokuzuncu sınıf öğrencilerinin maddenin halleri ve hal değişiklikleri konusundaki kavramları anlamaları bakımından kavram değişimi yaklaşımına dayalı öğretim yöntemi ile geleneksel kimya öğretim yönteminin verimliliğinin karşılaştırılması yapılmış ve cinsiyet farkının etkisi sorgulanmıştır. Ek olarak, bu öğretim yöntemlerinin öğrencilerin kimyaya bir ders olarak tutumlarına etkileri de karşılaştırılmıştır.

Çalışmaya Ankara Atatürk Anadolu Lisesi'nde 2003-2004 öğretim yılının ilk döneminde aynı öğretmen tarafından kimya dersi verilen iki dokuzuncu sınıftan 56 öğrenci katılmıştır. Sınıflar kontrol ve deney grubu olarak rasgele atanmıştır. Üç haftalık sürede deney grubuna kavram değişimi yaklaşımına dayalı ve gösteri yöntemiyle desteklenen kavramsal değişim metinleri uygulanırken kontrol grubuna geleneksel kimya öğretim yöntemi uygulanmıştır. Öğrencilerin maddenin halleri ve hal değişiklikleri kavramlarını anlamalarını değerlendirmek için Maddenin Halleri ve Hal Değişimi Kavram Testi Her iki gruba da ön test ve son test biçiminde verilmiştir. Bunun yanında öğrencilerin bilimsel işlem beceri seviyelerini ölçmek için Bilimsel İşlem Beceri Testi uygulama öncesinde, tutumlarını belirlemek içinse Kimya Tutum Ölçeği uygulama sonrasında verilmiştir.

Araştırmanın hipotezleri ortak değişkenli varyans analizi (ANCOVA), bölünmüş örneklem t-testi ve değişkenli varyans analizi (ANOVA) kullanılarak test edilmiştir. Çalışmanın bulguları maddenin halleri ve hal değişiklikleri kavramlarını anlamada kavram değişimi yaklaşımına dayalı öğretim yönteminin geleneksel kimya öğretim yönteminden daha etkili olduğunu, hal değişiklikleri konusunda erkeklerin kızlardan daha az kavram yanılgısına sahip olduğunu ve bilimsel işlem becerilerinin bu kavramları anlamada istatistiksel olarak anlamlı katkısı olduğunu göstermiştir. Öte yandan öğrencilerin bir ders olarak kimyaya karşı tutumlarını etkileme konusunda kavram değişimine dayalı öğretim yöntemiyle geleneksel kimya öğretim yöntemi arasında ve cinsiyetler arasında bir fark bulunamamıştır.

Anahtar Kelimeler: Kavram Yanılgısı, Kavramsal Değişim, Hal Değişiklikleri, Bilimsel İşlem Becerileri, Kimyaya Karşı Tutum

To all my beloved

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EG	:	Experimental Group
CG	:	Control Group
CCOI	:	Conceptual Change Oriented Instruction
TDCI	:	Traditionally Designed Chemistry Instruction
PPCCT	:	Phases and Phase Changes Concept Test
SPST	:	Science Process Skills Test
ASTC	:	Attitude Scale toward Chemistry as a School Subject
df	:	Degrees of freedom
F	:	Fischer's F Statistics
Sig.	:	Significance level
$\overline{X}$	:	Mean of the sample

CHAPTER 1

INTRODUCTION

People try to explain phenomena both for themselves and for others. Because the unknown is always a challenge for human beings, we always seek for the explanation of things that are unknown to us. To understand and further to conceive, we usually charge a "causal-relational explanatory mechanism" and we make them known. However, as it is expected, those understandings and conceptions are mostly far from being the truth because the scientific method is not the means for the discovery. That is to say, the causes and the relations we propose are naïve attempts to explain our world.

Those misapplied conceptions and untrue beliefs are commonly called as alternative conceptions, or shortly, the misconceptions because; people mistake their alternative explanations of the real world for the correct explanations. However, the term "alternative conceptions" is recently preferred to the originally dominant term misconception. According to Abimbola (1988), it refers to experience based explanations constructed by a learner for natural phenomena and objects. Additionally, it gives an impression that alternative conceptions are contextually valid and can lead to more conceptions and thus it brings about intellectual respect on the learner who holds those ideas. On the other hand, misconception means a vague, imperfect, or mistaken understanding of something and thus it may hold a wrong impression that such ideas have negative value on researchers. Nonetheless, we will use the term "misconception" more dominantly throughout the text because the ideas of students presented in this text in fact have some negative attribution to the learning of the subject and construction of some general ideas.

Misconceptions are inevitable in education and formal instruction. Learners come to class with a diverse set of alternative conceptions of real world (Pfundt & Duit, 1985, 1988, 1991). Though those misconceptions seem as parallel explanations of phenomena to the explanations by scientists and philosophers, they are still not the truth. For the side of positive science, parallelism or probability are not enough to take as explanation, or further as the “fact”. Therefore, removing misconceptions is a challenging task to cope with.

Schools are indispensable places for the education whereas; they are not the only ones. Whatever the personal characteristics and previous experiences of the individuals are, the optimal, methodological and scientifically correct education takes place there. Because, education, or more technically; instruction, needs to be optimized in terms of the quantity of the learners, speed of learning, degree of comprehension, response to instruction, being contemporary and finally the concurrency of all these mentioned items. For the time being, schools seem to be the best places for providing us with that, especially when concerning science and the nature. Therefore, for the society formal instruction comes to be a requirement.

Science education is a part and an important aspect of formal instruction. Because science stays on the basis of positive knowledge and of correct explanations for nature and events, each individual should obtain science process skills and scientific methods to understand and rule the nature. For that ideal case, progress in technology and socioeconomic status will take place and the society will live in prosperity. So, we can say that the main purpose of science education is to provide individuals with required skills to live in nature and with aspects of views to the events.

However, it is often argued that many concepts learned in science courses are never generalized to the real world (Davis, 2003). Students take the science course subjects that they do not encounter in their daily lives as if they are not worth learning. At first look, this may seem meaningful. However, subjects and research in science cannot be classified as useful or useless. All endeavors of scientists to explore and understand have their individual aims. For the part of students, giving up segregating subjects in science for usability, observing first hand, and participating directly in the scientific process would help them acquire the mentioned skills to live and rule the nature.

Many common misconceptions that students bring with them to the chemistry class have been identified. Even students in university level chemistry courses hold for these (Banerjee, A. C. 1991; Chang, J.-Y., 1999). Those misconceptions are related to concepts that involve proportional relationships, and to concepts that require students to interpret observations of phenomena which cannot be experienced directly. To illustrate, in secondary level and university level most common topics that students have misconceptions about are density, equilibrium, mole, atomic models and probabilistic models.

A phase is a specific state of matter and can be thought of as the physical characteristics of a substance. The three general categories that all matter can be divided into are solid, liquid, and gas. However, a phase is not a permanent physical property of a substance and different phases of a particular substance can be observed. For example, steam, water, and ice have the same chemical structure but are in different physical states.

To obtain a different substance, one should be able to change the chemical structure of it. However, changing physical structure without changing the chemical structure does not mean changing the substance. Matter does not have to maintain the same physical structure once it reaches one. When some conditions are certain, it changes its physical structure. That is to say; matters change phase on phase transition points.

The most frequently observed and well-known phase change is that of water and it is familiar to every individual though they are unaware of the mechanism (Stavy & Stachel, 1985). Nonetheless, they know that some change occurs.

Phase changes now have been included in the regular secondary science curricula for a long period and students are expected to have adequate knowledge about phase changes. They are expected to know about the conditions for phase changes, a bit of the mechanism, and results of phase changes. When asked about phases and phase changes, most students tend to visualize phases of water. However, that most familiar example itself defies some rules about phase changes that students learn.

In particular, chemistry courses require students to develop understanding at the molecular level. Now we know that for all ages and at all levels of schools including university, misconceptions exist about molecular level interpretation of even simple processes such as phase changes. Though the phenomenon of phase changes is regarded as simple, it includes complex aspects of chemistry and is a key to deep understanding of further chemical concepts.

Most may say that the process of phase change is simple but those probably will have difficulties or mistakes in explaining it. That simple process involves physical and chemical aspects that seems complex to students. Density, molecular interactions, bonds, transfer of energy; especially heat, equilibrium, pressure relationship, and solutions can be given as examples of those aspects and all these topics mentioned are challenging for chemistry students. As it is the situation, phases and phase changes are open to many alternative conceptions. Detecting and removing those misconceptions will have valuable effect on understanding chemical concepts and on improving learning of chemistry in schools.

Alternative conceptions are not ordinary obstacles of education to neglect. Learning is a process like building blocks one on another. Thus, detection of a misconception holds urgency to be removed.

The emerging research on alternative conceptions has brought about valuable knowledge and findings (Gabel, 1994). If modified for use in the science classroom, this potential will have observable impact on the quality of learning achieved in schools. Unfortunately, the large volume of the research, and the way the findings are reported makes it unavailable to the classroom teacher. Thus we hope that the results and the implications of this study give some insight to the teacher about the feasibility of the newly acquired methods.

Recently, several conceptual procedures have been designed to deal with the conceptions and misconceptions of students. The aim is to enhance the effectiveness and quality of learning science topics.

Conceptual change is generally defined as learning that changes an existing conception, belief, idea or way of thinking. Learning for conceptual change is not just building up new facts or learning new skills. In conceptual change, an existing conception is fundamentally changed, or even replaced with new ones such that students use it to solve problems, explain phenomena, and function in their world. This restructuring of existing knowledge is what distinguishes conceptual change from other types of learning.

Traditional methods in science education do not focus on alternative conceptions; traditional instruction even shows no awareness of their existence. Because learners rely on their existing notions to function in their world, they cannot easily discard their ideas. Thus, simply presenting a new concept or telling them that their views are inaccurate will not result in conceptual change.

On the other hand, conceptual change instruction can help students overcome misconceptions and learn difficult concepts in all subject areas. Besides being relevant to teaching in the content areas, conceptual change is applicable to the professional development of teachers and administrators. Teachers reconceptualize the meaning of teaching. Teaching for conceptual change requires a constructivist approach in which learners take an active role in restructuring their knowledge and defining their own ways of learning. With that, teachers become facilitators, that is, they change roles from “the wise giving blocks of information” to “guide on the side of children to discover information”.

Teachers must learn different instructional strategies to provide teaching for conceptual change. Because conceptual change oriented instruction involves uncovering students' alternative conceptions about a particular phenomenon and using various techniques to help students change their conceptual framework.

As a result, several misconceptions are encountered about phases and phase changes, especially when the matter taken is water. In accordance with recent studies (Osborne & Cosgrove, 1983; Stavy & Stachel, 1985), mainly water and phases of water were taken into consideration and discussed in this study although the topic of phases and phase changes of matter was not specialized in only water. It is the representative substance when discussing the phase changes subject and during classroom discussions and in the conceptual change text, water is focused.

CHAPTER 2

LITERATURE REVIEW

This chapter is devoted to give relevant thinking and research preceding the present research, to integrate the previous findings with those of the current research, and to identify the ideas, results and inquiry on which this study was established. Literature that is necessary to understand the underlying phenomena is given.

In modern times, developments in science and technology bring about enhancements in the economy and the morale of the nation. Though most developments are outcomes of the endeavors of scientists and professionals, science literacy is now a requirement for every citizen. Thus, a basic level education about science takes place for each individual during elementary and secondary education and curriculums are designed so that even the nonscience major students have knowledge of basic scientific concepts. However, the key to providing that is an optimum science education with proficient educators.

Learning is defined as change and reorganization of behaviors. Students develop ideas even without teaching takes place. Whether learning of an individual is a result of formal instruction or not, adding information to the cognitive structure of the individual is not enough. During the learning process restructuring of existing ideas and beliefs takes place.

There is no well defined and thus widely accepted learning theory as physical science theories. However, two broad perspectives; behaviorism and constructivism have shaped science education research. Behaviorism asserts that there is no way to observe the mind directly; therefore it is best to describe learning in terms of stimuli that stimulates our senses and the observed responses to those stimuli. Behaviorist theories take knowledge as having its own existence and the job of teacher as getting the knowledge in the students' minds. Teachers transmit knowledge by providing the appropriate stimuli and conditioning the students to respond (behave) appropriately.

On the other hand, constructivism asserts that knowledge is not passively received or transmitted, but it is actively built (constructed) by the learner. Constructivist approach claims that what the learner gets directly cannot be an idea and that ideas cannot be transmitted from one person to another. A constructivist view of learning emphasizes some basic aspects (Driver & Bell, 1986):

1. Learning outcomes depend not only on the learning environment but also on the existing knowledge of the learner. Students' existing cognitive structure and knowledge influence the way they interact with learning materials in various ways.
2. Learning involves construction of meanings; either in a manner it is intended or not. Though, the construction of meaning is influenced to a large extent by existing knowledge.
3. Construction of knowledge is a continuous and active process. Learners are actively hypothesizing, checking and changing ideas as they interact with phenomena and with others.
4. Ideas once constructed are evaluated and can be accepted or rejected.
5. Learners are responsible for their own learning. Learners are expected to make sense of what they are experiencing.
6. Constructivist view is not necessarily assuming the inexistence of any pattern; contrarily, there are patterns in the ideas that students construct because of the shared experiences with the physical world and through the natural language.

Constructivism is a theory of learning that draws from a variety of fields, including psychology, philosophy, and science. On the other hand, conceptual change theory is one of the theories that have been built on constructivist principles. It is based on the constructivist notion that all learning is a process of personal construction. For both constructivism and conceptual change approach, learner self-constructs new knowledge from existing knowledge, and teacher is the facilitator and the guide for change in knowledge. Naturally, conceptual change theory has developed over time, as an aspect of constructivist approach.

2.1 Conceptual Change Theory

Conceptual change is usually defined as learning that changes an existing conception, i.e. beliefs, ideas, and sometimes ways of thinking are changed by learning. The term names a family of theories, approaches, and research concerned with evolution of knowledge systems as a result of formal and informal learning.

