EFFECT OF CONCEPTUAL CHANGE ORIENTED INSTRUCTION ACCOMPANIED WITH COOPERATIVE GROUP WORK ON UNDERSTANDING OF ACID-BASE CONCEPTS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

ARZU AYHAN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
SECONDARY SCHOOL SCIENCE AND MATHEMATICS EDUCATION

JULY 2004

Approval of the Graduate School of Natural and Applied Sciences.

Prof. Dr. Canan Özgen
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Ömer Geban
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Prof. Dr. Ömer Geban
Supervisor

Examining Committee Members

Prof. Dr. Hamide Ertepınar	(METU, ELE)	____________________
Prof. Dr. Ömer Geban	(METU, SSME)	____________________
Asst. Prof. Dr. Esen Uzuntiryaki	(METU, SSME)	____________________
Asst Prof. Dr. Semra Sungur	(METU, ELE)	____________________
Asst. Prof. Dr. Jale Çakıroğlu	(METU, ELE)	____________________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Arzu AYHAN

Signature :

ABSTRACT

EFFECT OF CONCEPTUAL CHANGE ORIENTED INSTRUCTION ACCOMPANIED WITH COOPERATIVE GROUP WORK ON UNDERSTANDING OF ACID-BASE CONCEPTS

AYHAN, Arzu

M.S., Department of Secondary School Science and Mathematics Education

Supervisor: Prof. Dr. Ömer GEBAN

July 2004, 102 pages

The main purpose of this study was to compare the effectiveness of conceptual change oriented instruction accompanied with cooperative group work and traditionally designed instruction for removing misconceptions related to acid-base concepts.

In this study 33 tenth grade students from two classes from METU Development Foundation Private School in the spring semester of 2003-2004 participated.

There were two groups in the study. Students in experimental group received conceptual change oriented instruction with cooperative group work, and students in control group received traditionally designed instruction over a period of six weeks. Acid-Base Concept Test was administered to both groups as pre- and post-test. Students were also received Science Process Skill Test to determine their science process skills as pre-test and Attitude Scale Toward Chemistry to measure their attitudes toward chemistry as pre- and post-test.

The hypotheses were tested by t-test, ANCOVA, and ANOVA. The results showed that the students in experimental group had significantly higher scores with respect to achievement related to acid-base concepts than the students in control group. On the other hand, there was no significant difference between attitude mean scores of students in experimental and control groups. Also, science process skill was a strong predictor for the achievement related to acid-base concepts. Alternatively, there was no significant difference between girls and boys in terms of understanding of acid-base concepts and attitudes toward chemistry. Alternatively, there was no significant interaction between gender and treatment on understanding of acid-base concepts and attitudes toward chemistry.

KEYWORDS: Conceptual Change Oriented Instruction, Cooperative Group Work, Traditionally Designed Instruction, Misconception, Acid-Base Concepts, Science Process Skills, Attitude Toward Chemistry.

ÖZ

KAVRAMSAL DEĞİŞİM YAKLAŞIMINA DAYALI ORTAK GRUP ÇALIŞMALARININ ASİT-BAZ KAVRAMLARINI ANLAMAYA ETKİSİ

AYHAN, Arzu

Yüksek Lisans, Orta Öğretim Fen ve Matematik Alanları Eğitimi

Tez Yöneticisi: Prof. Dr. Ömer GEBAN

Temmuz 2004, 102 sayfa

Bu çalışmanın başlıca amacı öğrencilerin asit-baz konusunda kavram yanılgılarını ortadan kaldırmaktır. Bu amaç için kavramsal değişim yaklaşımına dayalı ortak grup çalışmaları ile geleneksel yöntemin etkileri karşılaştırılmıştır.

Bu çalışmaya 2003-2004 ilkbahar döneminde ODTÜ Geliştirme Vakfı Özel Lisesi'nden 33 lise ikinci sınıf öğrencisi katılmıştır.

Bu çalışmada iki grup kullanılmıştır. 6 hafta boyunca deney grubuna kavramsal değişim esaslı ve ortak grup çalışmalı yöntem uygulanırken kontrol grubuna geleneksel yöntem ile ders anlatılmıştır. Asit-Baz Kavram Testi her iki grubu da ön ve son-test olarak verilmiştir. Öğrencilerin kimya dersine olan tutumlarını ölçmek için Kimya Tutum Ölçeği ön-test ve son-test olarak uygulanmıştır. Ayrıca öğrencilerin bilimsel işlem becerilerini ölçmek için Blimsel İşlem Beceri Testi öntest olarak uygulanmıştır.

Bu çalışmanın hipozlerini test etmek için t-testi, ANCOVA ve ANOVA kullanılmıştır. Sonuçlar kavramsal değişim yaklaşımına dayalı ortak grup çalışmaları yönteminin asit-bazlarla ilgili kavramların anlaşılmasında daha etkili olduğunu ancak kimya dersine yönelik daha olumlu tutuma neden olmadığını göstermiştir. Ayrıca bilimsel işlem becerisinin asit-baz kavramlarını anlamada güçlü bir katkısı olduğu belirlenmiştir. Diğer taraftan cinsiyet farkının asit-baz kavramlarını anlamada ve kimya dersine yönelik daha olumlu tutum sahibi olmada belirli bir katkısı olmadığı tespit edilmiştir. Ayrıca cinsiyetin ve uygulanan yöntemin asit-baz kavramlarını anlamada ve kimya dersine yönelik daha olumlu tutum sahibi olmada etkileşimi olmadığı bulunmuştur.

ANAHTAR SÖZCÜKLER: Kavramsal Değişim Yaklaşımına Dayalı Ortak Grup Çalışmaları, Kavram Yanılgısı, Asit-Baz Kavramları, Bilimsel İşlem Becerileri, Kimya Dersi Tutum Ölçeği.

To My Parents

ACKNOWLEDGEMENTS

I would like to thank especially to Prof. Dr. Ömer Geban for his endless support and guidance through the research. I could not complete this study without his encouragement.

I also would like to thank to Asuman Ulubalcı who applied my instructional materials in METU Development Foundation Private School.

My greatest thanks go to my family. What I have tried to do is insufficient if compared to what you have done for me.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURE

LIST OF SYMBOLS

CCOI & CGW	:	Conceptual Change Oriented Instruction and Cooperative Group Work
TDI	:	Traditionally Designed Instruction
ABCT	:	Acid – Base Concepts Test
ASTC	:	Attitude Scale Toward Chemistry
SPST	:	Science Process Skill Test
df	:	Degrees of Freedom
MS	:	Mean Square
SS	:	Sum of Squares
p, α	:	Significance Level
F	:	F Statistic
t	:	t Statistic
$\overline{X}$	:	Mean of the Sample

CHAPTER I

INTRODUCTION

Children relate the environment they live and discover the world from an early age. It is possible to learn many things wrongly during this discovery, so learning process is important, but for almost a century, students of education have suffered under the yoke of behavioral psychologists, who see learning as synonymous with a change in behavior. We reject this view, and observe instead that learning by human leads to a change in the meaning of experience (Novak and Gowin, 1984).

Learning in science entails more than just adding new concepts to knowledge. Science learning often requires alignment in thinking and construction of new ideas that may be in conflict with earlier ideas (Fellows, 1994). One of the factors affecting students' learning in science is their existing knowledge prior to instruction. The students' prior knowledge provides an indication of the alternative conceptions as well as the scientific conceptions possessed by the students (Hewson and Hewson, 1983). Students' real-world conceptions play a critical role in their views of the world (Nussbaum and Novick, 1982), and real-world conceptions are often difficult to change (diSessa, 1982; Posner et al., 1982).

Many science concepts require difficult thinking changes for students and special instructional techniques to assist and guide students in their learning (Anderson and Roth, 1988; Carey, 1986; Glaser, 1982; Posner, Strike, Hewson, and Gertzog, 1982). Learning science is often difficult for students because their theories about how the world works –their schemas for understanding phenomena- conflict with scientific understandings they are to learn (Fellows, 1994). The best learning theory that focuses on concept and propositional learning as the basis on which individuals construct their own idiosyncratic meanings is the one proposed by David Ausubel (1968; Ausubel, Novak, and Hanesian, 1978). David Ausubel was one of the first researchers to study the connection between meaning and the learning. In his 1968 book, *Educational Psychology: a Cognitive View,* he wrote, "If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. There is a general agreement (Nelson, 1977; Novak, 1977; Driver and Easley, 1978; Resnick, 1981) that a significant characteristic of a person's knowledge is its structure defined as the units of information as well as the ways in which they are linked together and used.

Research into conceptions held by students has shown that there can be significant differences between conceptions of the same phenomenon. According to Lipson (1984) preexisting ideas that are at variance with the concepts teachers attempt to teach in science, mathematics, social studies, and other content areas. More significantly, students often hold conceptions which are at variance with the scientifically acceptable conceptions, even after formal instruction (Hewson and Hewson, 1983).

Many students at all levels struggle to learn chemistry, but are often unsuccessful. One possible answer that is beginning to emerge is that many students are not constructing appropriate understandings of fundamental chemical concepts from the very beginning of their studies (Gabel; Samuel; Hunn, 1987). Other factors which make chemistry difficult include its specialized language, mathematical nature, and the amount of material needed to be learned (Johnstone, 1984), and its abstract conceptual nature (Carter and Brickhouse, 1989; Lawson and Renner, 1975) showed that majority of science concepts at the high school and college levels are abstract. For example, chemistry requires students to deal with a variety of objects, which cannot be directly perceived, such as atoms, molecules, and ions (Ward and Herron, 1980).

Research in students' conceptual knowledge of chemistry is based on a model of learning in which students construct their own concepts (Osborne & Wittrock, 1983). Since students do build their own concepts, their own constructions of chemical concept sometimes differ from the one that the instructor holds and has tried to present. Most of the work that has been done on misconceptions in chemistry was done relatively recently –in the 1980's (Nakhleh, 1992). Most of the misconceptions that have been identified reveal a weak understanding of the currently accepted model of matter. Peterson and Treagust (1989) used a paper and pencil test to study the understanding attained by grade 12 chemistry students concerning simple covalent molecules.

Anderson (1986) asked them to explain the appearance and disappearance of substances in chemical change. Students' answers showed that they lack an understanding of matter are composed of particles; these particles are in constant motion; and these particles can react with each other by breaking or forming bonds.

One of the clear findings of recent research on the learning of science has been that who have completed science courses commonly use conceptions held before instruction to interpret natural phenomena. This is often the case, even when students passed conventional tests. This has led to an obvious concern with conceptual change in students; a concern with exploring alternative approaches to instruction, assessment, etc., which might better promote an acceptance and understanding of the concepts of science.

Constructivists hold that the alternative conceptions so commonly found among science students are the outcomes of this personal construction process. This difficulties shown to exist when attempts are made have students abandon an alternative conception and accept a science conception are sometimes seen as an inevitable consequence of the alternative conception being a personal construction of the reality the student experiences (Gunstone, Gray, Searle, 1992).