In the early 1980s, a group of science education researchers and science philosophers developed a theory of conceptual change (Posner, Strike, Hewson, & Gertzog, 1982). This theory is based on Piaget's notions of accommodation and disequilibration, and Thomas Kuhn's description of scientific revolution (Kuhn, 1970). Kuhn named the paradigm-dominant research as "normal science". In his description, he claimed that scientific revolutions have followed a consistent pattern. First, a scientific paradigm fails to provide solutions or explanations to problems identified by the scientific community and falls into "state of crisis". Then, an alternative paradigm with the potential to solve those problems becomes available. The existence of these conditions causes the adoption of a new framework. This paradigm shift is analogous to conceptual change.

Posner et al. (1982) described the conceptual change in learning with Piaget's words; "assimilation" and "accommodation" but those words were not commitment to Piaget's theories. When students use their existing concepts to deal with new phenomena, it was called assimilation. However, a more often and a radical case is the replacement or reorganization of an individual's central concepts and that situation is called accommodation. Posner et al. derived the four conditions of conceptual change:

1. There must be dissatisfaction with existing conceptions. Learners' current concepts and idea must be unsatisfactory to make sense of a phenomenon.
2. A new conception must be intelligible. Learning individual must be able to grasp the alternative conception.
3. A new conception must appear initially plausible. Newly adopted concept must have the capacity to solve the problems generated by its predecessors.
4. A new concept should be fruitful for research. It should be extended and it should open up new areas of inquiry.

If the current understanding and ideas of the learner seem to make sense of the phenomenon, he or she will be less likely to accept a new concept. Moreover learners must understand what alternative conception means and they may be able to see how it can be applied in a given situation. And for the sense of fruitfulness, alternative conception must be useful in a variety of new situations, rather than solving the current problem.

Posner et al.'s theory of conceptual change has been the most widely accepted and influential one. The central concepts of the theory were status and conceptual ecology. The degree to which learners know and accept an idea is the status of a conception (Hewson, Beeth, Thorley, 1998). Evaluating for the conditions of conceptual change, the more intelligible, plausible and fruitful a conception, the higher its status is. On the other hand, conceptual ecology is shortly all the knowledge and beliefs of the learner. Those are existing conceptions, relationships among conceptions, new knowledge about alternative conceptions, and epistemological belief. The interaction of knowledge and beliefs determines the status of specific conceptions. These interactions support some ideas and discourage others, that is; they raise and reduce the status respectively (Hewson et al., 1998, p. 200).

Though Posner et al.'s theory is the basis and has guided numerous studies; recently the original theory has faced criticisms and extensions from educational researchers. Nonetheless, originating in the conceptual change theory and constructivism, many instructional strategies were developed and adapted to classrooms. Cognitive conflict, derived from Piaget's constructivist view of learning, has been the basis for developing those strategies and models. Though those strategies and models are many in number, they share a similar structure to the strategy proposed by Nussbaum and Novick (1982). The strategy suggested four steps:

1. Determine and reveal the students' misconceptions.
2. Discuss and evaluate those misconceptions.
3. Create conceptual conflict with those misconceptions.
4. Encourage and guide conceptual restructuring.

2.2 Effects of Conceptual Change Approach

Several studies investigated the effectiveness of conceptual change oriented instruction and it was compared with other instructional techniques. Hewson & Hewson (1983) studied with 90 Form 2 (Grade 9 equivalent) students with ages ranging from 13 to 20. They formed experimental and control groups from those 90 students of mixed abilities and various ethnic groups. With a pretest-posttest strategy, Hewson & Hewson compared the conceptual change oriented instruction with traditional way of instruction. Their results indicated that conceptual change oriented instruction with special strategy and materials brought about higher acquisition of scientific conceptions and better removal of alternative conceptions than traditionally designed instruction.

Niaz (2002) conducted an experimental study with 68 students registered to chemistry course at a university. Both the experimental and control groups were taught by the researcher and the conceptual change in freshman students' understanding of electrochemistry was investigated. The control group was instructed with traditional method and no extra activities were done, whereas experimental group was exposed to teaching experiments so that they would be in contact with situations and experiences of alternative conceptions. Niaz's results indicated that the improvement of conceptual change group was significant but that of the control group was not. That is, instructional strategy facilitating conceptual change was more effective than the traditional instruction.

Smith, Blakeslee, and Anderson (1993) examined the teaching strategies associated with conceptual change model. The researchers worked with thirteen science teachers teaching at 7th grade in their regular classes under conditions that are conceptual change oriented or not. During instruction, conceptual change teaching strategies were associated with use of special materials. Their findings were that; students in classes provided with special instructional materials to facilitate conceptual change performed better than those not provided with materials; and the use of conceptual change strategies by teachers was associated with higher student performance on tests designed to assess conceptual change learning.

Uzuntiryaki (2003) conducted a study to investigate the effectiveness of instruction based on constructivist approach and to compare its effectiveness on removing misconceptions related to chemical bonding concepts with traditionally designed instruction. She worked with 42 ninth grade students from two chemistry classes instructed by the same teacher during one semester. Uzuntiryaki's findings showed that instruction based on constructivist approach resulted in better understanding of chemical bonding concepts and better removal of misconceptions related to chemical bonding when compared with traditionally designed method.

Çetin (2003) investigated the effectiveness of conceptual change approach on students' understanding of ecology concepts. In the study, 82 ninth grade biology students from a public high school aged 15 and 16 were enrolled. The results indicated that conceptual change approach yielded significantly better understanding of ecology concepts than traditional instruction.

Azizoğlu (2004) worked with 100 tenth grade students that are enrolled in a chemistry course and investigated the effectiveness of conceptual change oriented instruction accompanied by demonstrations on their understanding of gases concepts. Comparison of conceptual change oriented instruction with traditionally designed chemistry instruction in understanding of gases concepts showed that conceptual change oriented instruction caused a significantly better understanding of gases concepts.

Research based on conceptual change approach has brought about a new dimension to instructional strategies. Traditional instruction mostly does not concern the process of students' acquiring knowledge or their cognitive structures. Common view about traditional instruction is that it is not effective enough to deal with or remove students' misconceptions. This has directed researchers and instructors to investigate the effects of conceptual change oriented strategies on understanding scientific concepts. As conceptual change oriented methods primarily concerns the conceptions of learners, misconceptions are now an important aspect of educational research.

2.3 Misconceptions and Research-Based Findings

Students mostly come to science class with alternative conceptions concerning natural objects and events (Gabel, 1994, p. 181). They may each have their own and distinct assortments of alternative conceptions. However, this diversity does not mean the infinity of the set. On the contrary, most researchers believe that the set of alternative conceptions for a given topic is relatively small.

Those misconceptions have their origins in personal experiences, direct observation and perception, peer culture and language, teaching explanations, and instructional materials (Gabel, 1994, p. 188). Those origins are difficult to document because the evidences for them are often inferential. Nevertheless, a number of studies give us some useful insight about those origins.

Several researchers have suggested that many intuitive concepts of children are results of repeated interactions between children and objects or events they encounter in their environments of direct contact (Driver & Bell, 1986; Pope & Gilbert, 1983). With the origins mentioned being the diverse parameters, students may have early ideas about simple phenomena in both physical and biological domains, but one cannot expect advanced theorizing about what lies beneath.

Besides these initial characteristics, alternative conceptions play an organizational role in constructing new knowledge and students' interpretation of new information. Their prior knowledge interacts with knowledge presented in formal instruction and that results in a diverse set of unintended and undesired learning outcomes. Learners often misinterpret the knowledge presented by their teachers and use them to support their alternative conceptions on a scientific basis (Gabel, 1994, p. 190).

The alternative conceptions that students bring to the classroom cut across age, ability, gender, and cultural boundaries (Gabel, 1994, p. 185). We encounter remarkable findings in literature that students' conceptions are robust with respect to such factors as age, ability, gender, culture. Regardless of age, gender, ability or nationality, the naïve explanatory system of students shows similarity and consistency (Aron, Francek, Nelson, & Bisard, 1994).

Misconceptions are widespread and highly resistant to extinction by conventional teaching strategies (Gabel, 1994, p. 186). Although resistance to change has been noted several times in literature of alternative conceptions research and in a variety of knowledge domains, we should clearly note that learning is itself a process of changing. So, resistance will retard the learning.

The worse side for education is that, teachers and candidate teachers often subscribe to the same alternative conceptions as their students (Ameh & Gunstone, 1985; Banerjee, A. C., 1991; Chang, J.-Y. 1999; Lawrenz, F., 1986). A study of Schoon (1995) with 122 preservice elementary teachers, suggested that many misconceptions originate in classroom. Also, he found that those preservice teachers have many of the same misconceptions with their future students. Similarly, in a study of Shymansky, Woodworth, Norman, Dunkhase, Matthews and Liu (1993), it was found that in-service teachers, like their students, held a variety of erroneous ideas about science topics and they were tending to hold those ideas. However, Shymansky et al. suggested that teacher understanding of a science topic can be enhanced when students' ideas about the topic and ways to examine those ideas are used to focus during instruction.

Accepting alternative conceptions as the reality of learning, science education eventually acquired new diversions of research and teaching methods. There has been a dramatic increase in the volume of research on alternative conceptions in the last 20 years. Examining three editions of the bibliography of research on the field, Pfundt and Duit (1985, 1988, and 1991) listed 700 references in the first, 1400 in the second, and 2000 in the latest. Since the latest version cited, a much greater number is reached.

Though later editions of the bibliography were being prepared by Reinders Duit again with the name of Pfundt and Duit, they were not published yet. For example, the fourth edition was to be prepared in 1994 with 3600 references. For all versions of the bibliography of Pfundt and Duit, main focus was on the students' conceptions of science topics. Later on, Duit has changed the name, and thus the focus of the bibliography. As it was shown that teachers are also vulnerable to same misconceptions as their students, now research on teachers' alternative conceptions is also included in the work of Duit. A compilation by Duit now has the name Bibliography – STCSE (Students' and Teachers' Conceptions and Science Education, http://www.ipn.uni-kiel.de/aktuell/stcse/) and currently holds around 6300 items.

In a recent compilation study, Henriques (2002) reviewed literature about misconceptions. Main topic was the weather; however, she discovered that most of the misconceptions fell under the category of physical sciences, not Earth science. Although the focus was on weather, Henriques classified the misconceptions she compiled into headings: properties of water, phase changes, water cycle, cloud formation, atmosphere, and gases.

2.4 Research on Misconceptions about Phases and Phase Changes

Osborne and Cosgrove (1983) conducted interviews and a written test to explore children's conceptions of boiling, evaporating, condensation, and melting using the water as sample substance. From coeducational and single sex schools of New Zealand, 43 students between the ages of 8-17 were interviewed and 725 students of the age range 12-17 were given the paper and pencil test. Interviewees between the ages 8 and 15 were studying integrated science, whereas 16- and 17-year-old are chemistry, physics and biology students. On the other hand, students of ages 12-14 were studying integrated science, 15-year-old ones were studying science (physics, chemistry and biology) and 16- and 17-year-old students were studying chemistry only.

Osborne et al. (1983) detected many views of children about phase changes of water. Most of those views were results of the misconceptions that children hold; however, some were due to the lack of explanation and missing of the mechanism. For example, one of the views encountered in the interviews is water's going into the air and its coming back as rain. Examining those views, Osborne and Cosgrove concluded that students' understandings of scientific terms are frequently superficial and that they had no sound scientific concepts supporting the labels of terms. The researchers also found that children of all ages hold views about commonly observed phenomena, but older ones can have similar views to younger ones despite the exposure to considerable science teaching. Though the popularities of certain misconceptions change with the age, some misconceptions are more popular among older children. The final finding was that scientific models that teachers use to teach are rather abstract to students and not relatable to their daily lives.

Bar and Travis (1991) used an open-ended oral individual test, an open-ended written test, and a multichoice test to investigate the conceptual development of grade 1 to grade 9 Israeli students about phase changes between liquid and gas. The students assigned to each test were of the same background; however, groups were at age ranges 6-12, 10-14, and 11-15. Development of ideas from concrete to abstract was followed and evaluation of Osborne et al.'s (1983) conclusions was aimed. Also, some concepts and contexts not included in Osborne et al.'s research such as the permanent existence of vapor in the air were included. The main findings of Bar et al. (1991) were: (1) 6- to 12-year-old students' development of the views concerning the concepts of evaporation and the nature of the matter inside the bubbles coming from the boiling water followed certain attainment stages; (2) understanding of boiling precedes that of evaporation; and (3) the format of the testing has significant effect on the distribution of the results. Moreover, the researchers defined some possible sources of misconceptions. The claimed sources were the tendency of young children to give concrete explanations, difficulty of applying learned information into a specific situation, and observing energy as matter.

In another study of Bar (1989), views of children between the ages 5 to 15 about water cycle and phase changes were described. Three hundred participants of about equal ratio of girls and boys were given clinical interviews to test the hypotheses: a) explanations of water cycle can be ordered into stages and b) each stage is dependent on the level of understanding of the concepts concerning phase changes. Here, the order of stages means each of them is typical to a given age range. Bar then concluded that there exist structured schemes as stages of development and those structured schemes are persistent and resist contradiction. That is, at each stage of the explanations concerning the water cycle the intuitive notions that the child has can be attributed to a structured scheme.

Bar and Galili (1994) used clinical interview, open-ended investigation and multiple-choice written tests to explore children's conceptions of evaporation at the age range 5-14. Participants of the tests were 735 Israeli children and results showed that their development related to evaporation concept involved four interpretations; water disappeared; water was absorbed by floor or ground; water evaporated meaning become unseen and transferred to another location; and water changed to vapor. Moreover, Bar and Galili determined an obvious relation between the change in evaporation concept and students' cognitive development.

Chang (1999) conducted a study with 364 students from a teachers college in Taiwan. Those teacher college students' conceptions about boiling, evaporation and condensation were investigated using an open-ended written test accompanied by demonstration. Because the participants of the study had different scientific learning backgrounds and some were from nonscience majors such as Language Arts and Literature Education, Music Education, and Special Education, they were divided into groups but the task were all the same for each group. Interviews were also conducted regarding the result of the test because Chang believed students might have alternative conceptions that they did not reflect.

Study of Chang (1999) is worthwhile in regard that the participants were candidate teachers, even some of them were from science education major. In accordance with the research-based claim, teachers or candidate teachers subscribed to the same alternative conceptions as students despite the considerable science education both at the secondary level and at university level. Nonetheless, findings of the study were helpful with respect to understanding students' conceptions of evaporation, condensation, and boiling:

1. Science major students had higher level of achievement on these concepts than the nonscience major students. Nevertheless, science major students' learning of condensation and boiling concepts still needs to be enhanced.
2. Most students had no clear or sufficient understanding of water vapor. They could not imagine the existence of water vapor and/or its status in the air or their ideas about the existence of water vapor in the air were ambiguous.
3. Most students did not understand the concept of saturated vapor.
4. Learning difficulties on the concepts of evaporation, condensation, and boiling could be a result of the rough understanding of vapor form of the water.

To determine and reveal the ideas of children about solids and liquids, Stavy and Stachel (1985) conducted a study with 200 students in the ages 5 to 13. They aimed to question the criteria of children for discrimination between the concepts solid and liquid, and the age that children start to discriminate between solids and liquids. Moreover, the age that children are capable of discriminating between specific properties of a material and general properties of solids and liquids was also investigated. The findings were worth a lot in regard for phase concepts and conceptual development of the children. Stavy and Stachel concluded that children of all ages know the characteristic behavior of solids and liquids; however, they recognize similarity between two liquids better and at an earlier age than they recognize that between two solids. Also they found that the definitions of children for solid and liquid related only to the physical behavior of the materials, not related to the particulate theory. But a remarkable finding is that water serves as the exemplar for liquids where there is no similar exemplar for solids. To further illustrate the conceptions of children, a misconception existing at all ages detected by Stavy et al. can be given here: "All liquids are like water."

Stavy (1990) conducted interviews independently with 120 children from fourth grade (age 9-10) to ninth grade (ages 14-15) to examine their conceptions of changes in the state of matter from liquid or solid to gas. She also tried to investigate students' understanding of the reversibility of those processes. The materials were demonstrated to the children during interviews and effect of visual properties on their understanding of conservation and reversibility was investigated. As demonstrations, the first task was a change from liquid to an invisible gas in a closed system using acetone, and the second was a change from solid to a visible gas in a closed system using iodine. Main findings of Stavy (1990) were as follows: (1) matter is grasped as a concrete and solid object; (2) children believe that matter is made up of material core and nonmaterial properties such as color, smell, or weight; (3) children accept the existence of matter depending on the existence of its perceptual evidence; (4) weight is not seen as intrinsic property of matter. She reported that children believe in the existence of weightless matter, or the possibility that weight can change with the state of matter. Moreover, children believe that nonmaterial properties can be dissociated from the material especially when the matter undergoes a change. Stavy, also mentioned the results in terms of conservation and reversibility. Children who recognized weight conservation in one task did not necessarily recognize the same in the second task. Moreover, students recognizing weight conservation were not always aware of the reversibility of the processes.

Dibar Ure and Colinvaux (1989) worked with a class of about 15 adult students aged 15 to 27 years to examine the misconceptions of changes of physical state in water and to examine the evolution of phase change concepts within the dynamics of classroom situation. They used a methodology consisting of simple experiments, group work, and discussion with the teacher and the class. Subjects of the sessions focused on boiling and condensation. The results of the study showed that, students thought water can turn into air, and air can turn into water; or air and water in the form of air is the same thing. Moreover, they found that it was difficult for the students to leave their alternative conceptions that are close explanations to the reality.

2.5 Science Process Skills and Attitudes toward Chemistry

Science contributes its unique skills with emphasis on hypothesizing, manipulating the physical environment and reasoning from data. The terms scientific thinking, scientific method, and critical thinking have been used at various times and situations. Recently, "science process skills" has become the commonly used term for those unique skills of science. Science process skills are divided into two functional groups; basic and integrated. Basic science process skills include observing, measuring, inferring, classifying, predicting and communicating. On the other hand, integrated science process skills involve controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models (Padilla, 1986).

Science process skills have a central role in learning with understanding. Therefore, they are important in the construction and development of ideas that must make sense of the scientific aspects of the world (Wynne, 1999). In practice, science process skills are inseparable from learning and applications of science. So, science process skills and their development should be a part of formal education.

In a study investigating the relationships between the level of science process skills and the degree of acquiring new science knowledge, Flehinger (1971) worked with a sample consisting of 257 preservice teachers. She determined the existence of a positive correlation between level of process skills and level of knowledge acquisition. Students with high level of science process skills performed significantly better in acquiring new science knowledge.

In studies of Uzuntiryaki (2003) and Azizoğlu (2004) effect of students' science process skills on their understanding of chemical concepts were also investigated besides the effect of instructional method. Both Uzuntiryaki (2003) and Azizoğlu (2004) individually found that science process skills contribute to students understanding of chemical concepts significantly. That is, science process skills are important predictors of understanding chemistry concepts.

Attitudes have long been taken as important predictors of achievement and individual differences in education. Science educators have given importance to attitudinal dimensions of their subjects (Koballa, 1988). As a consequence, researchers have diverted to the investigation of attitudes towards science during childhood and adolescence

There have been numerous studies in science education investigating the effect of various types of instruction on attitudes toward science and science achievement. However, much of the research has concerned attitudes as outcomes, rather than examining the effect of attitude on achievement. Various studies found positive correlations between attitudes and achievement (Cukrowska, Staskun, Schoeman, 1999).

In study of Cukrowska et al. (1999) with students from freshmen chemistry courses of two universities of South Africa, a substantial positive relationship between attitudes of students and their achievement in first-year chemistry course was detected. Cukrowska et al. suggested that attitudes are not easily changed and therefore it increases the importance of development of a positive attitude toward chemistry in secondary schools.

Main factors influencing students’ attitudes toward science are gender, curricula, teachers, cultural background, classroom environment and physical conditions. Of these the crucial ones are gender and quality of teaching (Osborne, Simon, Collins, 2003). The kind of classroom environment, various instructional methods and activities might raise students’ interest in studying science at school, and consequently might bring about better attitudes of them toward science.

To summarize, misconceptions are inevitable in science education and are highly widespread. They are obstacles to scientific understanding and learning science. Even educators are affected by that situation and new instructional strategies have been developed to cope with misconceptions because the traditional methods do not seem effective enough. Instructional approaches that facilitate conceptual change can be effective classroom tools in improving understanding of scientific concepts and removing related misconceptions. Phases and phase changes concepts are familiar to everyone and process seems simple. However, fundamental aspects of chemistry such as the structure of matter, chemical bonding and molecular interactions, energy transfer, and equilibrium are involved in the processes. Consequently, many misconceptions related to phases and phase changes have been detected. This study is focusing on phases and phase changes concepts and findings of this study are expected to give some insight to researchers and teachers.

CHAPTER 3

PROBLEMS AND HYPOTHESES

In this chapter, the main problems, related subproblems and hypotheses are presented.

3.1 The Main Problems and Subproblems

3.1.1 The Main Problems

The first purpose of this study is to compare the effectiveness of conceptual change oriented instruction (CCOI) over traditionally designed chemistry instruction (TDCI) on 9^{th} grade students' understanding of phases and phase changes in regard for removing related misconceptions, and on their attitudes toward chemistry as a school subject.

The second purpose of this study is to identify the role of sex, and the interaction between sex and treatment on secondary school students' understanding of phases and phase changes of matter.

3.1.2 The Subproblems

1) Is there a significant difference between the effects of conceptual change oriented instruction and traditionally designed chemistry instruction on students' understanding of phases and phase changes concepts, when the effects of students' science process skills are controlled as a covariate?

2) What is the effect of gender difference on students' understanding of phases and phase changes concepts, when the effects of students' science process skills are controlled as a covariate?
3) What is the effect of interaction between gender difference and treatment on students' understanding of phases and phase changes concepts?
4) What is the effect of students' science process skills on their understanding of phases and phase changes concepts?
5) What is the effect of CCOI on students' understanding of phases and phase changes concepts?
6) What is the effect of TDCI on students' understanding of phases and phase changes concepts?
7) Is there a significant difference between CCOI and TDCI on students' attitudes toward chemistry as a school subject?
8) What is the effect of gender difference on students' attitudes toward chemistry as a school subject?
9) What is the effect of interaction between gender difference and treatment on students' attitude toward chemistry as a school subject?

3.2 Hypotheses

1) H_0 : There is no significant difference between posttest mean scores of the students taught with CCOI and those taught with TDCI with respect to their understanding of phases and phase changes concepts when the students' science process skills are controlled.
2) H_0 : There is no significant difference between posttest mean scores of males and females with respect to their understanding of phases and phase changes concepts when their science process skills are controlled.
3) H_0 : There is no significant effect of interaction between gender difference and treatment on students' understanding of phases and phase changes concepts.

4) H_0 : There is no significant contribution of students' science process skills to their understanding of phases and phase changes concepts.
5) H_0 : There is no significant effect of Conceptual Change Oriented Instruction (CCOI) on improvement of students' understanding of phases and phase changes concepts.
6) H_0 : There is no significant effect of Traditionally Designed Chemistry Instruction (TDCI) on improvement of students' understanding of phases and phase changes concepts.
7) H_0 : There is no significant difference between posttest mean scores of students acquiring CCOI and those acquiring TDCI with respect to attitudes toward chemistry as a school subject.
8) H_0 : There is no significant difference between the posttest mean scores of males and females with respect to students' attitudes toward chemistry as a school subject.
9) H_0 : There is no significant effect of interaction between gender difference and treatment on students' attitudes toward chemistry as a school subject.

CHAPTER 4

DESIGN OF THE STUDY

In this chapter, experimental design, subjects, variables, instruments, treatment, assumptions, and limitations are discussed.

4.1 The Experimental Design

To collect data in this study, the nonequivalent control group design was used (Gay, 1987).

Table 4.1 Research design of the study

Groups	**Pretest**	**Treatment**	**Posttest**
EG	PPCCT SPST	CCOI	PPCCT ASTC
CG	PPCCT SPST	TDCI	PPCCT ASTC

In the table, EG represents the experimental group, which is instructed with conceptual change oriented method. Control group is represented with the symbol CG and the students in that group are instructed with traditionally designed method. PPCCT is the Phases and Phase Changes Concept Test. ASTC is the Attitude Scale towards Chemistry as a School Subject test and SPST is the Science Process Skills Test. For the side of treatment, CCOI represents the Conceptual Change Oriented Instruction method and TDCI represents the Traditionally Designed Chemistry Instruction method.

To examine the effect of treatment on the dependent variables and to control students' previous learning in phases and phase changes subject and to estimate their scientific processing powers, the two instruments; PPCCT and SPST were respectively given to both of the groups as pre-testing.

4.2 Subjects of the Study

The subjects of this study consisted of 56 ninth grade students from two classes of a chemistry course taught by the same teacher in Atatürk Anatolian Lycee in first semester of 2003-2004 educational year. Groups to be assigned to either of the methods were selected randomly. In the experimental group, which was exposed to conceptual change oriented instruction, 29 students (14 female and 15 male) participated, whereas in the control group, which was instructed with traditional methods, the number of the participants was 27 (12 female and 15 male).

4.3 Variables

4.3.1 Independent Variables

The first independent variable was the type of the treatment. The two different types of the treatment, which are Conceptual Change Oriented Instruction and Traditionally Designed Chemistry Instruction, were the defining values of this variable. Second independent variable was the gender. Also, the science process skills of the students were controlled by the results of the third independent variable; SPST.

4.3.2 Dependent Variables

Students' understanding of phases and phase changes concepts measured by PPCCT and their attitudes toward chemistry as a school subject measured by ASTC were the dependent variables in this study.

4.4 Instruments

4.4.1 Phases and Phase Changes Concept Test (PPCCT)

This test was developed by the researchers. The test consisted of 20 multiple choice questions, each having five choices such that one was the correct answer and the remaining four were the distracters. The items used in the test were related to the phases and phase changes of matter concepts. Originally, the test was prepared in English because the materials obtained from the books and the literature were in that language and it is an accepted language for publishing. However, the test was translated to Turkish carefully and given that way in order to minimize the effects of lingual problems of students in this research. Moreover, as the teacher's preference, Turkish was used during chemistry lessons for 9th graders she was teaching instead of English. Thus, the test is ready to be examined by researchers in both languages (See the Turkish version in Appendix B).

Most of the distracters were common misconceptions encountered in the literature about the topic and they were adapted and applied to the cases of the questions in the test. The remaining distracters were not encountered yet but they were expected to be some possible misconceptions. The items in the questions of the test were selected from the literature related to students' alternative conceptions with respect to phases and phase changes concepts. Based on those misconceptions, a taxonomy was constructed (see Table 4.2).