Many science educators recommend the application of constructivism to teaching (e.g., Cheung & Taylor, 1991; Cleminson, 1990; Roth, 1990; Vosniadou; 1991). Constructivist theory maintains that learner bring to classrooms ideas that affect new information received. What a student learns, therefore, results from the interaction between what is brought to the learning situation and what s experienced while in it. Some constructivist science educators have advocated the use of conceptual change approaches in the science education. Conceptual change pedagogy is grounded in constructivist learning theory, recognizing that powerful theories are brought to the classroom and affect the learning of new material. This instructional theory holds that learners must become dissatisfied with their existing conceptions, as well as find new concepts intelligible, plausible, and fruitful, before conceptual restructuring will occur (Posner, Strike, Hewson, & Gertzog, 1982). An intelligible concept is understood and internally represented by a learner. For a concept to be plausible, the learner must find it potentially believable and consistent with his or her experiences and world view. Finally, to be fruitful the learner must be “aware of, generate, or understand novel practical applications or experiments which the new conception suggests” (Strike & Posner, 1984).

Commercial investments about acid-base industry and its effects on environment make people concerned about acids and bases. On the other hand, one of the concepts of chemistry that students exhibit misconceptions is acid-base chemistry. One of the reasons is its abstract nature. Also teaching methods of acid-base concept is important. We have tried to determine misconceptions about acid-base concepts and investigate the effect of conceptual change instruction on understanding of acid-base concepts of high-school level.

CHAPTER 2

REVIEW OF LITERATURE

The science education reveals the students' capabilities about science concepts and deals with their needs about scientific phenomena. A variety of methods has been developed to probe children's understandings of natural and technological concepts and to discover the meanings children have for the words they use in explaining things that happen in the world (Osborne and Wittrock, 1983). Over the last decade, significant efforts have been made to bring change to science classrooms. Anderson and Helms (2001) have pointed to the need to examine reform efforts systematically to understand the pathways and impediments to successful reform. Parallels are drawn between student and teacher learning and the importance of autonomy and decision making structures for both populations of learners (Davis, 2001).

Following Vygotsky (1978), there are two sources of individual knowledge:

1. The knowledge that children spontaneously acquire from their interactions with the environment.
2. The knowledge children acquire in a formal fashion through the intervention of the school.

Spontaneous knowledge has been referred to as "naive knowledge". It is important to recognize that before children ever get to school they have constructed an impressive body of informal knowledge from their environment. This informal knowledge constitutes the child's total belief system about the world and how it works. Such knowledge is a product of efforts to make sense of the environment, tempered and manipulated through interactions with parents, peers, television, and other influences; it is influenced by language, by culture, and by other individuals (Pines & West, 1986).

On the other hand, formal knowledge is a product of planned instruction, usually in the school setting. Formal knowledge is someone else's interpretation of the world, someone else's reality. Formal knowledge is approved by the consensus of respected adults who are usually older and more highly regarded than the student. The second characteristic of formal knowledge is that it is acquired via a goal-directed process. Typically, students set out to learn a particular body of knowledge and are expected to master it in a certain time period. Students are usually then expected to demonstrate, by and large through tests, what they have learned.

Novak (1977) has identified three key factors about learning:

1. Meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures;
2. Knowledge is organized hierarchically in cognitive structure, and most new learning involves subsumption of concepts and propositions into hierarchies; and
3. Knowledge acquired by rote learning will not be assimilated.

For a young child, perception of regularity in the world is a genetic capacity, such as the ability to use language. By age three, most children can label several hundred concepts and use them to form thousands of propositions. This incredible accomplishment is normally achieved by discovery, not instruction. Language gives the child the ability to gain new concepts and meanings by reception learning. The process proceeds until it is slowed in school by the barrage of rote learning to which most children are subjected. The unfortunate truth is that much school instruction inhibits student learning (Novak, 1977).

Although it is conceivable that infrahuman primates can acquire rudimentary concepts, their conceptual learning, even compared to those of two year old children, are faltering, limited to simple, concrete representations, and are not very transferable to analogous situations. It is largely because of their superior ability to formulate abstract concepts (which both makes possible and is dependent on language symbols) that human beings are singularly capable of solving complex relational problems without coming into direct contact with the objects and phenomena involved.

Concept formation consists of a process of abstracting the essential common features of a class of objects out of a series of situations in which they vary contextually, in unessential details, or along dimensions other than the particular ones under scrutiny. These “common features” are not discrete elements shared by a number of stimulus patterns but are comparable configurations or sets of relationships (Ausubel, 1958). It is essential to know prior knowledge and misconceptions and apply the correct instructional methods while concept formation is structured. There are sub-titles related to these subjects below.

2.1 Misconception

It has become commonplace belief that learning is the result of the interaction between what the student is taught and his current ideas or concepts. This is by no means a new view of learning. Its roots can be traced back to early Gestalt psychologists. However, Piaget’s (1974) early studies of children's explanations of natural phenomena and his more recent studies of causality (Piaget, 1974) have perhaps had the greatest impact on the study of the interpretive frameworks students bring to learning situations (Posner, Strike, Hewson, & Gertzog, 1982).

During the last decade there has been an increasing interest in science misconceptions. Misconceptions are connected with the thought that they are instinctive. Pupils have not alternative conceptual frameworks; the real reason for their misconceptions is a "strategic inattention" when they are obliged to answer questions on physical phenomena which are not salient enough for them. But again facts are against such simple answer: it is true that young pupils give very quick answers, without paying too much attention; the trouble is that misconceptions do not affect only children: some of the errors – particularly those in the domain of mechanics- are committed also by university students.

Dykstra, Boyle, and Monarch (1992) summarized the meaning of misconceptions as;

1. The mistaken answer students give when confronted with a particular situation.

2. The ideas about particular situation students have which invoke the mistaken answer.

3. The fundamental beliefs students have about how the world works, which they apply to a variety of different situations. These are beliefs in an explanatory sense about causality.

Students' misunderstandings and misconceptions in school sciences at all levels constitute a major problem of concern to science educators, scientist-researchers, teachers, and, of course, students (Johnstone & Kellett, 1980; Nussbaum, 1981). Within this framework, chemistry has a particular status (Campbell, 1978).

Be that as it may, most of the work dealing with students' misunderstandings, learning difficulties, and misconceptions in chemistry has been focused on relatively "classical" examples, such as mole concept (Duncan & Johnstone, 1973; Novik & Mannis, 1976), entropy (Campbell, 1978; Frazer, 1980), and chemical equilibrium (Camacho & Good, 1989; Gussarsky & Gorodetsky, 1990). Creating a cognitive structure of a complex body of knowledge such as chemistry is not easy, and it is small wonder that students from middle school to college level find chemistry difficult. Nakhleh (1992) determined some implications about misconceptions. First, apparently there are profound misconceptions in the minds of many students from a wide range of cultures concerning the particulate and kinetic nature of matter. Some of these misconceptions persist even up to the graduate level. Second, apparently students do not spontaneously visualize chemical events as dynamic interactions. Without an understanding of the kinetic behavior of particles, many topics in chemistry do not make conceptual sense and are learned by rote. Third, the cognitive model of learning implies that misconceptions can occur when students come for instruction holding meanings for everyday words that differ from the scientific meaning. For example, "heat" and "temperature" are commonly used scientific terms for which students hold persistent misconceptions (Krajcik & Layman, 1989; Wiser & Kipman, 1988; Linn & Songer, 1988; Erickson, 1979; Erickson, 1980). Fourth, learning is much more difficult if student must master different definitions for the same phenomenon. for instance, if students who take both chemistry and physics at the same time, they may confound some concepts.

A helpful course of action would be to include questions on examinations that specifically probe for misconceptions. This would accomplish two goals. Educators would have a more accurate estimate of students' actual cognitive structures, and students might give more serious thought to understandings the concepts. Students would then have a better chance of becoming meaningful learners of chemistry (Nakhleh, 1992).

2.2 Misconceptions in Acids and Bases

There is a little question that chemistry involves aspects of what Piaget calls formal operational thought. Students must deal with stoichiometry and gas law problems involving proportions, variables, and mass conservation; with abstract concepts such as chemical bonds and molecular orbitals; with intensive properties such as concentration, density, and pressure; as well as a whole host of generalized variables, including reaction rates, force, energy, entropy. Furthermore, students are asked to understand and explain all observations of the macroscopic, observable world in terms of the properties of microscopic, unseen atoms and molecules. As reasonable as this may seem to the instructor, it may represent an overwhelming exercise in formal reasoning for some students (Kavanaugh & Moomaw, 1981). Accordingly, existence of misconceptions and misunderstandings about these topics and/or more of them is not a surprised result.

Beginning students are often confused by the many subtleties of acid-base chemistry (Treptow, 1986). Within high-school chemistry, the topic of acids, bases, and pH is particularly challenging because the student must possess a deep understanding of atoms, molecules, ions, and chemical reactions. Typically, students with deep understanding have propositional networks that are sufficiently developed to allow the students to explain observed phenomena and predict the behavior of new phenomena (Nakhleh & Krajcik, 1994). Studies have found that students have difficulties in understanding the reactions in the topic of ‘Acids, bases, and salts’. For example, Butts and Smith (1987) found that students could not relate the formation of precipitate in a double decomposition reaction to the low solubility of the salt, Boo (1994) found that students believed the driving force for a double decomposition reaction was the difference in reactivity between the metallic elements present in the compounds involve. Another alternative conception of double decomposition reactions was that the ions from the reactants had to return the electrons to their original atoms before a new electron transfer occurred to form the precipitate (Taber, 2001). In another study, Schmidt (2000) reported that students believed the reaction between magnesium oxide/hydroxide and hydrochloric acid was a redox reaction because of the oxygen present in the oxide and hydroxide.

The most common alternative conception is that the precipitate dissolved in excess acid because no further reaction is seen except the disappearance of the precipitate and no new reagent is added. Students usually identify anions such as carbonate, iodide, and sulfate by adding a barium/silver/lead solution to the unknown followed by a dilute acid, or visa versa. Many students have difficulty understanding the tests for anions. For example, some of the students believe that the addition of aqueous barium nitrate followed by a dilute nitric acid is to test for sulfate only; some other students believe that to test for a carbonate, acid had to be added directly to the unknown sample. On the other hand, some of them believe that the addition barium nitrate invalidated the test for carbonates. These responses show that students did not understand that if a carbonate is present, insoluble barium carbonate would be formed and it would react with the nitric cid to give carbon dioxide gas which could be identified. Sulfate would give similar results to carbonate, the difference being the formation of sulfur dioxide.

However, many students indicated that a displacement reaction resulted in the formation of the precipitate because the sodium ion is more reactive than the zinc ion; this is similar the finding of Boo (1994) mentioned earlier. This showed that students did not understand that the precipitate was the result of a double decomposition reaction, and that, in a displacement reaction, a more reactive element displaces the ion of a less reactive ion (Tan, Goh, Chia, & Treagust, 2003).