Table 4.2 Distribution of students' misconceptions over test items

Misconceptions	**Items**
When water boils and bubbles come up, the bubbles are air.	1-A
The bubbles coming up from the boiling water are oxygen and hydrogen.	1-D
The bubbles coming up from the boiling water are oxygen.	1-E

Table 4.2 (continued)

Misconceptions	**Items**
The bubbles coming up from the boiling water are oxygen and carbon dioxide.	1-E
The bubbles coming up from the boiling water are heat.	1-B
The white substance coming from the boiling water is smoke.	2-C
The white substance coming from the boiling water is water vapor.	2-A
The white substance coming from the boiling water is precipitate of impurities.	2-D
Hydrogen and oxygen separates during boiling and then recombine to form water in the air.	2-E
Water changes into gas by the process of boiling but water left in an open container does not boil, thus, disappears.	3-B
Water in an open container is absorbed by the container.	3-A 4-C
Water penetrated into solid objects during drying of the object.	3-E 4-C
Water left in an open container changes into air or disappears and turns into air.	3-C
The water dries up but not as steam, just dries up and goes into the air.	3-B 3-C
Condensation is when air turns into a liquid.	5-C 6-A
Condensation occurring after a while on the outside surface of a dried container which has cold water or ice in it is the water coming through the walls of the container.	6-B
The cold surface of the closed container and dry air react to form water via the combination of hydrogen and oxygen on the surface.	6-C
When the hand is held above boiling water it gets wet with the water vapor.	7-B
Weight can change with the state of matter.	16-D 16-E
Evaporation is limited to water and water solutions, it would not occur in other solutions or liquids.	15-A 15-B 15-C 15-D

Table 4.2 (continued)

Misconceptions	**Items**
The concept of vapor pressure is confused with that of atmosphere.	18-A 18-C
Evaporation only relates to atmosphere, it has nothing to do with the vapor pressure of solution.	18-E
When the water vapor is evaporating, the solute particles come out with the solvent particles.	11-A 12-A
There is not a well-defined relationship between temperature and molecular kinetic energy.	10-C 10-D
Temperature of the boiling liquid would keep rising upon continued heating.	10-A 10-B
Evaporation in a closed system is not different from that in an open system.	9-B 9-C
For the evaporation in an open system, water will gradually diminish or disappear due to evapotranspiration.	4-B
When placed over a cup of just-boiled water, tiny water droplets form under the glass because water vapor is blocked by the glass and cannot get out.	5-A
During evaporation and condensation in a closed system, tiny water droplets form on the inner surface of the container because the water vapor inside the container encounters coldness.	8-A
During evaporation and condensation in a closed system, tiny water droplets form on the inner surface of the container because water vapor adheres to the inner surface of the container.	8-B
During evaporation and condensation in a closed system, tiny water droplets form on the inner surface of the container because of the temperature difference from outside and inside the container.	8-D
During evaporation and condensation in a closed system, tiny water droplets form on the inner surface of the container because of the pressure difference from outside and inside the container.	8-E

The set of misconceptions mentioned in Table 4.2 is only a subdomain of misconceptions about the phases and phase changes subject. Including all is a highly challenging task and it is not feasible. Those misconceptions used in the PPCCT are selected as representative distracters from the most common ones.

The test was examined by a group of experts in chemistry, physics, and science, by the course teacher, by the researchers for the appropriateness for measuring a representative sample of the domain of tasks with respect to “matter, phases and phase changes of matter” unit of 9th grade chemistry course and for checking the validity of the test.

The reliability of the test was found to be 0.63. This test was given to students in both groups as a pretest to control students’ understanding of phases and phase changes subject at the beginning of the instruction. After the treatment, it was again given to both groups as posttest to compare the effects of two types of instructions (CCOI vs. TDCI) on understanding of phases and phase changes concepts.

4.4.2 Attitude Scale toward Chemistry (ASTC)

To measure students’ attitudes toward chemistry as a school subject, a previously developed scale (Geban, Ertepınar, Yılmaz, Altın, & Şahbaz, 1994) was used. The scale consisted of 15 items in 5-point likert type scale. Each item was a proposition sentence about the attitudes toward chemistry and the scale to measure the agreement of students was such that it had choices “Totally Agree”, “Agree”, “Undecided”, “Partially Agree”, and “Totally Disagree”. The attitude scale was given to students in both the experimental and control groups after the treatment. The reliability of the scale was found to be 0.83 (See Appendix C).

4.4.3 Science Process Skills Test (SPST)

This test was originally developed by Okey, Wise, and Burns (1982). It was translated and adapted into Turkish by Geban, Aşkar, and Özkan (1992). SPST consisted of 36 multiple-choice questions with four alternatives for each. The test measured intellectual abilities of students related to identifying variables, stating and identifying hypotheses, operationally defining and designing investigations, and graphing and interpreting of data (See Appendix D). The reliability of the test was found to be 0.85.

4.5 Treatment (CCOI vs. TDCI)

This study was conducted over three weeks in the first semester of 2003-2004 educational year at Ankara Atatürk Anatolian Lycee. 56 students from two 9th grade chemistry classes of the same teacher were enrolled in the study.

The number of students in the experimental group was nearly balanced with that of the control group. Before the treatment, both of the groups were administered PPCCT and SPST as pretests in order to determine whether there would be a significant difference between the groups after the treatment.

During the treatment, the chemistry subject related to matter and phases was covered as part of the regular classroom curriculum in the Chemistry I course, which is an introductory course for science and mathematics division of 9th graders. Classroom instructions of the groups were held as three 45-minute sessions per week during three weeks.

In the control group, students were instructed with traditionally designed chemistry texts, in accordance with the curriculum in use. During the sessions, lecture and discussion methods were used to teach concepts about matter and phases of matter. However, lecturing was the dominant method and the best practice of the subject was solving some representative questions about the subject using the textbook and some supplementary test books. Nonetheless sufficient discussion took place from time to time when appropriate conditions and questioning aroused. For most of the sessions a strict following of the subjects from the textbook and solving some problems and exercises at the end were common. Moreover, most of the discussion came into being on the exercises and was not synchronous with the introduction of the subject matter.

Students in the experimental group worked with the conceptual change texts supported with demonstration of the mentioned materials in the texts (See Appendix A). The text did not directly inform the students on the subject but stated common misconceptions about phases and phase changes of the matter. The topic of matter and phase changes of matter is dissociated into sub-topics such as evaporation, condensation, melting, freezing, open systems, and closed systems.

For each sub-topic, a suggestive and divergent question was asked and students were expected to note down their answers. The purposes of the initial questions were to arouse the interest on the subject and to analyze the students' conceptions on the subject. Most of the discussion was on the judgment of students' written alternative conceptions. Where appropriate, some supplementary material was demonstrated to help visualization, and to remind some previous experiences of the students. For example, boiling some water or exhibiting the water droplets in a closed bottle were empowering tools for visualization of the situations they are familiar with. In the task of boiling, water was boiled in a transparent beaker during the discussion of the subject and let the students to observe the process. Moreover, for the task of evaporation and condensation in a closed system, a transparent bottle half-filled with drinking water and set for rest for 24 hours for the equilibrium to be reached, was exhibited to the students. For the rest, demonstration was not necessary because students observed them repetitively in such cases as drying of dishes or the laundry. Thus, all students seemed adequate.

In the main part of each sub-topic, some common misconceptions picked from the literature were stated. Students compared their conceptions revealed in their answers with those misconceptions for a matching. Discussions took place and below each stated misconception there were some guidance. The texts followed a conceptual change with refutation method. Here, Nussbaum and Novick's (1982) steps (determining misconceptions, discussing and evaluation, creating conceptual conflict, and guiding restructuring) were followed. The guidance part was on why the conception mentioned could be wrong and therefore it refuted the students' supporting bases on alternative conceptions. By this refutation and some information given on the guidance part conceptual conflicts were tried to be created. Blocks of information were given directly only when necessary and after the final discussion on the misconceptions was over in order to help restructuring of concepts.

At the end of each sub-topic, scientifically accepted concept was given to the students and then with the help of questions and extra discussion the teacher tried to determine whether the conceptual change has occurred or not. If not, the student is suggested to go over the section again.

After the treatment is over, both the control group and the experimental group were given PPCCT again. This time PPCCT is the posttest to determine students' understanding of phases and phase changes of matter concepts. Finally, ASTC was given to both groups so that effect of the treatment on students' attitudes toward chemistry lessons can be observed and investigated.

4.6 Analysis of Data

Statistical techniques used in this study to analyze the data gathered from the tools described in order to determine the effectiveness of two different instructional methods (CCOI and TDCI) on students' understanding related to phases and phase changes of matter concepts and on their attitudes toward chemistry as a school subject were Analysis of Covariance (ANCOVA), Analysis of Variance (ANOVA), independent samples t-test, and paired samples t-test.

At the beginning, to check the existence of differences between groups in terms of previous understanding of phases and phase changes concepts and in terms of science process skills independent samples t-test was used. For testing the hypotheses 1, 2, 3 and 4, ANCOVA was used with SPST scores as the covariate. Next two hypotheses; 5 and 6 were tested by using paired samples t-test. Finally, the remaining three hypotheses of this study; 7, 8 and 9 were tested using ANOVA.

4.7 Assumptions and Limitations

4.7.1 Assumptions

- Students in one group did not interact with the students in the other group.
- The teacher was not biased during the treatments.
- The tests were administered under standard conditions.
- All subjects in this study responded to the questions in the instruments sincerely.

4.7.2 Limitations

- This study was limited to 9th grade students from Ankara Atatürk Anadolu Lisesi during 2003-2004 academic year's first semester.
- This study is limited to only 56 students.
- This study is limited to only the unit of phases and phase changes of matter.

CHAPTER 5

RESULTS AND CONCLUSIONS

5.1 Results

This chapter presents the results of the analyses of hypotheses stated earlier. All hypotheses were tested at a significance level of 0.05. Statistical analyses were carried out by using the SPSS/PC (Statistical Package for Social Sciences for Personal Computers) packet program and Analysis of Covariance (ANCOVA), Analysis of Variance (ANOVA), independent samples t-test and paired samples t-test were used as statistical methods to test the hypotheses.

At the beginning of the treatment, there was no significant difference between the effects of conceptual change oriented instruction (CCOI) and traditionally designed chemistry instruction with respect to students' previous learning and understanding in phases and phase changes concepts ($t = 0.846$, $p > 0.05$). Also, no significant difference was found between CCOI students and TDCI students with respect to their science process skills ($t = 1.976$, $p > 0.05$).

Hypothesis 1

To answer the question posed by Hypothesis 1 stating that there is no significant difference between posttest mean scores of the students taught with CCOI and those taught with TDCI with respect to their understanding of phases and phase changes concepts when science process skills are controlled as a covariate, analysis of covariance (ANCOVA) was used. The summary of measures obtained is presented in Table 5.1.

Table 5.1 ANCOVA summary of PPCCT

Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Observed Power**
SPST (Covariate)	15.237	1	15.237	6.727	.012	.721
GROUP (Treatment)	9.797	1	9.797	4.326	.043	.532
GENDER	48.898	1	48.898	21.589	.000	.995
GROUP * GENDER	.550	1	.550	.243	.624	.077
Error	115.510	51	2.265			

The result showed that there was a significant difference between the posttest mean scores of the students taught with CCOI and those taught with TDCI with respect to their understanding of phases and phase changes concepts when science process skills are controlled as a covariate.

Table 5.2 Descriptive statistics for the effects of treatment and gender

GROUP	**GENDER**	**Mean**	**Std. Deviation**	**N**
1 (EG)	1 (F)	15.6429	1.33631	14
	2 (M)	17.7333	1.70992	15
	Total	16.7241	1.84964	29
2 (CG)	1 (F)	14.8333	1.94625	12
	2 (M)	16.2667	1.33452	15
	Total	15.6296	1.75736	27
Total	1 (F)	15.2692	1.66271	26
	2 (M)	17.0000	1.68154	30
	Total	16.1964	1.87248	56

The CCOI group scored significantly higher than TDCI group ($\overline{X}_{CCOI}$ = 16.72, $\overline{X}_{TDCI}$ = 15.63). For descriptive statistics for the effects of treatment, refer to Table 5.2.

The proportions of correct responses distributed to questions in the posttest for both groups are shown in Figure 5.1. As can be seen in the figure, there were differences of responses to the items between two groups. Only for few of the questions, proportions of correct responses of two groups are close to each other. For the rest, dramatic differences are observed. Though that may be due to the small size of the sample of the study, students in both groups tended to score poorer in some items. However, the CCOI group seems better even in poorly scored items.

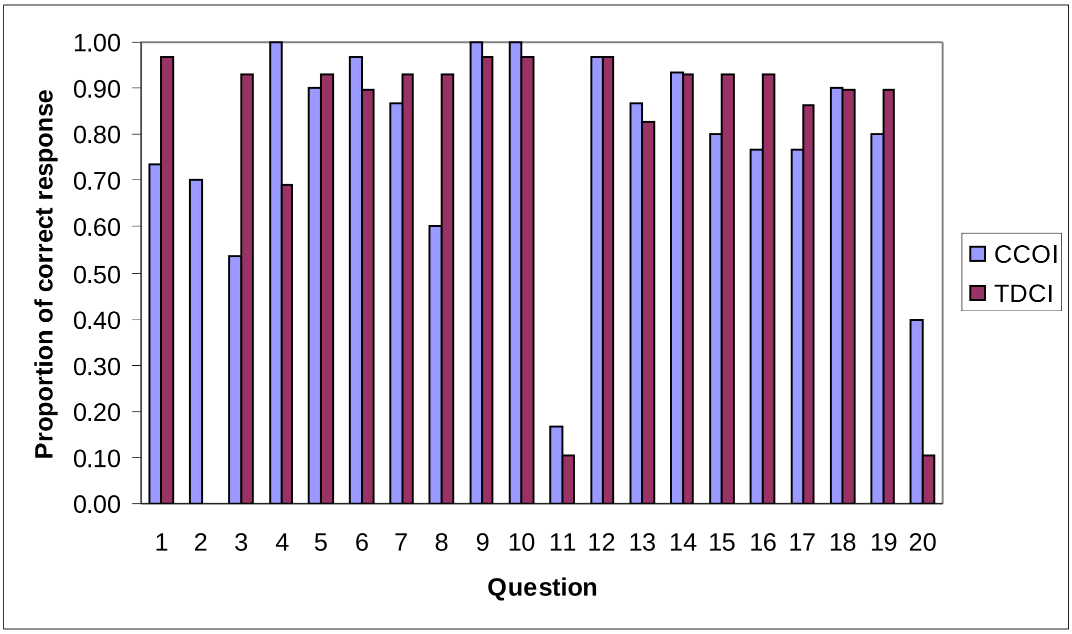

Figure 5.1 Comparison of CCOI group with TDCI group with respect to correct responses to the items in the posttest

Questions 11 and 20 were the most significant ones of the poorly scored items. Question 11 was about the shift of transition points when impurities or solutes are added, whereas question 20 was about the constancy of the temperature in transition points. The proportions of correct responses of CCOI and TDCI groups for question 11 were 17% and 10% respectively. Students were expected to respond in favor of intermolecular forces to explain the shift in transition points. But, they mostly explained it with an analog view with the arithmetic mean. One of the distracters was stating that different substances have different transition points and according to the concentration of the solute, a new common transition point occurs. That misconception is the most dominant one for both groups in question 11. However, regarding the difference, it can be said that CCOI seems more effective in students' understanding of intermolecular forces and their outcomes.