On the other hand, Nakhleh and Krajcik (1994) speculated that level of information provided by the technology would influence the learner's understanding of acid-base chemistry. The technologies provided different levels of information about the chemical systems, and students responded differently regarding how they elaborated acceptable and unacceptable understanding. For example, students using microcomputer-based laboratories (MBL) created more acceptable and unacceptable relationships and cross links than students using a chemical indicator or those using a pH meter. Furthermore, students using MBL also used more essential critical nodes than students using a chemical indicator or a pH meter.

Zoller (1990) made some studies about misunderstandings and misconceptions in college freshman chemistry. For example, most students never had the opportunity to internalize the 'pH' concept. Most commonly, the pH is used and/or manipulated by students in a "mechanical" or "technical" sense, without a real grasp and understanding of the concept. A common learning difficulty which is closely related to the problem of pH of aqueous solutions is associated with the acidity or basicity of aqueous solutios of acidic or basic salts respectively. The fundamental misconception here is a result of a common notion that salts, which are formed in a neutralization of acids with bases, are "neutral" species. As such, their aqueous solutions must be neutral (i.e., the pH is definitely 7). One possible approach to the problem is to deal with the particular example at hand, and point this out on the particular specie that will actually be formed as a result of the hydrolysis of sodium carbonate. In the final balance and summation of partial equations, the potential *formal* existence of sodium hydroxide will convince students that the aqueous solution of sodium carbonate is indeed basic. On the other hand, the extension of the concept of acids and bases in accord with Brønsted and Lowry does not cause any particular problem to freshman nonmajors. However, the introduction of the Lewis generalization which combines acidity, basicity, electrophility, and nucleophility within a broad integrated scheme opens a "Pandora's box" of difficulties and misconceptions.

Hand and Treagust (1991) studied about students' achievement and science curriculum development using a constructive framework. Their strategy of conceptual conflict was the form of constructivism adopted in developing curriculum material for a unit on acids and bases. They conducted individual semi-structured student interviews through three months and from these interviews, they determined five misconceptions and misunderstandings about acids and bases.

These were:

1. An acid is something that eats material away; an acid can burn you.

2. Testing of an acid can only be done by trying to eat something away.

3. To neutralize is to break down an acid or to change from an acid.

4. A base is something which makes up an acid.

5. A strong acid can eat material away faster than a weak acid.

2.3 Constructivism and Conceptual Change Model

Constructivist ideas about learning have had a major influence on the thinking of science educators over the last decade (Fensham, Gunstone, &White, 1994). This has been particularly evident in attempts to understand the origins of students' misconceptions in science (e.g., Cleminson, 1990; Freyberg & Osborne, 1985), how teachers may deal with these in the classroom (e.g., Hewson & Hewson, 1983), and how they may improve the effectiveness of their teaching (e.g., Appleton, 1993a). The main tenet of constructivist theories is that existing ideas which learners may hold are used to make sense of new experiences and new information. Learning therefore occurs when there is a change in the learner's existing ideas, either by adding some new information or by reorganizing what is already known. Emphases in constructivist thought include considerations of constructs and processes seen to be internal to the learner (Freyberg & Osborne, 1985) as well as the influence of the social context and social interactions (O'Loughlin, 1992; Tobin, 1990).

Several models of learning in science based on constructivist theories have been proposed, such as that suggested by Posner, Strike, Hewson, and Gertzog (1982). They describe the conditions, which determine whether cognitive change in learners will occur. Their four main points to understand the new conception are;

1. Dissatisfaction with existing knowledge.
2. A new conception must be intelligible.

3. A new conception must appear initially plausible.
4. A new conception should suggest the possibility of a fruitful research program.

Roth (1990), citing Mayer (1983), used schema theory to suggest three conditions necessary for learning:

1. The learner must receive presented material;
2. The learner must have relevant prior knowledge or schema;
3. The learner must activate that relevant prior knowledge.

However, the models tend to be limited in scope and provide few clear indications for what a teacher might do to help students learn. For instance, ideas similar Cleminson's (1990) tenets and Mayer's (1983) conditions for learning are the basis for the cognitive change conditions outlined by Posner et al. (1982). None elaborated on what learners and/or teachers might do to satisfy the conditions for learning to occur.

The theoretical constructs on which this proposed model is based are drawn from three main streams of constructivist thought which have held sway in science education, developmental psychology (Piaget, 1978), cognitive psychology (Claxton,1990; Howard, 1988), and social constructivism (O'Loughlin, 1992). The Piagetian notions of accommodation and disequilibrium rather than his developmental emphasis have been incorporated into the learning model, although to Piaget they were inseparable. Views of cognitive structure based on schemata (Howard, 1988) are an important feature in that ideas which students bring to a learning experience are used to interpret the experience and are modified as inadequacies in schemata are revealed through disequilibrium. Since schooling is a social experience, however, the interpretation of experiences and consequent learning are also considerably influenced by the social context (Vygotsky, 1978). The notion of scaffolding (Bruner, 1985; Vygotsky, 1978), for instance, demonstrates the key role of interactions between teacher and student, and perhaps student and student.

Gagnon and Collay (2001) proposed that constructivist learning design was composed that six basic parts flowing back and forth into one another in the actual operation of classroom learning: situation, groupings, bridge, questions, exhibit, and reflections.

1. The *situation* frames the agenda for student engagement by delineating the goals, tasks, and forms of what Gagnon and Collay (2001) call the learning episode.

2. *Groupings* are the social structures and group interactions that will bring students together in their involvement with the tasks and forms of learning episode.

3. *Bridge* refers to the surfacing of students' prior knowledge before introducing them to the new subject matter. The bridge is at the heart of the constructivist methodology; students are better able to refocus their energies on new content when they can place it within their own cognitive maps, values, attitudes, expectations, and motoric skill.

4. Fourth, *questions* aim to instigate, inspire, and integrate students thinking and sharing of information. Questions are prompts or responses that stimulate, extend, or synthesize student thinking and communication during a learning episode.

5. An *exhibit* asks students to present publicly what they have learned; this social setting provides a time and place for students to respond to queries raised by the teacher, by peers, or by visitors about Gagnon and Collay (2001) call the "artifacts of learning."

6. *Reflections* offer students and teachers opportunities to think and speak critically about their personal and collective learning. This encourages all participants to synthesize their learning, to apply learning artifacts to other parts of the curriculum, and to look ahead to future learning episodes.

Meaningful learning of science involves coming to understand scientific ideas as they are used for their intended purposes, including description, prediction, and explanation of phenomena in the natural world. Thus, teachers need to pursue class activities that engage students in using scientific conceptual schemes to describe, explain, or make predictions about the world around them.

Complex activities such as making explanations require conceptual understanding. Science teaching, therefore, needs to develop conceptual understanding in students, rather than encouraging rote memorization or avoiding conceptual issues in favor of procedures and activities. The conceptual frameworks that students develop as they learn science make remembering a consequence of understanding, because facts, definitions, laws, etcetera, are understood as part of the conceptual framework (Smith, Blakeslee, & Anderson, 1993).

Conceptual change is simple idea. If students are given an opportunity to construct scientifically orthodox conceptions, if they then come to see that these conceptions are more intelligible, plausible, and fruitful than other conceptions, the students will change their conceptions for scientific ones (Cobern, 1996). Researchers have variously defined a superior conception as one that is “useful in making sense of the world” (Roth, 1989), or that is “more powerful and useful in explaining and predicting phenomena” (Hewson, 1981).

Helping students to understand and use the conceptual schemes of science is complicated by the fact that students enter instruction with other, nonscientific conceptual schemes of their own. Students bring to instruction a variety of conceptional frameworks that are often at odds with scientific ideas (Anderson & Smith, 1987, Bishop & Anderson, 1990; Clement, 1982; Driver & Erickson, 1983; Helm & Novak, 1983). These misconceptions often persist following instruction. To learn science in a meaningful way means, then, realigning, reorganizing, or replacing existing conceptions to accommodate new ideas. This has been called a process of conceptual change (Smith, Blakeslee, & Anderson, 1993).

Chambers and Andre (1997) used conceptual change text and they saw that it provided students with better understanding of electric circuit than the traditionally text. In addition, Hynd, McWhorter, Phares, and Suttles (1994) investigated that refutational texts assisted students to modify their intrinsic thoughts with the scientific facts. On the other hand, they saw that demonstration or discussion method couldn’t succeed to change their thoughts as good as texts did.

Conceptual change texts are appropriate to apply in crowded classrooms. These texts are developed to make readers know their intrinsic thoughts about a topic and assist students to change them with the scientific ones.

There are four conditions for accommodation developed by Posner, Strike, Hewson, and Gertzog (1982).

1. There must be dissatisfaction with existing conceptions. Scientists and students are unlikely to make major conceptual changes until they believe that less radical changes will not work.

2. A new conception must be minimally understood. The individual must be able to grasp how experience can be structured by a new conception sufficiently to explore the possibilities inherent in it.

3. A new conception must appear initially plausible. A new conception adopted must at least appear to have the capacity to solve the problem generated by its predecessors, and to fit with other knowledge, experience, and help. Otherwise, it will not appear a plausible choice.

4. A new conception should suggest the possibility of a fruitful research program. It should have the potential to be extended, to open up new areas of inquiry, and to have technological and/or explanatory power.

On the other hand, Hewson and Hewson (1983) presented some teaching strategies related with the conceptual change strategies.

Integration: The aim is to integrate new conception with existing conceptions with each other. This is the dominant teaching strategy in science teaching today, and is based on the assumption that the students' existing conceptions are those which the teacher has taught.

Differentiation: The aim is to differentiate existing conceptions into more clearly defined, separated, but closely related conceptions. The student needs to see that what was plausible in one situation is no longer plausible in a different, more complex one.

Exchange: The aim is to exchange an existing conception for a new one, because they contradict one another and cannot, therefore, both be plausible. Since a student is not going to exchange a plausible conception for one which is seen to be implausible, it becomes necessary to create dissatisfaction with the existing conception as well as showing that the new conception has more explanatory and predictive power than the old.

Conceptual Bridging: The aim is to establish an appropriate context in which important abstract concepts can be linked with meaningful common experiences (Novak, 1977). The posing of a question which has to be answered in terms of the abstract concepts being taught creates a setting in which these concepts can be seen to be plausible and fruitful.

Acquisition of relativity large bodies of complex, conceptual, interrelated knowledge in school settings is usually pursued without taking into account the rich spontaneous knowledge base that already exists. Given the authority and the demands of schooling, novices are usually forced to begin by ignoring their own reality. If learners make a genuine effort to make sense of the formal, symbolic knowledge presented (as opposed to rote learning numerous, isolated bits of information and memorizing lists of propositions), they will need to integrate and differentiate the symbolic knowledge within cognitive structure. This process of learning, where the major learning is the development of the downward growing vine, called "conceptual development".