For a similar situation, the proportions of correct responses of CCOI and TDCI groups for question 20 were 40% and 10% respectively. There, students were asked to explain the energy consideration of the constancy of temperature during a phase transition. Similar to question 11, question 20 concerns molecular level phenomena and that seems rather abstract to students. Students were expected to explain the phenomenon with the transfer of heat in order to restrict or loosen the vibrations of molecules rather than increase or decrease the temperature. Two ideas were prevalent in both of the groups; transfer of heat causes the phase transition of the molecule itself within the substance and transfer of heat causes shortening or loosening of the intramolecular bonds. Both misconceptions have a similar point of view; phase change occurs within the molecule. But, explanations in favor of changes within the molecule are wrong and that point of view brings about some misconceptions placed in the distracters of question 20. Nonetheless, the CCOI group seems to perform better in the question.

However, the question that is most worth to mention is the second one. Situation stated in question 2 was an ordinary boiling in an open system and students were asked to define the white foggy substance coming out. None of the students in TDCI group gave the correct response though it is a widely observed situation. Students in the TDCI group claimed without an exception that the white foggy substance was water vapor. On the other hand, 70 % of the students in the CCOI group were able to pick the right explanation, which is a great proportion when taking the other group into consideration. Though, the rest of the CCOI group was all holding the same misconception as the TDCI group. This situation of TDCI group may be a result of the fact that traditionally designed instruction does not concern misconceptions or preconceptions. So, we can conclude that CCOI is significantly more effective in students understanding of phases and phase changes concepts and in removing misconceptions related.

Besides these, for three of the items; questions 4, 9 and 10, the proportion of correct responses for CCOI group are 1.00, i.e. all students in the CCOI group were able to give correct answers to those questions. On the other hand, in any of the questions TDCI group was not able to do this after the treatment.

As a result, the students in the experimental group, which were instructed with CCOI, understood phases and phase changes of matter concept better than the students in the control group, which were instructed with TDCI.

Hypothesis 2

To answer the question posed by Hypothesis 2 stating that there is no significant difference between the posttest mean scores of males and females with respect to their understanding of phases and phase changes concepts when science process skills are controlled as a covariate, again the ANCOVA summary presented in Table 5.1 is referred.

The result showed that there was a significant difference between the posttest mean scores of males and females with respect to their understanding of phases and phase changes concepts when science process skills are controlled as a covariate.

Males performed significantly higher than females in the posttest ($\overline{X}_{Males}$ = 17.00, $\overline{X}_{Females}$ = 15.27). For descriptive statistics for the effects of gender, refer to Table 5.2.

As a result, there is significant difference between the posttest mean scores of males and females with respect to their understanding of phases and phase changes concepts when science process skills are controlled as a covariate.

Hypothesis 3

To answer the question posed by Hypothesis 3 stating that there is no significant effect of interaction between gender difference and treatment on students’ understanding of phases and phase changes concepts, again the ANCOVA summary presented in Table 5.1 is referred.

The result showed that there is no significant effect of interaction between gender difference and treatment on students’ understanding of phases and phase changes concepts.

As a result, interaction between gender difference and treatment has no significant effect on students’ understanding of phases and phase changes concepts.

Hypothesis 4

To answer the question posed by Hypothesis 4 stating that there is no significant contribution of students’ science process skills to their understanding of phases and phase changes concepts, again the ANCOVA summary presented in Table 5.1 is referred.

The result showed that there is significant contribution of students’ science process skills to their understanding of phases and phase changes concepts.

As a result, students’ science process skills have a significant contribution to their understanding of phases and phase changes concepts.

Hypothesis 5

To answer the question posed by Hypothesis 5 stating that there is no significant effect of Conceptual Change Oriented Instruction (CCOI) on improvement of students’ understanding of phases and phase changes concepts, paired samples t-test is used as the statistic. Table 5.3 gives the paired samples test statistics for the CCOI group.

Table 5.3 Paired samples test for CCOI group

	Paired Differences					t	df	Sig.
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
PREACH - POSTACH	-4.0345	1.95453	.36295	-4.7779	-3.2910	-11.116	28	.000

The figures show that the difference between pretest and posttest mean scores of the CCOI group is significant. To test the existence of an improvement, Table 5.3 can be referred.

For the CCOI group, pretest mean scores and posttest mean scores have a significant difference and mean scores are as $\overline{X}_{Pre} = 12.690$ and $\overline{X}_{Post} = 16.724$.

Table 5.4 Paired samples statistics for CCOI group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PREACH	12.6897	29	2.57881	.47887
	POSTACH	16.7241	29	1.84964	.34347

To examine the within group changes of CCOI group before and after the treatment, Figure 5.2 can be referred. The figure represents the proportions of correct responses to the items in the pretest and posttest. As it is seen in the figure, an improvement in students' correct responses can be observed for almost every item in the test and some of those increases are drastic.

As a result, CCOI has a significant effect on improvement of students' understanding of phases and phase changes concepts. Moreover, improvement has been observed from pretest to posttest for the CCOI group.

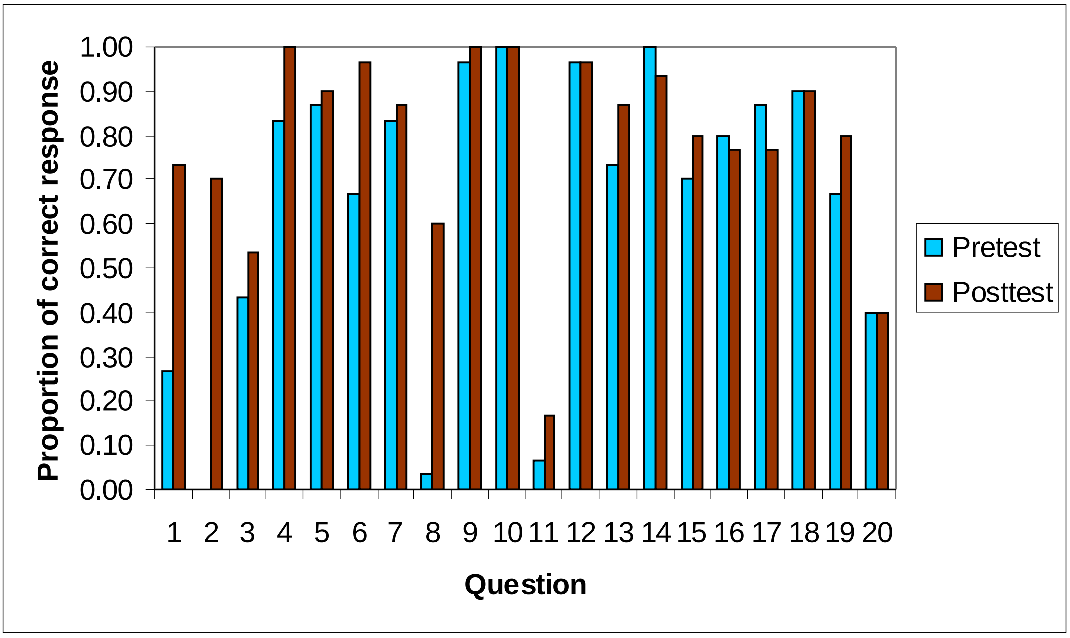

Figure 5.2 Comparison between pretest and posttest scores of CCOI group with respect to correct responses to the items in the test

Hypothesis 6

To answer the question posed by Hypothesis 6 stating that there is no significant effect of Traditionally Designed Chemistry Instruction (TDCI) on improvement of students' understanding of phases and phase changes concepts, paired samples t-test is used as the statistic. Table 5.5 gives the paired samples test statistics for the TDCI group.

Table 5.5 Paired samples test for TDCI group

	Paired Differences					t	df	Sig
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
PREACH - POSTACH	-3.4815	1.96841	.37882	-4.2602	-2.7028	-9.190	26	.000

The figures show that the difference between pretest and posttest mean scores of the TDCI group is significant. To test the existence of an improvement, Table 5.6 can be referred.

Table 5.6 Paired samples statistics for TDCI group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PREACH	12.1481	27	2.17863	.41928
	POSTACH	15.6296	27	1.75736	.33820

For the TDCI group, pretest mean scores and posttest mean scores have a significant difference and mean scores are as $\overline{X}_{Pre}$ = 12.148 and $\overline{X}_{Post}$ = 15.630.

To examine the within group changes of TDCI group before and after the treatment, Figure 5.3 can be referred. The figure represents the proportions of correct responses to the items in the pretest and posttest.

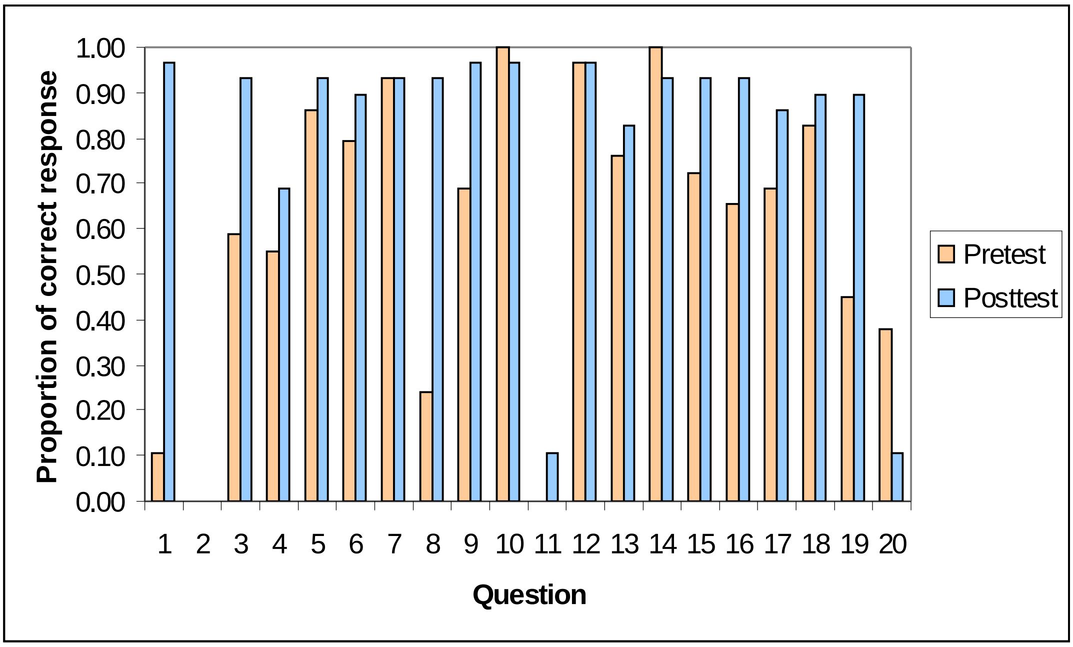

Figure 5.3 Comparison between pretest and posttest scores of TDCI group with respect to correct responses to the items in the test

As it is seen in the figure, an improvement in students' correct responses can be observed for items in the test.

As a result, TDCI has a significant effect on improvement of students' understanding of phases and phase changes concepts. Moreover, improvement has been observed from pretest to posttest for the TDCI group.

Hypothesis 7

To answer the question posed by Hypothesis 7 stating that there is no significant difference between posttest mean scores of the students acquiring CCOI and those acquiring TDCI with respect to attitudes toward chemistry as a school subject, analysis of variance (ANOVA) was used. The summary of measures obtained is presented in Table 5.7.

Table 5.7 ANOVA summary of ASTC

Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Observed Power**
GROUP	64.322	1	64.322	.628	.432	.122
GENDER	64.322	1	64.322	.628	.432	.122
GROUP * GENDER	42.636	1	42.636	.416	.522	.097
Error	5328.362	52	102.468			

The result showed that there was no significant difference between the posttest mean scores of the students acquiring CCOI and those acquiring TDCI with respect to attitudes toward chemistry as a school subject.

As a result, there is not enough evidence about a significant difference between posttest mean scores of students acquiring CCOI and those acquiring TDCI with respect to their attitudes toward chemistry as a school subject.

Hypothesis 8

To answer the question posed by Hypothesis 8 stating that there is no significant difference between the posttest mean scores of males and females with respect to students’ attitudes toward chemistry as a school subject, again the ANOVA summary presented in Table 5.7 is referred.

The result showed that there was no significant difference between the posttest mean scores of males and females with respect to attitudes toward chemistry as a school subject.

As a result, there is not enough evidence about a significant difference between posttest mean scores of males and females with respect to their attitudes toward chemistry as a school subject.

Hypothesis 9

To answer the question posed by Hypothesis 9 stating that there is no significant effect of interaction between gender difference and treatment on students’ attitudes toward chemistry as a school subject, again the ANOVA summary presented in Table 5.7 is referred.

The result showed that there is no significant effect of interaction between gender difference and treatment on students’ attitudes toward chemistry as a school subject.

As a result, there is not enough evidence about a significant effect of the interaction between gender difference and treatment on students’ attitudes toward chemistry as a school subject.

5.2 Conclusions

From the results of the hypotheses tested, the following conclusions can be deduced:

1. The CCOI caused a significantly better understanding and acquisition of concepts related to phases and phase changes of matter and better elimination of alternative conceptions than TDCI.
2. The effect of gender difference on students' understanding of phases and phase changes concepts was significant. Males scored better in both the CCOI and TDCI groups and in total.
3. The interaction between gender difference and type of the treatment had no significant effect on students' understanding of phases and phase changes concepts. Treatment is independent of gender difference with respect to students' understanding of phases and phase changes concepts and gender difference is independent of treatment with respect to students' understanding of phases and phase changes concepts.
4. Science process skills were strong predictors for the understanding related to phases and phase changes concepts.
5. Students acquiring CCOI showed improvement in understanding and acquisition of concepts related to phases and phase changes.
6. Students acquiring TDCI showed improvement in understanding and acquisition of concepts related to phases and phase changes.
7. The difference between posttest mean scores of students acquiring CCOI and those acquiring TDCI was not significant with respect to their attitudes toward chemistry as a school subject. The type of the treatment did not significantly affect students' attitudes toward chemistry as a school subject.
8. The difference between posttest mean scores of males and females was not significant with respect to their attitudes toward chemistry as a school subject. Gender difference did not significantly affect students' attitudes toward chemistry as a school subject.
9. The effect of the interaction between gender difference and treatment was not significant on students' attitudes toward chemistry as a school subject. Treatment is independent of gender difference with respect to students' attitudes toward chemistry as a school subject and gender

difference is independent of treatment with respect to students' attitudes toward chemistry as a school subject.