In certain cases, a conceptual development approach inappropriate. For example, when a child has an alternative conception that somewhat clashes with the scientific one, we cannot simply expect integration and differentiation to occur. Here, conceptual resolution is necessary. For children such conflicts between they know to be true and what they are told is true may be of major importance.

On the other hand, conceptual exchange is used to describe the process of accepting a new framework while abandoning what was previously held to be true. Strike and Posner (1984), Hewson and Posner (1982), and Hewson (1980, 1981) have explored the nature of conceptual exchange at a theoretical level. As West and Pines (1983) pointed out, however, the theoretical descriptions ignore important nonrational elements and components of conceptual exchange (Pines & West, 1986).

2.4 Cooperative Group Work

Active learning entails a student-centered classroom with assignments that fully engage students in higher-order thinking skills (Bonwell & Eison, 1991). Students in general education science courses often have little appreciation for the process of science or how science affects their everyday lives. In a recent report, students in most science disciplines were found to need more higher-order thinking skills than those in biology courses (Donald, 2002). Mysliwiec, Shibley, and Dunbar (2004) presented that they choose pedagogical activities that use higher-order thinking skills. To generate a deeper understanding and appreciation for science, activities in each course encourage students to critically analyze recent advances in science.

Anything new or different that causes global thinking or reflection among students can potentially enhance learning environments. Education is still a human business, and we, as humans, all need to be recognized and appreciated. If at times teachers are intensive or oblivious, one thing has the ability to smooth over lots of misunderstandings: Whether the learner is a preschooler, an elementary student, a middle-school student, or a graduating senior, all students regardless of ethnic background innately recognize one thing— sincerity (Whittemore & Mecca, 2003).

Here, the most important rule emphasizes that class members respect each other and work together to understand the each the each other. One result of recent, concerted attention to science students' thinking about physical phenomena is that science educators are now brought face-to-face with a direct and difficult challenge: how to design classroom instruction that effectively addresses individual students' preconceptions and changes their concepts to scientifically accurate understandings.

Recent experiments implementing conceptual change strategies in regular classroom settings with typical teachers, however, have had, at best, limited success. A high proportion of students retain their misconceptions, and recommended teaching strategies are difficult for many teachers to manage (cf. Anderson & Smith, 1993; Roth, 1987a; Neale, Smith, & Weir, 1987).

The small cooperative group as described by Slavin (1983), is an instructional environment in which individual and group incentives are use to promote student engagement in tasks structured to increase helping behaviors among group members. Studies employing this strategy have consistently found positive effect on student achievement (Slavin, 1984). Analysis of student verbal interaction within small groups (Webb, 1982b; 1983) found that the "giving of explanations" was a variable positively related to achievement. Neither Webb nor Slavin's work focused on conceptual change in science, but several aspects of group work would appear to support conceptual change efforts. Fisher & Lipson (1985) suggest that if concept learning requires students to give up previously held concepts, then an atmosphere must prevail in which students feel free to express their ideas. The absence of the teacher authority figure in small group settings provides opportunity for individuals to express their misgivings, relate their experiences, explain, debate, and clarify their thinking through peer verbal interaction (Basili & Sanford, 1991).

There are five elements related with cooperative learning.

Positive Interdependence: Individual success depends on the success of the group.

Face-to-Face Interaction: Students need to interact physically and verbally to maximize the benefits of cooperative groups.

Individual Accountability: The goal of instruction is for every student to learn the material.

Interpersonal and Small Group Skills: Skills necessary to function effectively in groups must be taught.

Group Processing: Feedback on group functioning is necessary to encourage improvement.

Lonning (1993) presented that interpersonal and small group skill instruction consisted of activities designed to encourage students to develop and use the following skills:

1. extend another member's ideas with new information,
2. provide direction to the group,

3. paraphrase and clarify what has been said,
4. summarize what has been read or discussed,
5. encourage participation,
6. provide help or clarification,
7. provide support and acceptance,
8. seek justification of another member's assertions.

On the other hand, the teacher and the investigator monitor the use of skills while students are engaged in cooperative group activities. Also, students are encouraged to discuss their success in using cooperative skills during processing time at the end of the class period. Positive interdependence is structured by basing individual grades on group products and/or by awarding bonus points to all group members when a selected member is able to correctly answer questions posed during group activities. Therefore, this study is concerned with students' prior conceptions and with conceptual change oriented instruction accompanied with cooperative group work as science teaching to affect the learning of acid-base chemistry.

CHAPTER 3

PROBLEMS AND HYPOTHESES

3.1 The Main Problem and The Sub-Problems

3.1.1 The Main Problem

The main purpose of this study is to determine the effectiveness of conceptual change oriented instruction accompanied with cooperative group work over traditionally design instruction on tenth grade students' understanding of acid- base concepts.

3.1.2 The Sub-Problems

1. Is there a significant difference between the effects of conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and traditionally designed instruction (TDI) on students' understanding of acid-base concepts, when their science process skills are controlled?

2. Is there a significant difference between girls and boys on understanding of acid-base concepts, when their science process skills are controlled?

3. Is there a significant effect of interaction between gender and treatment on students' understanding of acid-base concepts?

4. Is there a significant contribution of students' science process skills to understanding of acid-base concepts?

5. Is there a significant difference between the effects of conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and traditionally designed instruction (TDI) on students' attitudes toward chemistry?

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

7. Is there a significant interaction between gender and treatment with respect to attitudes toward chemistry?

3.2 Hypotheses

$H_0$1: There is no statistically significant difference between the post-test mean scores of students taught by conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and those taught by traditionally designed instruction (TDI) on students' understanding of acid-base concepts, when their science process skills are controlled.

$H_0$2: There is no statistically significant difference between the post-test mean scores of girls and boys on understanding of acid-base concepts, when their science process skills are controlled.

$H_0$3: There is no statistically significant effect of interaction between gender and treatment on students' understanding of acid-base concepts.

$H_0$4: There is no significant contribution of students' science process skills to the variation in achievement related to acid-base concepts.

$H_0$5: There is no statistically significant difference between post scale mean scores of students taught by conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and those taught by traditionally designed instruction (TDI) with respect to their attitudes toward chemistry as a school subject.

$H_0$6: There is no statistically significant difference between the post scale mean scores of girls and boys with respect to their attitude scale toward chemistry.

$H_0$7: There is no statistically significant effect of interaction between gender and treatment on students' attitudes toward chemistry as a school subject.

CHAPTER 4

DESIGN OF THE STUDY

4.1 The Experimental Design

Table 4.1 Research Design of the Study

Groups	Pre-tests	Treatment	Post-tests
EG	ABCT, ASTC, SPST	CCOI&CGW	ABCT, ASTC
CG	ABCT, ASTC, SPST	TDI	ABCT, ASTC

In the above table, EG represents the experimental group who received conceptual change oriented instruction accompanied with cooperative group work. CG represents the control group who received traditionally designed instruction. CCOI & CGW represents Conceptual Change Oriented Instruction and Cooperative Group Work whereas TDI represents Traditionally Designed Instruction. ABCT is the Acid – Base Concepts Test, ASTC is Attitude Scale Toward Chemistry and SPST is Science Process Skill Test. To determine the effect of the instruction ABCT, ASTC, and SPST were administered before the treatment and ABCT, ASTC after the treatment to the students in both experimental and control groups.

4.2 Subjects of the Study

The subjects of the study were 33 tenth grade students from two classes of a chemistry course from METU Development Foundation Private School in the spring semester of 2003-2004 school year.

Two instruction methods were used in this study. The group who received CCOI & CGW consisted of 16 students (9 females and 7 males) whereas the group who received TDI consisted of 17 students (8 females and 9 males).

4.3 Variables

4.3.1 Independent Variables

The independent variables of this study were Conceptual Change Oriented Instruction Accompanied with Cooperative Group Work (CCOI&CGW) vs. Traditionally Designed Instruction (TDI) and gender.

4.3.2 Dependent Variables

Dependent variables of this study were students' understandings of acid-base concepts measured by ABCT, and their attitudes toward chemistry as a school subject measured by ASTC.

4.4 Instruments

4.4.1 Acid-Base Concept Test (ABCT)

The test consisted of 20 multiple-choice questions. Each questions had one correct answer and four distracters. The items were related with the acid-base chemistry. The items used in the test were prepared from the lecture materials and chemistry books of METU Development Foundation Private School. Since the language of the instruction of the school is English, the test was constructed in English.

The items used in ABCT were conceptual questions that revealed students' misconceptions related with acid-base concepts. These questions tend students give wrong response to the items because of their misconceptions about acid-base concepts.

During the formation period of the test the following procedure was followed: Firstly, the instructional objectives of acid-base chemistry were stated (see Appendix A) and each item in the test was constructed according to instructional objectives. Then, students' misconceptions related with acid-base concepts were determined from related literature and opinion of chemistry teachers and a classification was constructed (Table 4.2).

Table 4.2 Classification of Students' Alternative Conceptions

MISCONCEPTION	**ABCT ITEM**
The strength of an acids increases with an increase in pH	**1(a, b, c, d, e), 3a, 10a,13b**
2. The strength of a bases increases with an increase in pOH	**3d, 13c,15c**
3. The strength of acids are directly proportional with mass	**4a, 8b**
4. The strength of acids are directly proportional with volume	**8a**
5. The strength of an acid is related with the number of OH^- ions in the solution	**8c**
6.Molecules of strong acids contain always more than one H^+ ions	**11b, 11e**
7. Acids have bitter taste	**4b, 6b, 15e**
8. Bases have sour taste	**6a**
9. Acids are slippery substances	**6e**
10. Acids and bases give composition reaction	**4c**
11. Acids and bases give decomposition reaction	**2b**
12. There is no water production after a reaction of an acid and NH_3	**4d**
13. Dissociation of water is exothermic	**4e**

14. Acids turn red litmus paper into blue	**7d, 14c**
15. Bases turn blue litmus paper into red	**6d, 7d, 14c**
16. The pH of a solution only gives the acidity of the solute	**2a, 9a**
17. The pOH of a solution only gives the basicity of the solution	**9b**
18. The pH of a solution only gives the basicity of the solution	**3a, 9d**
19. pH and pOH refer to the same number in both acid and base solutions	**5a, 9e**
20. pH of a solution is related with the type of solution	**5e**
21. Solutions at pH=7 are bases	**10a**
22. Solutions at pH=7 are acids	**10b**
23. Fruits have always basic characteristics	**12d, 12e, 16c**
24. A gas is released after a reaction of an acid and a base	**13a**
25. Acids are toxic subtances	**13e**
26. Acids are flammable substances	**16a, 16e**
27. All subtances containing H have acidic characteristics	**2d, 16d, 16e**
28. All subtances containing OH^- have basic characteristics	**2e**
29. Salt formed at the end of a neutralisation reaction is always acid	**17a**
30. Salt formed at the end of a neutralisation reaction is always basic	**17d**
31. Salt formed at the end of a neutralisation reaction is always neutral	**17b**
32. A salt contains neither H_3O^+ nor OH^- ions	**18a**
33. Neutralization always results in a neutral solution	**19d**
34. Confusion the relationship between pH/pOH and $[OH^-]$ / $[H^+]$	**20**

The chemistry teachers in METU Development Foundation Private School and experts in science education examined the items in Acid-Base Concept Test (ABCT) and some questions were reconstructured to be more appropriate to our instructional objectives.