CHAPTER 6

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

6.1 Discussion

The main purpose of this study was to compare the effectiveness of conceptual change oriented instruction with that of traditionally designed chemistry instruction on 9^{th} grade students' understandings of phases and phase changes concepts and on their attitudes toward chemistry as a school subject and.

Regarding the analyses results given in Chapter 5, it can be concluded that conceptual change oriented instruction caused a better understanding of phases and phase changes concepts and a better elimination of related misconceptions than traditionally designed chemistry instruction. This finding is in accordance with findings of previous research about the effectiveness of instruction based on conceptual change model (Hewson & Hewson, 1983; Niaz, 2002; Smith et al. 1993).

The conceptual change text used in this study as the treatment to the experimental group, used a strategy of detection and conceptual change by refutation. The text was supported with demonstration of available tasks and discussion of students' ideas. Instead of giving blocks of information to the students and expecting them to process, the text focused on the alternative conceptions of the students and gave small bits of information when necessary to create a conflict and refute the bases of student misconceptions. This methodology of the text is in accordance with Nussbaum & Novick's (1982) suggested steps. For each task, students noted down their ideas of given situation, a comparison of those ideas with the existent common misconceptions in the text was done, with the explanations matching the misconceptions some conflicts created, and finally with the class discussion conceptual change was tried to be guided.

For all the tasks in the text, water was used as the sample substance to investigating phases and phase changes. The purpose for doing that is to eliminate some discrepancies coming from students understanding of the structure of different substances. Besides, water is the exemplar (Stavy & Stachel, 1985) and everyone is somehow familiar with its behaviors. However, water itself defies some rules that students know about phase changes.

By the results of this study, it is clear that science process skills of students are strong predictors for their understanding of phases and phase changes concepts. This result shows similarity with previous findings (Azizoğlu, 2004; Flehinger, 1971; Uzuntiryaki, 2003). As science process skills facilitates understanding of phases and phase changes concepts like understanding of many other topics, those skills should not be taken as separate phenomena from learning (Wynne, 1999). Therefore, when the instructional methods that are used during this research were compared taking the scores of science process skills test as covariate, conceptual change oriented instruction yielded significantly better scores.

Regarding the three figures 5.1, 5.2 and 5.3 the comparison and the effects of the methods would be much clearer. A common feature observed in all three figures is the poorly scored items Question 2, Question 11 and Question 20, as stated earlier. Nonetheless, in all the three items, CCOI group seems better. Question 2 was about defining the white foggy substance coming out during boiling of water. This is a well-known phenomenon and it is mentioned even in elementary school science courses. However, most students could not realize the gaseous form of the water. Water vapor is an invisible gas and it exists in the air. On the other hand, the white foggy substance is named steam and is an intermediate form. That intermediate form of water also exists in the air beside water vapor. This complexity may make the children confuse their concepts of vapor and the steam. Students accepting the invisibility of water vapor may define the steam as gaseous water. For the case of this study, the proportions of correct responses to Question 2 were both zero in CCOI and TDCI groups. After the treatment the proportion became 70% for the CCOI group and stayed zero for the TDCI group (Figure 5.2 and Figure 5.3) and this increase is drastic. That is; for the case of a common misconception, TDCI showed no effect in understanding the concept of steam or in removing the misconceptions. All students in TDCI group still picked the distracter according to their existing misconception and claimed that the white foggy substance was water vapor.

In Question 11, both groups exhibited an increase of 10 points; correct responses of CCOI group rose from 7% to 17% and those of TDCI group rose from 0 to 10%. But, the responses can still be classified as poor.

Moreover, there has been an obvious decline in correct responses to Question 20 for the TDCI group. For CCOI group, the proportion stayed constant before and after the treatment (40%). The question was about the constancy of the temperature during phase transitions despite the continuing energy transfer and in the pretest, 38 % of the students from TDCI group picked the right answer. Unfortunately, in the posttest the proportion of correct response fell to almost one fourth of that of the pretest; 10%. There was no student who did not pick the right answer in the pretest but picked up the right answer after TDCI. Most of the students those picked the right answer in the pretest but picked a wrong one in the posttest revealed a new misconception; they believe that molecule itself changes its phase.

That invokes a suspicion about traditionally designed method. Besides not concerning and not addressing misconceptions, traditionally designed instruction may retard learning and bring about more alternative conceptions. If that is the case, traditional methods can be said to have a major flaw in constructing new knowledge and alternative methods should be assigned in order to prevent undesired outcomes in such cases as Question 20.

Another point to mention is the items of fully correct responses. For three of the items, all students in the CCOI group were able to pick the right answer after the treatment but for one of the items which gained fully correct response in pretest showed a little decrease after the treatment (Figure 5.2). On the other hand, the two items of fully correct response in pretest showed decreases in the posttest, though; none of the items gained fully correct response from the TDCI group in the posttest (Figure 5.3).

Effect of gender on understanding of phases and phase changes concepts was also investigated in this study. From the results, we can conclude that males performed better in understanding phases and phase changes concepts and in removing misconceptions related to phases and phase changes (Table 5.2). Within both groups and overall, males exhibited higher mean scores than females. This finding is in accordance with the research based claim of Gabel (1994, p. 185) on effect of age, ability, gender, and cultural boundaries. For studies concerning alternative conceptions among males and females, the results that Gabel mentioned suggests that males have fewer alternative conceptions than females. Yet, those and the results of this study concerning the effect of gender difference could be a subtle result of focus and design. Though numbers of females and males are close to each other in this study, the sample is still small and thus, a generalization about the effect of gender difference on students' understanding of phases and phase changes concepts does not seem feasible.

The results obtained from this study also indicate that the type of the treatment did not affect students' attitudes toward chemistry as a school subject. In accordance with the case Koballa (1988) stated, this study also investigated the effect of conceptual change oriented instruction on students' attitudes toward chemistry as a school subject when compared with that traditionally designed instruction rather than investigating a relation between attitudes and achievement. However, there was no significant difference between attitudes of CCOI and TDCI groups toward chemistry as a school subject at the end of the treatment.

This situation may be a result of the claim that attitudes are not easily changed (Cukrowska et al., 1999). Because the three-week duration of the study is short to observe changes in the attitudes of students' toward chemistry, the treatment type may have not affected the attitudes of students toward chemistry lessons differently.

Gender type also did not affect students' attitudes toward chemistry as a school subject differently. This, again, may be due to the observation of no significant change in student' attitudes toward chemistry as a school subject. Though, it is not evidence that gender difference has no effect on students' attitudes. Further and longitudinal studies are suggested to be made in order to let the changes occur and obtain evidence.

To conclude, conceptual change oriented instruction seems to bring about better understanding of phases and phase change concepts than traditional methods of instruction. Moreover, the findings in literature that; males have less alternative conceptions than females and that; science process skills are predictors of understanding of concepts were again supported with the findings of this study. On the other hand, no significant effect of conceptual change oriented instruction was observed on students' attitudes toward chemistry as a school subject when compared with the traditionally designed instruction.

6.2 Implications

Science teachers should be aware of students' prior knowledge and existing alternative conceptions. They should understand how students learn scientific concepts. Moreover, teachers should be aware of instructional techniques and situations that are open to yield more alternative conceptions or techniques not concerning students' cognitive structure and alternative conceptions. Also, teachers should use effective instructional strategies to identify and remove alternative conceptions.

Conceptual change oriented instruction, when enriched with diverse activities and methods; could be an effective classroom tool. Students are responsible of changing their conceptions, thus the role of the teacher should be guiding students to explore their own conceptions.

Traditional instruction methods with limited activities are known to neglect misconceptions and the way students construct knowledge. Thus, curriculum programmers should give more emphasis on constructivist approach and instructional materials including the textbooks should be improved in that sense.

Attitude is shown to have strong positive correlation with achievement, thus, teachers should be aware of their students' attitudes toward science and try to enhance students' positive attitudes.

Teachers and candidate teachers subscribe to the same alternative conceptions as their students. Therefore, teacher education programs should be revised and constructivist approach should be paid more importance.

6.3 Recommendations

Based on the findings of this study, the following are recommended:

This study can be extended in terms of the sample size, grade levels, and school. A larger sample will result in more accurate and diversified findings because the discrepancies resulting from small sample size would be reduced or eliminated. Phases and phase changes of matter is included in elementary school and tenth grade curricula and diversification of sample will result in detection of alternative conceptions at different age levels. Moreover, selecting more and different schools will help generalization of results to countrywide.

Research about the material development regarding the different aspects of learning and different instructional strategies can be conducted to improve the quality of learning. Within this perspective, computers and computer aided instruction can be investigated.

Students' attitudes toward chemistry and other science courses can be investigated in regard for their effect on understanding of concepts rather than investigating the effect of instructional strategy on attitudes. On the other hand, duration of this study can also be extended in order to assign sufficient time for the changes in attitudes to occur, if it occurs.

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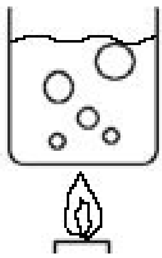
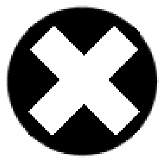
APPENDIX A

CONCEPTUAL CHANGE TEXTS SAMPLE

GÖREV 1: Kaynama

Soru:	Suyu kaynarken izlediğinizde birçok büyük baloncuk görürsünüz. Baloncukların içinde ne vardır?	

Kaynamayla İlgili Kavram Yanılgıları:

Kavram Yanılgısı 1:	Bir kaba su koyup kaynayana kadar ısıtılır ve kaynayan suyun içinde baloncuklar görülür. Bazıları bu baloncukların içinde hava olduğunu düşünür.	

Bu yanılgı önceki kişisel gözlemlerden veya havayı oluşturan ve suda çözünen maddelerle ilgili eksik bilgiden kaynaklanabilir. Eğer daha önce plastik balon şişirdiyseniz, balonu şişirmeye yarayan esas maddenin hava olduğunu bilirsiniz. Bu yüzden de şişirdiğiniz balonlarla kaynayan sudaki baloncuklar arasında benzerlik kurarak balon oluşturmak için hava gerektiğini düşünebilirsiniz. Balonunuzun veya baloncukların içinde gaz olduğu doğrudur ama hava tek başına bir gaz değildir, bazı gazların karışımından ve çok küçük katı ve sıvı parçacıklardan oluşan bir maddedir. Kaynayan sudaki baloncukların içindeki bir çeşit gaz mıdır, hava mıdır yoksa başka bir karışım mıdır?

Size ilköğretimde havayla ilgili öğretilen temel bilgileri hatırlayın. Havanın % 78'i Nitrojen (Azot), % 21'i Oksijen ve kalan % 1'i de Karbondioksit, diğer bazı gazlar ve kirletici katı ve sıvı parçacıklardan oluşmaktadır. Suyun yapısındaysa hidrojen ve oksijen bulunmaktadır. Kaynamayla suyun havaya dönüştüğünü ve baloncukları oluşturduğunu düşünüyorsanız aslında suda bulunmayan azot, karbon vb. maddeler nereden gelmektedir? Havanın suya girdiğini düşünüyorsanız baloncukların doğrudan yüzeyde oluşması gerekmez mi? Oysa dikkatli izleyin, dipten yukarı doğru yükselirler. Bunlara bakarak diyebiliriz ki baloncuklar hava baloncuğu değillerdir, baloncukların içinde hava olduğunu düşünmek yanlıştır.
Bunlarla birlikte bir de havadaki gazların da suda çözünebildiklerini biliyoruz, ancak bu çözünen miktar çok azdır. Suya ısı verip kaynatmaya devam edin. Çözünen hava çıkıp bittikten sonra kaynama duracak mıdır yoksa tüm su bitene kadar devam edecek midir? Eğer denerseniz göreceksiniz ki ısıtmaya devam ederek yeterince beklerseniz kaptaki suyun tamamı kaybolacaktır. Su hava değildir, hava da su değildir. Bunlar birbirlerine dönüşemezler. Öyleyse kaynayan sudaki baloncukların içindeki madde hava değildir.

Baloncuklar su buharından oluşurlar ve su buharı da suyun gaz halidir. Bir gazın özelliklerini taşır ve baloncuk oluşturabilir. Üstelik, baloncuklar oluşmaya dipten başlarlar çünkü alttan ısıttığımızdan ısıyla önce dipteki su karşılaşır ve önce dibe yakın su gaz haline geçer ve buhar oluşur.

Kavram Yanılgısı 2:	Kaynayan sudaki büyük baloncukları görünce bazıları bu baloncukların hidrojen ve oksijenden oluştuğunu, bazıları sadece oksijenden oluştuğunu, bazıları ise oksijen ve karbondioksitten oluştuğunu düşünmektedirler. Bu kişiler baloncukların suyun yüzeyine ulaşınca patladığını çünkü içinde gaz olduğunu ve sıvıdan kurtulunca gazın havaya karıştığını ve görünmez olduğunu söylemektedir ve bunlar doğrudur. Ancak baloncukların içindeki gazlar yukarıda sayılanlardan oluşur demektedirler.

Tabii ki baloncukların içinde en az bir çeşit gaz olmalıdır. Baloncuklar bu yüzden oluşurlar ve biz de gözlemleriz. Ancak bu gazın veya gazların hidrojen ve oksijen veya sadece oksijen veya oksijen ve karbondioksit olduğu şüphelidir.