This test was administered as pre- and post-test to both experimental and control groups to determine the effectiveness of the treatment.

4.4.2 Attitude Scale Toward Chemistry (ASTC)

This scale was developed by Geban and Ertepınar (Geban, Ertepınar, Yılmaz, Altın, Sahbaz, 1994) to measure students' attitudes toward chemistry as a school subject. This scale consisted of 15 items that is in a 5-point likert type scale (strongly agree, agree undecided, disagree, and strongly disagree). Its language is Turkish. On the other hand, there are both positive and negative expressions in the scale. The reliability was found to be 0,83. This scale was administered to both experimental and control groups at the beginning and end of the treatment as a school subject.

4.4.3 Science Process Skills Test (SPST)

Okey, Wise and Burns (1982) originally developed this test. It was adapted to Turkish by Geban, Aşkar and Özkan (1991). This instrument consists of 36 four-alternative multiple-choice questions. Its content covered all science areas. It measures five subsets from the different aspects of science process skills. Identifying variables, identifying and stating hypotheses, operationally defining, designing investigations, and graphing and interpreting data.

4.5 Treatment (CCOI&CGW vs. TDI)

This study was applied over six weeks during the spring semester of 2003-2004 school year at METU Development Foundation Private School. 33 tenth grade students from chemistry classes were included in this study.

There were two groups in this study. These were experimental group that was applied conceptual change oriented instruction accompanied with cooperative group work and the other one was control group that was applied traditionally designed instruction. Both experimental and control groups were administered ABCT, ASTC, and SPST as pre-test at the beginning of the treatment and ABCT, ASTC as post-test at the end of the treatment.

The topics related with acid-base concepts were covered during the regular chemistry courses. The course schedule was as 4 times a week and each session was 40 minutes. The treatment was administered as regular scheduled classroom curriculum of chemistry course.

In this study, two types of learning experiences were conducted to the students to determine differences of the outcomes because of the treatment.

In the control group, traditionally designed instruction was administered as regular chemistry courses. First, students in control group were administered ABCT and ASTC. They also received SPST. During the instruction, their teacher used lecturing and discussion methods as traditionally lecture methods. In addition, the teacher solved problems related with acid-base concepts and gave worksheets that include algorithmic problems and expressions related with acid-base concepts to make students use their learning about acid-base concepts. Here teacher behaved as facilitator. She answered some questions and helped them to avoid conflict if needed. Then she scored the worksheet and gave them back to be reviewed. After instructional period of six weeks, students were administered again ABCT to see if any change occurred in students' understanding of acid-base concepts, and ASTC to see if any changes occurred in students' attitudes toward chemistry.

On the other hand, in the experimental group students were given conceptual change texts (see Appendix C). However, before giving conceptual change texts they received ABCT, ASTC, and SPST as pretests. The purpose of giving ABCT to check their prior knowledge about acids and bases, and of giving ASTC to determine their prior attitudes toward chemistry before instruction. SPST was given to find out their science process skills. The purpose of giving conceptual change texts to the students is to inform them about misconceptions that are possible to be made. It informed students about possible misconceptions and gave hints to the students that made some errors at the concepts of acid-base. The conceptual change approach to dealing with students' misconceptions is based on Piaget's construct of disequilibrium. Piagetian theory, new experiences are understood by applying preexisting mental structures to them. There were eleven conceptual change texts developed including the following topics: the strength of acid-base, heat of the acid-base reaction, appearance and taste of acids and bases, reactions of acids and bases give, productions of acid-base reactions, color change of acid-base reactions, pH and pOH concepts, Arrhenius definition of acid-base concept, properties of acids and bases.

There were questions in the first part of the texts. These questions tended students to dissatisfy with their existing acid-base concepts. Then, students notice that the explanations about new conception were intelligible and plausible, that is, they could understand the new conception and realize that they could solve the problems about similar conceptions. Those conditions fitted with the conditions developed by Posner, Strike, Hewson, and Gertzog (1982).

Conceptual change texts were distributed during the lecture and each part of the texts were instructed by the teacher. First, students read them by themselves and answer the questions in the texts. If there was a misunderstanding about a topic, they had noticed them. Then after reading the remain part of the text they had learnt the correct form of those scientific facts. Sometimes their teacher explained the misunderstandings that were possible to be done by the students and she helped to overcome those misunderstandings. Students discussed their thoughts with each other and some students noticed that they had had misunderstandings about some topics.

Students were also given activity sheets that were designed suitable for conceptual change conditions (See Appendix D). Students worked as groups to answer the questions at the activity sheets. Groups were tried to be formed as homogenously, that is, by almost equal numbers of girls and boys, and students with different achievements. Each group chosed a group leader. In a group, they discussed the questions and tried to answer. Sometimes they could not come to an agreement for some questions, then the teacher guided them, and she gave support to the students who were more silent in their own groups to reveal their thinking about the questions. By studying in a group, students had a chance to notice some topics to be overlooked. After answering all questions, the group leaders declare their answers to the classroom. If answers of a question did not match with other groups' answers, they discussed why they believed their answer was correct. Teacher navigated the discussion. After discussing all questions, they had come to an agreement for all questions.

After six weeks period of treatment, students were received the ABCT and ASTC as post-test. The purpose of giving them again was determine if there was a difference with respect to their prior understanding of acid-base concepts and prior attitudes towards chemistry.

4.6 Analysis of Data

ANCOVA was used to determine the effects of the treatment, gender difference and, interaction between treatment and gender effects on understanding the acid-base concepts by controlling the students' science process skill as a covariate. ANOVA was used to determine effects of the treatment, gender difference and, interaction between treatment and gender effects with respect to attitude scale toward chemistry. On the other hand, independent t-test was used to determine the effects of two instructions on students' attitudes toward chemistry as a school subject.

4.7 Assumptions and Limitations

4.7.1. Assumptions

1. All students gave sincere and serious responses to all subjects in the instruments.

2. The teacher who applied the instruction was not biased.

3. The treatment was applied under standard conditions.

4. Students in experimental and control groups did not interact with each other.

4.7.2 Limitations

1. The subjects of the study were limited with 33 tenth grade students from METU Development Foundation Private School.

2. The study was limited to the unit of "Acid-Base" concept.

CHAPTER 5

RESULTS AND CONCLUSIONS

In this chapter, the results obtained through the hypotheses that were stated in the chapter 3 are presented. In dependent t-test, ANCOVA, and ANOVA were used with a significance level of 0,05 to test the hypotheses. Statistical analyses were carried out by using SPSS (Statistical Package for Social Sciences for Personal Computers).

5.1 Results

In order to determine the students' misunderstandings in acid-base concepts, their science process skills, and prior attitude toward science as a school subject, all students from both experimental and control groups were administered three different pre-tests; ABCT, SPST, and ASTC.

The results showed that there was no significant difference between CCOI&CGW and TDI group students in terms of acid-base concepts achievement ($t = 0,92$, $p = 0,53$); science process skill ($t = 1,91$, $p = 0,07$); and attitudes toward science as a school subject ($t = 1,21$, $p = 0,32$) before treatment.

Hypothesis 1:

To be able to answer the question posed by hypothesis 1 stating that there is no statistically significant difference between the post-test mean scores of students taught by conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and those taught by traditionally designed instruction (TDI) on students' understanding of acid-base concepts, ANCOVA was used. It was tested through analysis as assigning the effect of students' science process skills as covariate. The analysis of the data is presented in Table 5.1.

Table 5.1 ANCOVA Summary

Source	df	SS	MS	F	p
Covariate (Science Process Skill)	1	54,54	54,54	4,39	0,05
Treatment	1	170,45	170,45	13,73	0,01
Gender	1	0,44	0,44	0,04	0,85
Gender*Treatment	1	3,99	3,99	0,32	0,58
Error	28	347,71	12,42		

The results of the analysis presented in the Table 5.1 showed that there was a significant difference between the post-test mean scores of the students instructed with CCOI&CGW and students instructed with TDI with respect to acid-base concepts. CCOI&CGW group scored significantly higher than the TDI group ($\overline{X}_E$= 14,81; $\overline{X}_C$= 9,06)

Figure 5.1 showed the proportions of correct responses from the students in both CCOI&CGW group and TDI group to the questions in the post-test.

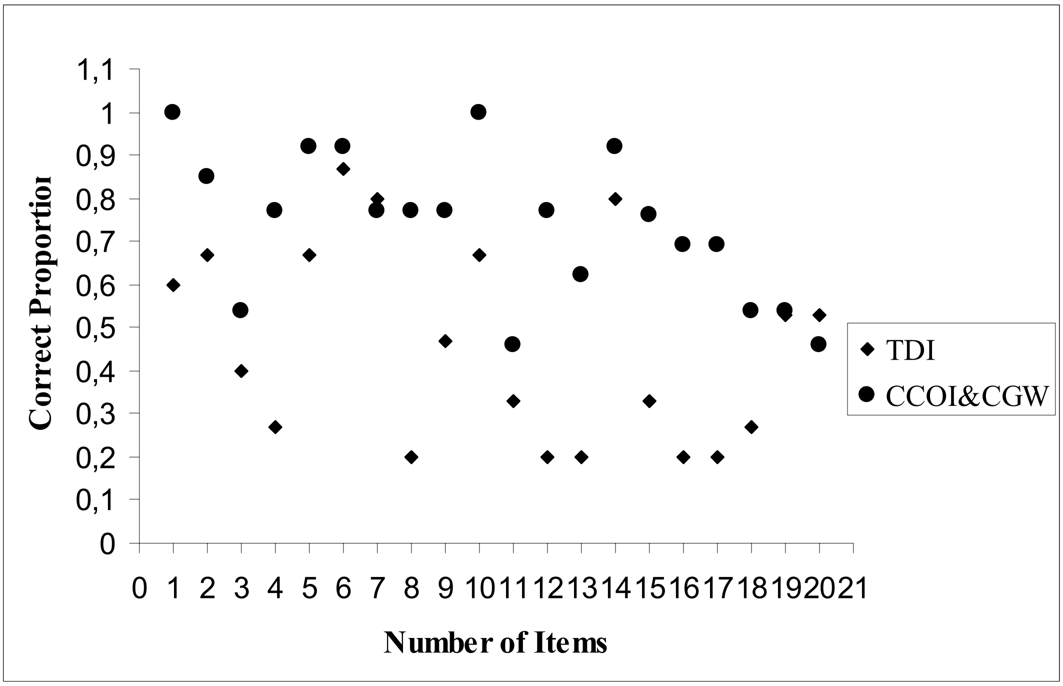


Figure 5.1 Comparison Between Post-Test Scores of CCOI&CGW and TDI

As seen in the figure, there are differences in responses between CCOI&CGW group and TDI group in achievement. The correct responses to the questions 1, 2, 5, 6, 7, 10, 14, and 19 were greater than 50% in both CCOI&CGW and TDI group. On the other hand, for questions 3, 11, 18, and 20, percent of students' correct response were low and close to each other. For example, question 11 which related to properties of strong acids was still misunderstood in both groups after treatment. 46% of the students in CCOI&CGW group responded this question correctly whereas 33% of the students in TDI group responded correctly.

A few students in TDI did questions 4, 8, 12, 13, 16, and 17 correctly whereas the students in CCOI&CGW group had more successful results. These questions have reflected the concepts related with the relationship between strength and volume of solution, properties of acids and bases, pH and pOH, productions of acid-base reactions. However, 27% of students in

TDI answered question 4 correctly; 20% of them answered questions 8, 12, 13, 16, and 17 correctly. On the other hand 77% of students in CCOI&CGW answered question 4 correctly; 77% of them answered question 12; 62% of them answered question 13; and 70% of them answered question 16 and 17 correctly. This show that most of the students in CCOI&CGW corrected their misunderstandings about the properties of acids and bases.

However, for questions 7 and 19, almost equal correct proportions were obtained for both groups. The average correct response percent was 46% for TDI group whereas 74% for CCOI&CGW group after treatment. Therefore, we can say that CCOI&CGW group had better understanding of acid-base concept than TDI group.

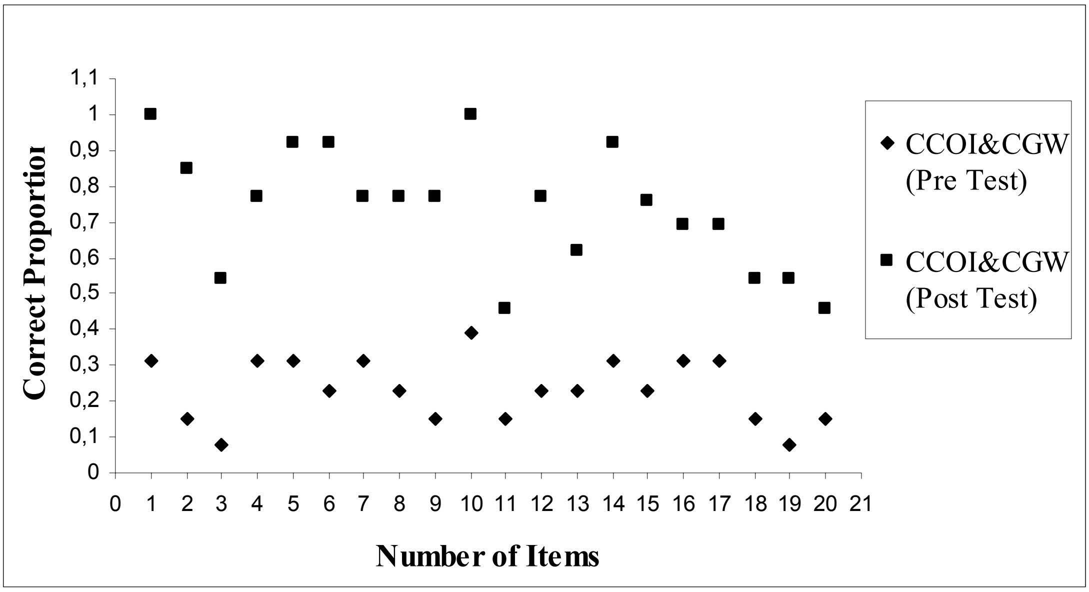


Figure 5.2 Comparison Between Pre-Test and Post-Test Scores of Students in CCOI&CGW Group

As it seen in the figure, before the treatment, the average correct response percent was 23% whereas after treatment, it as raised to 74%. The larger difference between pre-test and post-test correct proportions could be seen especially for questions 1, 2, 5, 6, 9, 10, and 14. For example, for question 1, 69% of students thought that acidity increases when pH of solution is increased. However, all of them correct their misconception after treatment. For question 6, 77% of the students had misunderstandings about common characteristics of acids and bases, but this percent decreased to 18% after treatment. Furthermore, correct response percent for question 3 was 8% whereas it was raised to 54% after treatment. This shows that 42% of the students overcome their misunderstandings about pH scale. On the other hand, for question 11, 85% of the students had misunderstandings about the properties of strong acids, this percent decreased to 54% after treatment. Alternatively, 92% of the students had misunderstandings about the results of the reactions of strong bases and weak acids, it decreased to 54% in question 18 after treatment.

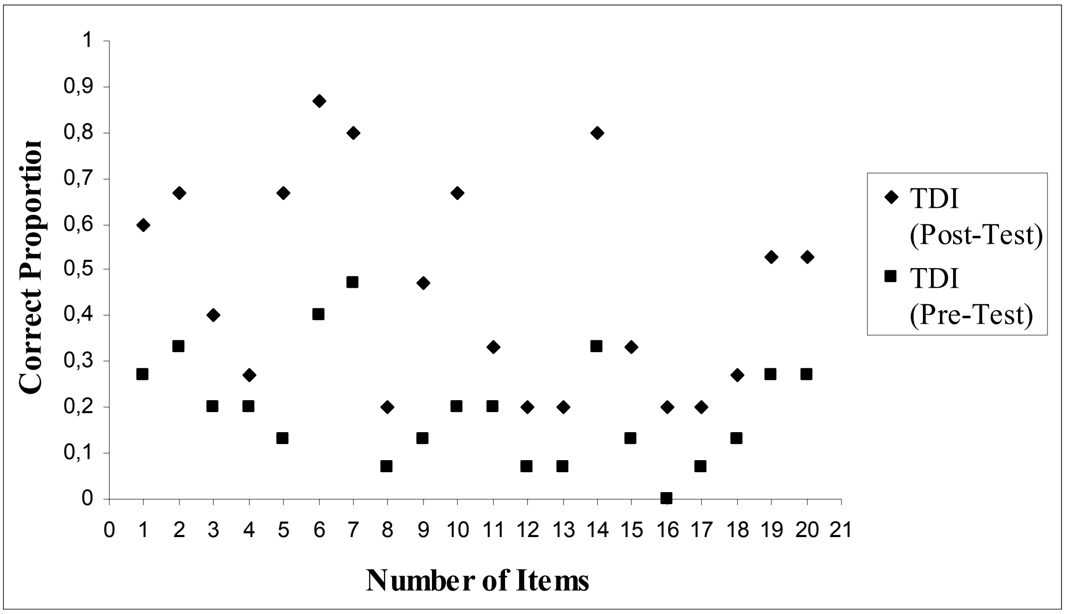


Figure 5.3 Comparison Between Pre-Test and Post-Test Scores of students in TDI

As it seen in the figure, before instruction, the average correct response percent was 20% whereas it was raised to 46% after instruction. If we compared the pre-test post-test percentages of TDI group, the difference is not as much as in CCOI&CGW group. Even though both CCOI&CGW and TDI groups showed improvement their understanding of acid-base concepts, they still have misunderstandings. The larger difference between pre-test and post-test proportions could be seen especially for questions 5, 10, and 14. The poorer student results were obtained in questions 8, 12, 13, 16, and 17 in both pre-test and post-test. For example, for question 8 which related with the strength of an acid, 7% of the students answered correctly and this percent only increased to 33% after instruction. Some of the properties of acids couldn't be achieved before instruction (question 16 referring to the properties of acids) whereas 20% of students answered correctly after instruction. This shows that traditionally designed instruction made a small effect on students' understanding of acid-base concepts.

Accordingly, we can conclude that students in CCOI&CGW group understood the acid-base concepts better than the students in TDI group.

Hypothesis 2:

To be able to answer the question posed by hypothesis 2 stating that there is no statistically significant difference between the post-test mean scores of girls and boys on understanding of acid-base concepts ANCOVA was used. Table 5.1 showed that there was no significant difference between post-test mean scores of girls and boys with respect to understanding of acid-base concepts.

Hypothesis 3:

To be able to answer the question posed by hypothesis 3 stating that there is no statistically significant effect of interaction between gender and treatment on students' understanding of acid-base concepts ANCOVA was used. Table 5.1 showed that there was no significant effect of interaction between gender difference and treatment with respect to understanding of acid-base concepts.

Hypothesis 4:

To answer the question posed by hypothesis 4 stating that there is no significant contribution of students' science process skills to the variation in achievement related to acid-base concepts ANCOVA was used. Table 5.1 showed that science process skills made a significant contribution to the variation in achievement. It means this skill accounted statistically significant portion of variation in achievement.

Table 5.2 ANOVA Summary

Source	df	SS	MS	F	p
Treatment	1	14,18	14,18	0,11	0,75
Gender	1	83,60	83,60	0,62	0,44
Gender*Treatment	1	11,60	11,60	0,09	0,77
Error	29	39,788	135,09		

The results of the analysis presented in Table 5.2 showed that there was no statistically significant difference between attitude scale scores of students taught by conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and those taught by traditionally designed instruction (TDI).

Hypothesis 5:

To be able to answer the question by hypothesis 5 stating that there is no statistically significant difference between post scale mean scores of students taught by conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and those taught by traditionally designed instruction (TDI) with respect to their attitudes toward chemistry as a school subject, ANOVA was used. The analysis of the data presented in Table 5.2 showed that there was no significant difference between post scale mean scores of students taught by conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and those taught by traditionally designed instruction (TDI).

Hypothesis 6:

To be able to answer the question posed by hypothesis 6 stating that there is no statistically significant difference between post scale mean scores of girls and boys with respect to their attitude scale toward chemistry, ANOVA was used. Table 5.2 showed that there was no significant difference between the post-test scale mean scores of girls and boys with respect to their attitudes toward chemistry.

Hypothesis 7:

To be able to answer the question posed hypothesis 7 stating that there is no statistically significant effect of interaction between gender and treatment on students' attitudes toward chemistry, ANOVA was used. Table 5.2 showed that there was no significant effect of interaction between gender and treatment on students' attitudes toward chemistry.

5.2 Conclusions

The following conclusions were obtained from the results:

1. The CCOI&CGW caused a significantly better acquisition of scientific conceptions related to acid-base concepts and elimination of misconceptions than TDI.

2. There is no statistically significant difference between the post-test mean scores of girls and boys on understanding of acid-base concepts.
3. There is no statistically significant interaction between gender and treatment on students' understanding of acid-base concepts.