Şimdi dikkatle düşünelim. Bir su molekülü iki hidrojen ve bir oksijen atomunun kimyasal bileşiminden oluşmuştur. Yani halihazırda oksijen ve hidrojen vardır. Üstelik su saf değilse saflığı bozacak şekilde karbondioksit de olabilir. Bu yüzden bahsedilen tüm elementler elimizdeki suda var kabul edilebilir. Ancak daha derin düşünmek gereklidir. Karbondioksitle başlarsak, suyu kaynatmaya devam ederseniz tamamının belli bir süre sonunda buharlaşıp kaybolacağını biliyoruz. Peki bu değişim su moleküllerinin karbondioksit moleküllerine dönüşmesi midir? Bu sadece ısıtmayla mümkün müdür? Bu yöntemle molekülün kimyasal yapısı değişir mi yada bir elementin atomları başka bir elementin atomlarına dönüşebilir mi? Gördüğünüz gibi bu pek olanaklı değildir. Her şeyden önce hal değişiklikleri fiziksel değişikliklerdir ve maddenin kimyasal bileşimini veya molekül yapısını değiştirmezler. Bu yüzden, suyu kaynatarak molekül yapılarını değiştiremeyiz ve molekülü oluşturan oksijen veya hidrojen gibi bazı maddelerin açığa çıkmasını sağlayamayız. Üstelik değişim kimyasal olmadığı için normalde suda bulunmayan bazı maddeler oluşmamalıdır. Başka bir deyişle, suda karbon atomları yoktur veya çok azdır ve baloncuklarda olduğu iddia edilen karbon atomları oksijen veya hidrojenden oluşturulamaz. Bununla birlikte, daha önce de değindiğimiz gibi, eğer su saf değilse ortamda biraz karbondioksit bulunabilir ancak bu suyla karşılaştırıldığında çok küçük bir miktardır. Suyu kaynatırsanız karbondioksit baloncuklarla çıkabilir fakat bunlar ancak küçük baloncuklar oluşturmaya yeter. Çözünen tüm karbondioksit serbest kalınca kaynama devam etmeyecek midir?

Karbondioksitin biteceğini, kimyasal değişim olmadığı için oksijenin veya hidrojenin de etrafa salınamayacağını biliyoruz. Öyleyse baloncukların içinde ne olabilir?

Evet, doğru. Baloncukların içindeki bir gazdır. Su molekülleri kimyasal değişime uğramadığından ve suyun bazı fiziksel özellikleri değiştiğinden baloncukların içindeki suyun başka bir hali olmalıdır. (Bu değişen fiziksel özellikleri neler olabilir?) Sonuç olarak baloncukların içinde suyun gaz hali vardır ve kimyasal yapısı hala iki hidrojen ve bir oksijenden oluşan moleküldür (H_2O), başka bir şey değil. Suyun bu gaz haline buhar diyoruz ve buhar bir gazın tüm özelliklerini taşır.

Kavram Yanılgısı 3:	Bazıları kaynama sırasında suda gördüğünüz baloncukların ısıdan oluştuğunu düşünmektedir.

Su bir maddedir fakat ısı bir enerji çeşididir. Bir enerji olduğundan ısının kütlesi olamaz ve daha ötesi suda baloncuk oluşturacak hacmi olamaz. Kütlesi ve hacmi olmayan bir şey, bir kütleye ve hacme sahip olan baloncukları oluşturabilir mi? Bu yüzden diyoruz ki baloncukların içindeki şey ısı değil yine gaz halindeki sudur.

APPENDIX B

PHASES AND PHASE CHANGES CONCEPT TEST

LÜTFEN AŞAĞIDAKİ SORULARI DİKKATLİCE OKUYUNUZ VE DOĞRU ŞIKKI SOLUNDAKİ HARFİ YUVARLAK İÇİNE ALARAK İŞARETLEYİNİZ. HER SORUNUN SADECE BİR TANE DOĞRU CEVABI VARDIR. BİRDEN FAZLA İŞARETLEME YAPMAYIN.

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

   A) Hava
   B) Isı
   C) Buhar
   D) Oksijen ve Hidrojen
   E) Oksijen ve Karbondioksit

2) Bir çaydanlıkta veya kettle’da kaynayan yada henüz kaynatılmış suya bakıldığında kapların ağzından çıkan sise benzer bir maddenin yükseldiği görülür. Bu sise benzeyen madde nedir?

   A) Su buharı
   B) Çok küçük su damlaları
   C) Duman
   D) Saflığı bozan maddelerin kalıntıları
   E) Sıcak hava

3) Bir tabağı yıkayıp yaş haliyle ve normal şekilde mutfak tezgahının üstüne koyarsanız bir süre sonra kuruduğunu görürsünüz. Tabağın üzerindeki suya ne olduğuyla ilgili doğru açıklama aşağıdakilerden hangisidir?

A) Su emilmeyle tabağın içine çekilir
B) Su kurur ve bir şeye dönüşmez
C) Su havaya Oksijen ve Hidrojen olarak karışır
D) Su çok küçük parçacıklar halinde havaya karışır
E) Su tabağın içinden geçerek tezgaha ulaşır ve orada yayılarak kaybolur

4) Bir odada yarıya kadar dolu plastik bir şişe vardır. Şişenin kapağı açılıp günlerce ellenmeden öylece bırakılır. Günler geçtikçe şişedeki suya ne olacaktır?

A) Su buharlaşmayla azalacak ve kaybolacaktır
B) Su buharlaşma-terleme dengesiyle azalacak ve kaybolacaktır
C) Su şişeden difüzyon (yayılma) ile azalacak ve kaybolacaktır
D) Su havadaki buharın yoğunlaşmasıyla artacaktır
E) Hiçbir değişiklik olmayacaktır

5) Bir parça camı henüz kaynamış, sıcak suyun üzerine kapatmadan tuttuğunuzda bir kaç dakika içinde camın alt yüzeyinde su damlacıkları oluştuğunu görürsünüz. Bu damlacıklar nasıl oluşur?

A) Su buharı cam tarafından bloke edilip bir yere kaçamazlar
B) Suyun yüzeyindeki moleküller hava tarafından cama taşınır
C) Sıcak hava soğuk havayla karşılaşıp yoğunlaşır
D) Su buharı soğuk camla karşılaşır ve yoğunlaşır
E) Su buharı sıcak suyla cam arasında doyuma ulaşınca yoğunlaşır

6) İyice soğumuş bir şişe buzdolabından çıkarılır. Kısa bir süre içinde şişenin dış yüzeyinde küçük belirgin su damlacıkları oluşur. Bu küçük damlacıklar nereden gelmektedir?

A) Şişenin etrafındaki hava soğutulunca ortaya çıkarlar
B) İçecekteki su molekülleri şişenin duvarlarından geçerek dışarı ulaşır
C) Şişenin soğuk yüzeyi ve hava oksijen ve hidrojeni birleştirmek için tepkimeye girerler
D) İçecekteki soğuk su ısı alınca buharlaşır ve yüzeye ulaşır
E) Havadaki su buharı soğutulunca yoğunlaşır

7) Bir çaydanlığa su koyup elinizi su kaynarken çaydanlığın üzerine tutarsanız elinizin ıslandığını fark edersiniz. Eliniz neden ıslanır?

A) El sıcaklıktan dolayı terler
B) Su buharı elinizle çarpışır
C) Su buharı elinizde yoğunlaşır
D) Sıcak havayla yükselen su parçacıkları elinize ulaşır
E) Nem ısınmadan dolayı yükselir ve elinize ulaşır

8. ve 9. soruları aşağıda belirtilen duruma göre cevaplayınız:

İçine bir miktar su konulmuş ve ağzı sıkıca kapatılmış bir plastik şişe birkaç gün boyunca hiç ellenmeden dinlenmeye bırakılıyor. Bu süre sonunda şişenin iç yüzeyinin suyun olmadığı boş kısımlarında çok küçük su damlacıkları oluştuğu gözleniyor.

8) Şişenin iç yüzeyinde su damlacıklarının oluşma sebebi nedir?

A) Su buharı şişenin duvarlarının soğukluğuyla karşılaşınca yoğunlaşır
B) Su buharı şişenin iç yüzeyine yapışır
C) Şişenin içindeki su buharı doyuma ulaşır ve yoğunlaşır
D) Su buharı dışarının ve içerinin sıcaklık farkından dolayı yoğunlaşır
E) Su buharı dışarının ve içerinin basınç farkından dolayı yoğunlaşır

9) Şişenin ağırlığı nasıl değişir?

A) Kapak açılmadığı sürece sabit kalır
B) Buharlaşmadan ortaya çıkan kayıp yüzünden azalır
C) İçeride fazladan oluşan su yüzünden artar
D) İçten dışa buharlaşma-terleme dengesiyle azalır
E) Dıştan içe buharlaşma-terleme dengesiyle artar

10) Saf bir madde için konuşursak hal değişimi sırasında sıcaklık nasıl değişir?

A) Kaynama sırasında gittikçe yükselir ve donma sırasında gittikçe düşer
B) Kaynama sırasında hafifçe düşer ve donma sırasında hafifçe yükselir
C) Etrafın sıcaklığına göre düşer veya yükselir
D) Çevresel basınca göre düşer veya yükselir
E) Hal değişimi tamamlanana kadar değişmez

11) Bir maddenin içinde başka bir madde çözerek saflığını bozduğunuzda hal değişimi noktalarında görülen kaymaların sebebi nedir?

A) Saflığı bozan maddeleri örneğimizle birlikte kaynatmak veya eritmek için fazladan gereken ısı
B) Örneğimizin molekülleriyle saflığı bozan maddenin molekülleri arasındaki etkileşimi aşmak için fazladan gereken ısı

C) Farklı maddelerin farklı hal değişim noktaları olur ve çözünen maddenin derişimine göre yeni bir ortak değişim noktası ortaya çıkar
D) Saflığı bozan maddeyle girilen tepkime farklı bir kimyasal yapı ortaya çıkarır
E) Hiçbiri doğru değildir

12) Sofra tuzuyla doyurulmuş su örneğini sürekli ısıtırsanız hangisinin olmasını beklersiniz?

A) Tüm çözelti buharlaşır ve kabı boş bırakır
B) Su buharlaşır ve tuz kristalleri oluşur
C) Su buharlaşır ve sıvı halde tuz kapta kalır
D) Çözünen tuz buharlaşır ve suyu saflaştırır
E) Bu koşullarda çözelti kaynamaz

13) İkisi de 0 °C'de aynı miktardaki sıvı halde su ile buzun hangi özellikleri birbirinin aynısıdır?

A) Hacimleri
B) Moleküller arası çekim kuvvetleri
C) Moleküllerinin potansiyel enerjileri
D) Molekül sayıları
E) Isı kapasiteleri

14) Aşağıdakilerden hangisi örnek bir sıvının kaynama noktasını etkilemez?

A) Atmosfer basıncı
B) Sıvının türü
C) Sıvının saflık derecesi
D) Yüzeye uygulanan basınç
E) Sıvının miktarı

15) Belirli koşullarda yeterince ısı verildiğinde kaynayamayan madde aşağıdakilerden hangisidir?

A) Su
B) Demir
C) Bakır
D) Etil alkol
E) Hiçbiri

16) Belirli bir miktar buz alınıp kapalı bir sistemde sürekli ısıtılıyor. Önce buz eriyor sonra da su kaynatılıyor. Bu işlem boyunca maddemiz iki hal değişimi noktasından geçiyor: erime ve kaynama noktaları. Suyun yoğunluğu ve ağırlığı bu hal değişimi noktalarında nasıl değişir?

A) Yoğunluk erime noktasında artar ve kaynama noktasında azalır fakat ağırlık her iki noktada da sabit kalır
B) Yoğunluk her iki noktada da azalır fakat ağırlık her iki noktada da sabit kalır
C) Yoğunluk her iki noktada da artar fakat ağırlık her iki noktada da sabit kalır
D) Yoğunluk ve ağırlık erime ve kaynama noktalarının ikisinde de azalır
E) Yoğunluk ve ağırlık erime ve kaynama noktalarının ikisinde de artar

17) Kuru buz (katı CO_2) yavaşça ısıtıldığında gaz halindeki bir madde açığa çıkarır ve kaybolmaya başlar. Bu süreç süblimleşme olarak adlandırılır. Aşağıdakilerden hangisi bu süblimleşmeyi açıklamaktadır?

A) Kuru buzun erimesi
B) Kuru buzun yoğunlaşması
C) Kuru buzun buharlaşması
D) Kuru buzun yanması
E) Hiçbiri

18) Su deniz seviyesindeyken 100 °C’ta kaynar fakat, deniz seviyesinden yükseklere çıkıldıkça kaynama sıcaklıklarını not ederseniz 100 °C’tan daha düşük sıcaklıklarda kaynadığını ve yükseldikçe daha da düştüğünü göreceksiniz. Bu düşüşü nasıl açıklarsınız?

A) Yükseklik arttıkça buhar basıncı düşer
B) Yükseklik arttıkça atmosfer basıncı düşer
C) Yükseklik arttıkça buhar basıncı artar
D) Yükseklik arttıkça atmosfer basıncı artar
E) Yükseklik arttıkça buhar basıncı da, atmosfer basıncı da artar

19) Kapalı bir kaptaki sıvının buhar basıncını aşağıdakilerden hangisi etkiler?

A) Atmosfer basıncı
B) Kabın hacmi
C) Kabın şekli
D) Sistemin sıcaklığı
E) Kaptaki sıvı miktarı

20) Hal değişimi noktalarında ısıtma yada soğutma devam etse de tüm madde hal değişimini tamamlayana kadar sıcaklık sabit kalır. Sisteme fazladan verilen veya sistemden fazladan alınan bu ısıyı ve sıcaklığın sabit kalmasıyla ilişkisini nasıl açıklarsınız?

A) Fazladan alınan veya verilen ısı sıcaklığı artırıp azaltmak yerine moleküllerin titreşimini sınırlamak veya serbestleştirmek için harcanır
B) Fazladan alınan veya verilen ısı sıcaklığı artırıp azaltmak yerine moleküllerin halini değiştirmeye harcanır
C) Fazladan alınan veya verilen ısı sıcaklığı artırıp azaltmak yerine molekül içi bağları kısaltıp uzatmaya harcanır

D) Fazladan alınan veya verilen ısı sıcaklığı artırıp azaltmak yerine molekülleri oluşturmaya veya parçalamaya harcanır

E) Fazladan alınan veya verilen ısı sıcaklığı artırıp azaltmak yerine moleküllerin kimyasal tepkimeleri yürütmesi sağlamaya harcanır

APPENDIX C

KİMYA DERSİ TUTUM ÖLÇEĞİ

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

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

APPENDIX 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. Türkçeye çevrisi ve uyarlaması ise Prof. Dr. İlker Özkan, Prof. Dr. Petek Aşkar ve Prof. Dr. Ömer Geban tarafından yapılmıştır.