4. Science process skills of the students were a strong predictor for the achievement of aid-base concepts.

5. There is no statistically significant difference between attitude scale scores of students taught by conceptual change oriented instruction accompanied with cooperative group work (CCOI & CGW) and those taught by traditionally designed instruction (TDI).

6. There is no statistically significant difference between the scores of girls and boys with respect to their attitude scale toward chemistry.

7. There is no statistically significant interaction between gender and treatment on students' attitudes toward chemistry.

CHAPTER 6

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

This chapter presents a discussion and interpretation of the results reported in the previous chapter and the implications and recommendations for further research.

6.1 Discussion

The main purpose of this study was to determine misconceptions of the tenth grade students of two chemistry classes of METU Development Foundation Private School in Acid-Base concepts and correct misconceptions of students from experimental group by using conceptual change oriented instruction accompanied with cooperative group work. On the other and, the control group received traditionally designed instruction.

The results of the study showed that conceptual change oriented instruction accompanied with cooperative group work were effective to correct the students' misconceptions of acids and bases. After the treatment, a few students from experimental group who received conceptual change oriented instruction accompanied with cooperative group work had misconceptions on the post-test when compared to the students in control group who received traditionally designed instruction. This means that the difference between learning activities provided in conceptual change oriented instruction and traditionally designed instruction may cause to difference in achievement of students in both experimental and control groups. Conceptual change oriented instruction accompanied with cooperative group work made students in experimental group change their prior knowledge or misconceptions with correct scientific ones. The conceptual change texts tend students to rethink their prior knowledge or thoughts about a topic, and then they had a chance to correct them with scientific ones. The conceptual change text also emphasized the convenience of targeted instruction with the idea posed by Posner, Strike, Hewson, and Gertzog (1982). They pointed out that the new information must be intelligible and plausible, fruitful for solving same kind of problems in the future.

Conceptual change model and cooperative group work was useful methods to overcome the misunderstandings about acid-base concepts. Students have misunderstanding about some topics of acids and bases and they were detected with pre-test of ABCT. For example, they had many misunderstandings about pH concept and pH scale as Zoller (1990) pointed out that most students never had the opportunity to internalize the 'pH' concept, they corrected with these misunderstandings with the scientific ones.

If the teaching sessions of the experimental and control group are compared, the main advantage of a constructivist classroom was that the facts that constructed by the classroom students whereas in the control group, scientific facts were narrated by the classroom teacher. In addition, students in experimental group had a chance of going back and discuss the topics that was not understood clearly, and discuss and share the ideas with each other by the way of cooperative group work. On the other hand, conceptual change approach gave students in experimental group opportunities to identify some common misconceptions about acid-base concepts while students in control group go over the instruction with presence of the misconceptions in their conceptual framework. Students in experimental group were able to consider their prior knowledge and rethink on them. Also this approach may provide students with the highlighted understandability and usefulness of the targeted scientific explanations.

While using conceptual change approach and cooperative group work, there were more interaction between students and teacher, and students and students since they were used to asking questions to the students, discussing some topics, and sharing ideas in a cooperative group. On the other hand, students in control group did not have so many chance to discuss or share ideas with each other since the teacher instructed their lecture. There was not strong interaction between teacher and students, and students and students in control group.

However, students in the control group were instructed as they did not have a chance to think of the conceptions since the teacher instructed the lecture. When the lecture started, students' in control group misconceptions were not considered, so they did not have a chance to remove those misconceptions. They received the teacher's truth while she lecturing.

We can conclude that conceptual change oriented instruction accompanied with cooperative group work had better effects on students' understanding of acid-base concepts than traditionally designed instruction.

On the other hand, Science Process Skill Test was applied to both experimental and control group to determine whether there was a difference by means of their science process skills. The analysis results showed that there was no significant difference between experimental and control groups with respect science process skills.

Alternatively, some analyses were done whether there were differences between girls and boys and interaction between CCOI&CGW and TDI and the gender with respect to the students' understanding of the acid-base concepts. The results showed that there was no statistically significant difference between the post-test mean scores of girls and boys on understanding of acid-base concepts and there was no statistically significant interaction between gender and treatment on students' understanding of acid-base concepts. On the other hand, some analysis was done to determine if there was a significant difference between the scores of CCOI&CGW and TDI groups with respect to their attitudes toward chemistry. In addition, it was analyzed that whether a significant difference between the scores of girls and boys with respect to their attitudes toward chemistry. Furthermore, analysis was done to determine if there was an interaction between treatment and gender difference with respect to attitudes toward chemistry.

Seeing that Johnstone & Kellett (1980) and Nussbaum (1981) stated that misconceptions about a topic cause many problems in a classroom, we have tried to construct an instruction to overcome these conflicts. Conceptual change oriented instruction and cooperative group work was one the appropriate solutions to beat with those problems.

Main results of this study are that the determining the students' misconceptions of acid-base concepts and development a test that reveal and remove misconceptions of acid-base concepts.

6.2 Implications

We can derive some implications from this study with respect to students' understanding of acid-base concepts.

The most of the students have misconceptions about acid-base concepts, so teacher should be aware of the students' prior knowledge and their misconceptions. They should use appropriate instruction methods to remove the existing misconceptions and/or to avoid occurring new misconceptions. Conceptual change approach and cooperative group work are effective methods used for therapy of misconceptions.

Accordingly, we can say that appropriately designed conceptual change text and well organized cooperative group work activities result in better acquisition of scientific conception and removing the misconceptions.

On the other hand, sometimes the scientific language and daily life language do not reflect each other. Some words in daily life language do not match same in the scientific language and this may cause misconceptions. Teachers should aware of this differences and use appropriate words to make students understand the scientific concepts clearly, without having misconceptions.

Alternatively, students should be asked questions that reveal their misconceptions and then remove those misconceptions with suitable treatment. Hence teacher should know variety of instructional techniques to remove misconceptions when needed.

During instruction, disequilibrium should be created so that students would rethink and reconstruct their understanding.

Equal chances should be given to each student to make them share their ideas with classroom and/or solving their problems about concepts.

Feedback should be given to the students with asking suitable questions. In addition, perceptions of students should be regarded during classroom session.

6.3 Recommendations

Based on the result of this study, the researchers recommend that:

Similar research studies can be performed with different grade levels and different science courses.

This study should be performed with a larger sample size to get more accurate results.

Different instructional techniques can be used other than conceptual change approach and cooperative group work such as, inquiry, and demonstration, concept mapping, analogy, problem solving, etc.

REFERENCES

Anderson, R. D., & Helms, J. V. (2001). The Ideal of Standards and The Reality of Schools: Needed Research. *Journal of Research in Science Teaching*, 38(1), 3-16.

Anderson, C. W., & Roth, K. J. (1988). *Teaching for Meaningful and Self-Regulated Learning of Science.* East Lansing, MI: Institute for Research on Teaching.

Anderson, C. W., & Smith, E. L. (1987a). Teaching Science. In V. Koehler (Ed.), *The Educator's Handbook: A Research Perspective.* New York: Longman.

Anderson, B. (1986). Pupils' Explanation of Some Aspects of Chemical Reactions. *Science Education,* 70*,* 549-653.

Anderson, C., & Smith, E. (1993). *Teaching Behavior Associated with Conceptual Learning in Science.* Paper Presented at The Annual Meeting of The American Educational Research Association, Montreal.

Appleton, K. (1993a). Using Theory To Guide Practice: Teaching Science From A Constructivist Perspective. *School Science and Mathematics,* 93, 269-274.

Ausubel, D. P (1958). Theory and Problems of Child Development. Grune and Stratton, New York.

Ausubel, D. P. (1968). *Educational Psychology: A Cognitive View.* New York: Holt, Rinehart and Winston.

Ausubel, D. P., Novak, J. D., and Hanesian, H. (1978). *Educational Psychology: A Cognitive View,* 2nd ed. New York: Holt, Rinehart and Winston.

Basili, A. P., & Sanford, J. P. (1991). Conceptual Change Strategies and Cooperative Group Work in Chemistry. *Journal of Research in Science Teaching,* 28 (4), 293-304.

Bishop, B. A., & Anderson, C. W. (1990). Students Conceptions of Natural Selection and Its Role in Evolution. *Journal of Research in Science Teaching,* 25(5), 415-427.

Bonwell, C. C., & Eison, J. A. (1991). *Active Learning: Creating Excitement in the Classroom.* Washington, D. C.: The George Washington University.

Boo, H. K. (1994). A Level of Chemistry Students' Conceptions and Understandings of The Nature of Chemical Reactions and Approaches to The Learning of Chemistry Content. Unpublished Phd Thesis, University of London.

Bruner, J. S. (1985). Vygotsky: A Historical and Conceptual Perspective. In J. V. Wertsch (Ed.), *Culture, Communication and Cognition: Vygotskian Perspectives.* Cambridge, MA: Cambridge University Press.

Butts, B. & Smith, R. (1987). HSC Chemistry Students' Understanding of The Structure and Properties of Molecular and Ionic Compounds. *Research in Science Education,* 17, 192-201.

Camacho, M. & Good, R. (1989). Problem Solving and Chemical Equilibrium: Successful Versus Unsuccessful Performance. *Journal of Research in Science Teaching,* 26(3), 251-272.

Campbell, J. A. (1978). *Chemistry, The Unending Frontier.* Santa Monica, CA: Goodyear.

Carey, S. (1986). Cognitive Science and Science Education. *American Psychologist, 41*, 1123-1130.

Carter, C. S., and Brickhouse, N. W. (1989). What Makes Chemistry Difficult? *Journal of Chemical Education,* 12, 223-225.

Chambers, S. K., & Andre, T. (1997). Gender, Prior Knowledge, Interest, and Experience in Electricity and Conceptual Change text Manipulations in Learning about Direct Current. *Journal of Research in Science Teaching,* 34(2), 107-123.

Cheung, K.C., & Taylor, R. (1991). Towards A Humanistic Constructivist Model of Science Learning: Changing Perspectives and Research Implications. *Journal of Curriculum Studies,* 23(1), 21-40.

Claxton, G. (1990). *Teaching To Learn: A Direction for Education.* London: Cassell.

Clement, J. (1982). Students' Preconceptions in Introductory Physics. *American Journal of Physics,* 50, 66-71.

Cleminson, A. (1990). Establishing An Epistemological Base for Science Teaching in The Light of Contemporary Notions of The Nature of Science and of How Children Learn Science. *Journal of Research in Science Teaching,* 27(5), 429-446.

Cobern, W. W. (1996). Worldview Theory and Conceptual Change in Science Education. *Science Education,* 80(5), 579-610.

Davis, K. S. (2001) "Change is Hard": What Science Teachers are Telling Us about Reform and Teacher Learning of Innovative Practices. *Science Education,* 87, 3-30.

diSessa, A. A. (1982). On Learning Aristotelian Physics: A Study of Knowledge-Based Learning. *Cognitive Science, 6,* 37-75.

Donald, J. (2002). *Learning to Think: Disciplinary Perspectives.* San Francisco, California.: Jossey-Bass.