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

a. Her oyuncunun almış olduğu günlük vitamin miktarını.

b. Günlük ağırlık kaldırma çalışmalarının miktarını.

c. Günlük antrenman süresini.

d. Yukarıdakilerin hepsini.

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

a. Arabaların benzinleri bitinceye kadar geçen süre ile.

b. Her arabanın gittiği mesafe ile.

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

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

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

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

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

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

c. Büyük evlerin ısınma giderleri fazladır.

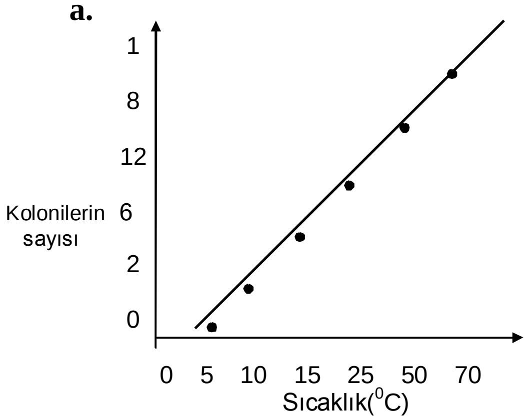
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

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

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

a.



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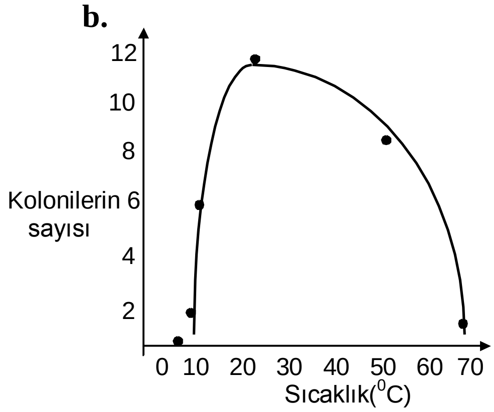

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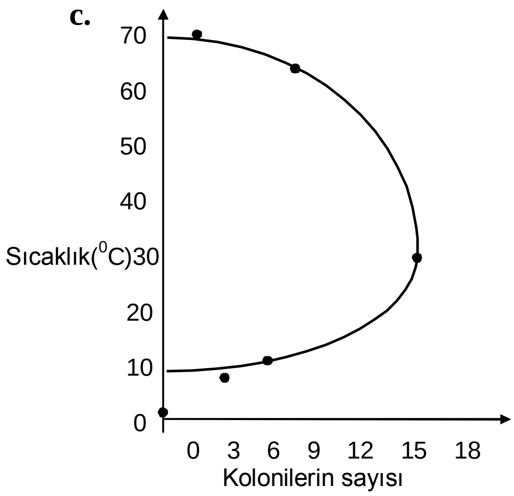
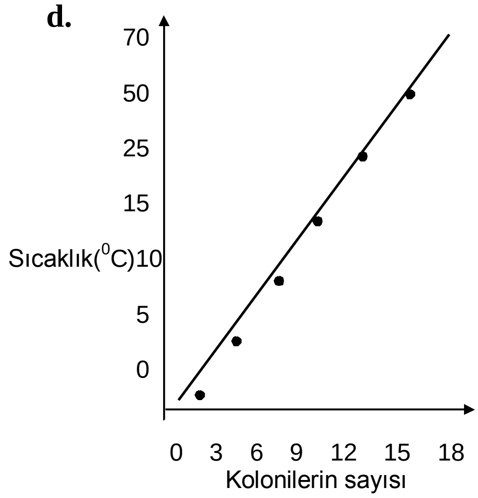


d.



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

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

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

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

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

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

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

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

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

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

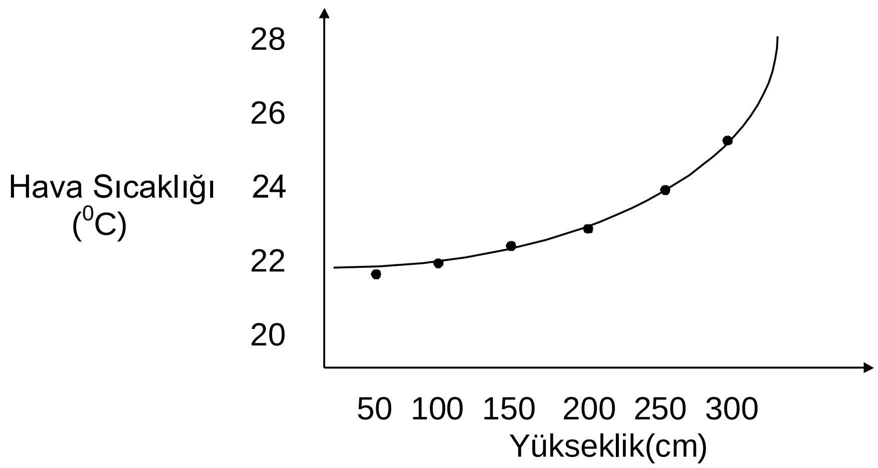
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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

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

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

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



a. Yükseklik arttıkça sıcaklık azalır.

b. Yükseklik arttıkça sıcaklık artar.

c. Sıcaklık arttıkça yükseklik azalır.

d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

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

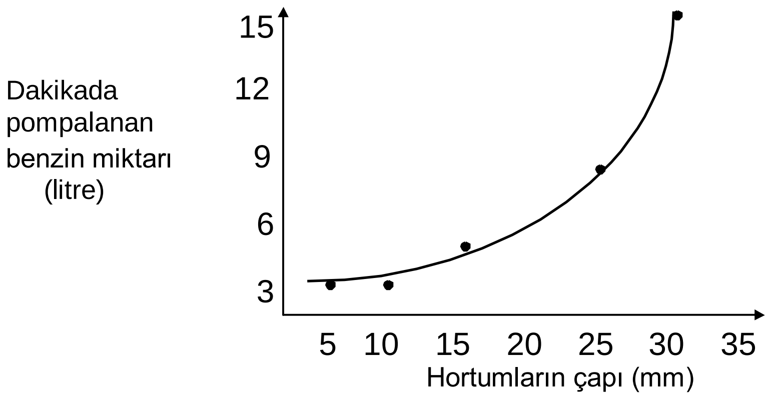
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

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

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

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

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

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

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

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

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

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

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

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

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

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

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

c. Güneş farklı maddeleri farklı derecelerde ısıtır.

d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

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

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gübrenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

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

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

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

17. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

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

a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.

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

c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.

d. Her alana ektiği tohum sayısına bakar.

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

a. Kullanılan toz ya da spreyin miktarı ölçülür.

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

c. Her fidede oluşan kabağın ağırlığı ölçülür.

d. Bitkilerin üzerinde kalan bitler sayılır.

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

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

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

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

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

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

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

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

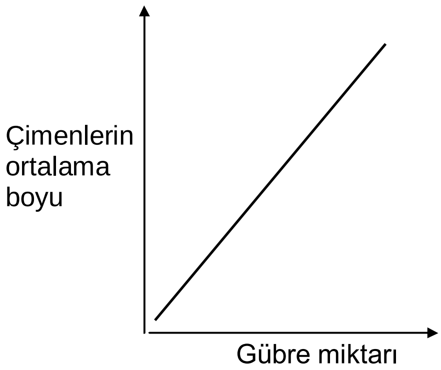
d. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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

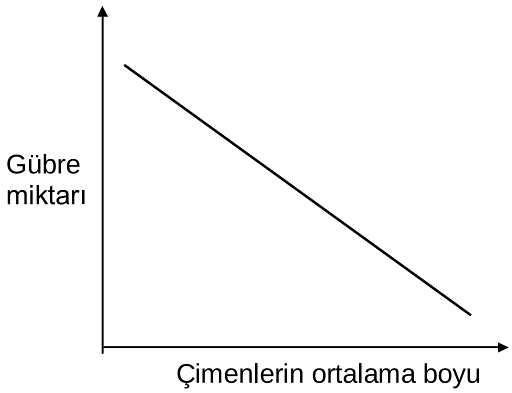
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

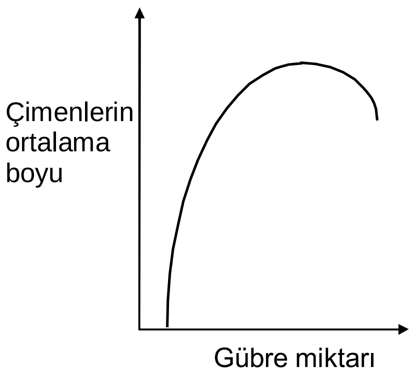
a.



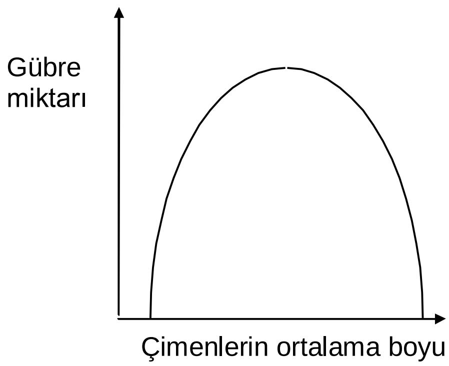
b.



c.



d.



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

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Hergün fareleri tartar.

d. Hergün farelerin yiyeceği vitaminleri tartar.

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

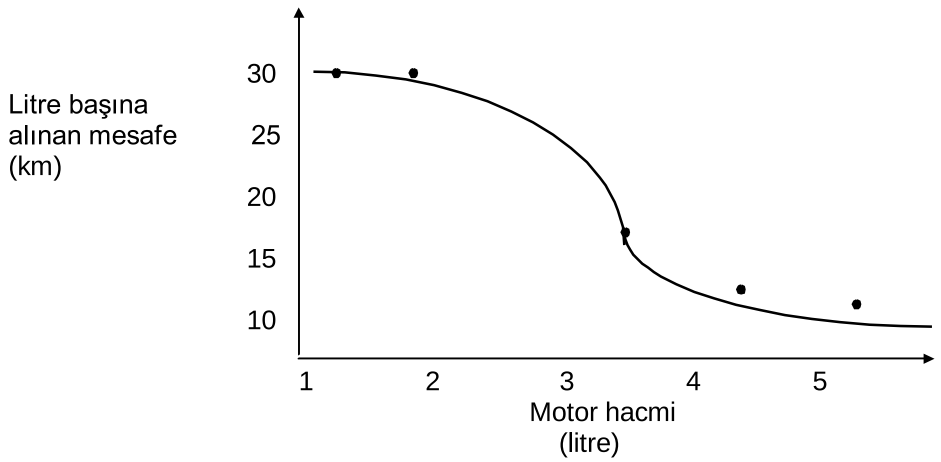
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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

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

d. Su ısındıkça şeker daha uzun sürede çözünür.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

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

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

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

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

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

29. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı.

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı.

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

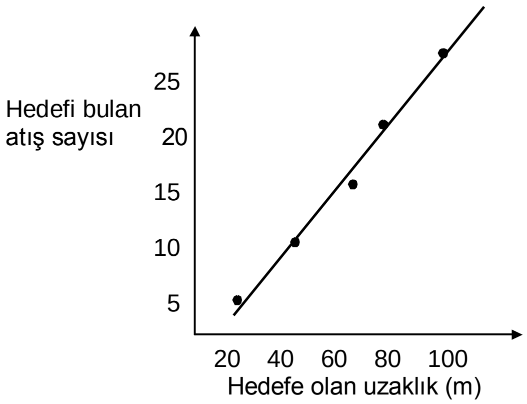
d. Çekilen demir tozlarının ağırlığı ile.

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

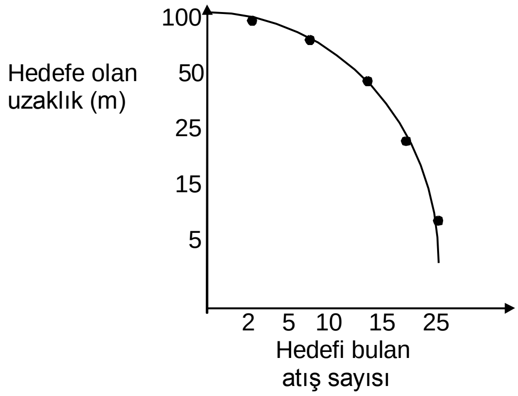
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

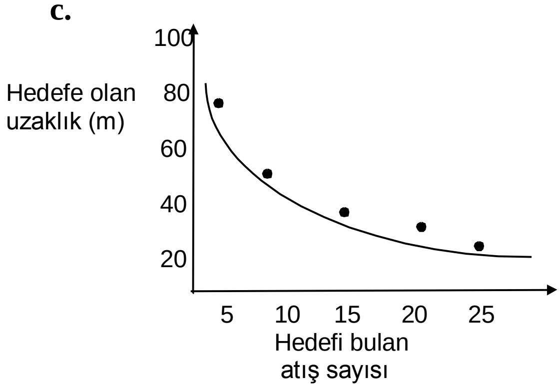
a.



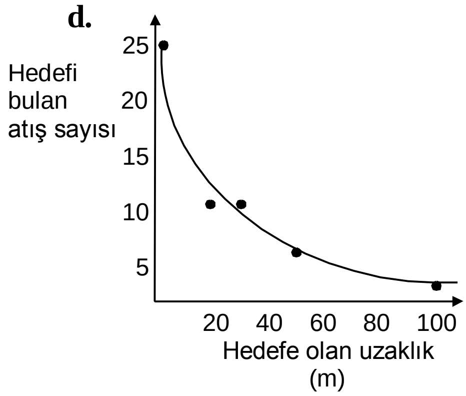
b.



c.



d.



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

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

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

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

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

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

a. TV’nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c.