Driver, R., & Easley, J. A. (1978). Pupils and Paradigms: A Review of Literature Related to Concept Development in Adolescent Science Students. *Studies in Science Education,* 5, 61-84.

Driver, R., & Erickson, G. (1983). Theories in Action: Theoretical and Empirical Issues in The Study Of Students' Conceptual Frameworks in Science. *Studies in Science Education,* 10, 37-60.

Duncan, I. M. & Johnstone, A. H. (1973). The Mole Concept. *Education in Chemistry,* 10, 213-214.

Dykstra, D. I. J. R., Boyle, F., Monarch, I. A. (1992). Studying Conceptual Change in Learning Physics. *Science Education,* 76(6), 615-652.

Erickson, G. L. (1979). Children's Conceptions of Heat and Temperature. *Science Education*, 63, 221-230.

Erickson, G. L. (1980). Children's Viewpoints of Heat: A Second Look. *Science Education*, 64, 323-336.

Fellows, N. J. (1994). A Window into Thinking: Using Student Writing to Understand Conceptual Change in Science Learning. *Journal of Research in Science Teaching,* 31(9), 985-1001.

Fensham, P., Gunstone, R., & White, R. (1994). *The Content of Science: A Constructivist Approach to Its Teaching and Learning.* London: Falmer Press.

Fisher, K., & Lipson, J. (1985). Information Processing Interpretation of Errors in College Science Learning. *International Science,* 14 (1), 49-74.

Frazer, M. J. (1980). Teaching the Second Law of Thermodynamics. Report of A Seminar Held At The University of East Anglia, pp. 2-8.

Freyberg, P., & Osborne, R. (1985). Assumptions about Teaching and Learning: In R. Osborne, & P. Freyberg, *Learning in Science: The Implications of Children's Science.* Auckland, New Zealand: Heinemann.

Gabel, D.L.; Samuel, K. V.; Hunn, D. (1987). Understanding Particulate Nature and Matter. *Journal of Chemical Education*, *64*, 695-697.

Gagnon, G. W. & Collay, M. (2001). Designing for Learning. Corwin Press, California.

Geban, Ö., Ertepınar, H., Yılmaz, G., Altın, A., & Sahbaz, f. (1994). Bilgisayar Destekli Eğitimin Öğrencilerin Fen Başarılarına ve Fen Bilgisi İlgilerine Etkisi. 1. Ulusal Fen Bilimleri Sempozyumu: Bildiri Özetleri Kitabı, ss: 1-2, 9 Eylül Üniversitesi, İzmir.

Geban, Ö., Aşkar, P., & Özkan, İ. (1991). Effects of Computer Simulations and Problem Solving Approaches on High School Students. *Journal of Educational Research,* 86 (1), 5-10.

Glaser, R. (1982). Instructional Psychology: Past, Present, Future. *American Psychologist, 37,* 291-299.

Gunstone, R. F., Gray, C. M. R., Searle, P. (1992). Some Long-Term Effects Uninformed Conceptual Change. *Science Education*, 76(2): 175-197.

Gussarsky, E. & Gorodetsky, M. (1990). On The Concept "Chemical Equilibrium": The Associative Framework. *Journal of Research in Science Teaching*, 27(3), 197-204

Hand, B. & Treagust, D. F. (1991). Student Achievement and Science Curriculum Development Using a Constructive Framework. *School Science and Mathematics,* 91(4), 172-176.

Helm, H., & Novak, J. D. (Eds.). (1983). *Misconceptions in Science and Mathematics. Proceedings of the International Seminar.* Ithaca, NY: Cornell University.

Hewson, M. G., & Hewson, P. W. (1983). Effect of Instruction Using Students' Prior Knowledge and Conceptual Change Strategies on Science Learning. *Journal of Research in Science Teaching*, 20, 8, 731-743.

Hewson, P. W., & Posner, G. J (1982). The Use of Schema Theory in The Design of Instructional Materials: A physics example. *Instructional Science.*

Hewson, P. W. (1980). *A Case Study of The Effect of Metaphysical Commitments on The Learning of a Complex Scientific Theory.* Paper Presented at The Annual Meeting of The American Education Research Association, Boston, MA.

Hewson, P. W. (1981). A Conceptual Change Approach to Learning Science. *European Journal of Science Education,* 3(4), 383-396.

Hewson, P. W. (1981). A Case Study of Conceptual Change in Special Relativity: The Influence of Prior Knowledge in Learning. *European Journal of Science Education,* 4, 61-78.

Howard, R. (1988). Schemata: Implications for Science Teaching. *Australian Science Teachers Journal,* 34(3), 29-34.

Hynd, C. R., McWhorter, J. Y., Phares, V. L., and Suttles, C. W. (1994). The Role of Instruction in Conceptual Change in High School Physics Topic. *Journal of Research in Science Teaching,* 31(9), 933-946.

Johnstone, A. H. (1984). New Stars for The Teacher to Steer by. *Journal of Chemical Education*, 61,847-849.

Johnstone, A. H. & Kellett, N. C. (1980). Learning Difficulties in School Science –Toward a Working Hypothesis. *International Journal of Science Education,* 2(2), 171-181.

Kavanaugh, R. D. & Moomaw, W. R. (1981). Inducing Formal Thought in Introductory Chemistry Students. *Journal of Chemical Education,* 58(3), 263-265.

Krajcik, J. S.; Layman, J. V. (1989). Paper presented at The National Association of Research in Science Teaching, San Francisco.

Lawson, A. E., and Renner, J. W. (1975). Relationship of Science Subject Matter and Developmental Levels of Learners. *Journal of Research in Science Teaching*, 12, 397-398.

Linn, M. C. & Songer, M. B. (1988). Paper presented at American Educational Research Association, New Orleans.

Lipson, M. (1984). Some Unexpected Issues in Prior Knowledge and Comprehension. *The Reading Teacher,* 37, 760-764.

Lonning, R. A. (1993). Effect of Cooperative Strategies on Student Verbal Interactions and Achievement during Conceptual Change Instruction in 10th Grade General Science. *Journal of Research in Science Teaching,* 30 (9), 1087-1101.

Mayer, R. E. (1983). What have we learned about increasing the meaningfulness of science prose? *Science Education,* 67, 223-237.

Mysliwiec, T. H., Shibley, I., & Dunbar, M. E. (2004). Using Newspapers to Facilitate Learning. *Journal of College Science Teaching,* 33 (3), 24-28.

Nakhleh, M. B. (1992). Why Some Students Don't Learn Chemistry. *Journal of Chemical Education,* 69(3), 191-196.

Nakhleh, M. B & Krajcik, J. S. (1994). Influence of Levels of Information as Presented by Different Technologies on Students' Understanding of Acid, Base, and Ph Concepts. *Journal of Research in Science Teaching,* 31(10), 1077-1096.

Neale, D., Smith, D., & Weir, E. (1987). *Teacher Thinking in Elementary Science Instruction.* Paper presented in The Annual Meeting of The American Educational Research Association, Washington, DC.

Nelson, K. (1977). Cognitive Development and Acquisition of Concepts. In R. C. Anderson, R. J. Spiro, and W. E. Montague (Eds.), *Schooling and The Acquisition of Knowledge.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Novak, J. D. (1977). *A Theory of Education.* Ithaca: Cornell University Press.

Novak, J. D. & Gowin, D. B. (1984). *Learning How to Learn.* Cambridge: Cambridge University Press.

Novik, S. & Mannis, J. (1976). A Study of Student Perception of The Mole Concept. *Journal of Chemical Education*, 53(9), 720-722.

Nussbaum, J. (1981). Towards The Diagnosis by Science Teachers of Pupils Misconceptions: An Exercise with Student Teachers. *International Journal of Science Education* ,3(2), 159-169.

Nussbaum, J., & Novick, S. (1982, April). *A Study of Conceptual Change in Classroom.* Paper presented at The Annual Meeting of The National Association for Research in Science Teaching. Lake Geneva, WI.

Okey, J. R., Wise, K. C., & Burns, J. C. (1982). Integrated Process Skill Test-2 (Available from Dr. James R. Okey, Department of Science Education, University of Georgia, Athens, GA 30362).

O'Loughlin, M. (1992). Rethinking Science Education: Beyond Piagetian Constructivism toward a Sociocultural Model of Teaching and Learning. *Journal of Research in Science Teaching*, 29, 791-820.

Osborne, R. J. & Wittrock, M. C. (1983). Learning Science: A Generative Process. *Science Education*, 67(4), 489-508.

Peterson, R. F., & Treagust, D. F. (1989). Grade-12 Students' Misconceptions of Covalent Bonding and Structure. *Journal of Chemical Education, 66,* 459-460.

Piaget, J. (1974). *Understanding Causality*. New York: W. W. Norton

Piaget, J. (1978). *The Development of Thought* (A. Rosin, Trans.). Oxford: Basil Blackwell.

Pines, A. L. & West, L. H. T. (1986). Conceptual Understanding and Science Learning: An Interpretation of Research within a Sources-Of-Knowledge Framework. *Science Education*, 70(5), 583-604.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W.A. (1982). Accommodation of a Scientific Conception: Toward a Theory of Conceptual Change. *Science Education*, 66(2), 211-227.

Resnick, L. B. (1981). Instructional Psychology. *Annual Review of Psychology*, 32, 659-704.

Roth, K. J. (1990). Developing Meaningful Conceptual Understandings in Science. In B. F. Jones & L. Idol (Eds.), *Dimensions of Thinking and Cognitive Instruction*, Hillsdale, NJ: Science Teaching, Fontana, WI.

Roth, K. J. (1989). Science Education: It is not Enough to 'Do' or 'Relate.' *American Educator*, 13, 16-48.

Roth, K. (1987a). *Helping Science Teachers Change: The Critical Role of Teachers' Knowledge about Science and Science Learning*. Paper presented at The Annual Meeting of The American Educational Research Association, Washington, DC.

Schmidt, H. J. (2000). Should Chemistry Lessons Be More Intellectually Challenging? *Chemistry Education: Research and Practice in Europe,* 1(1), 17-26. Published on the web at http://www.uoi.gr/conf_sem/cerapie

Slavin, R. (1984). Students Motivating Students to Excel: Cooperative Incentives, Cooperative Tasks, and Student Achievement. *The Elementary School Journal,* 85(1), 53-63.

Slavin, R. (1983). *Cooperative Learning.* New York: Longman.

Smith, E. L., Blakeslee, T. D., & Anderson, C. W. (1993). Teaching Strategies Associated with Conceptual Change Learning in Science. *Journal of Research in Science Teaching,* 30(2), 111-126.

Strike, K. A., & Posner, G. J. (1984). A Conceptual Change View of Learning and Understanding. In L.H.T. West & A.L. Pines (Eds.), *Cognitive Structure and Conceptual Change* (pp. 211-232), Orlando, FL: Academic Press.

Taber, K. S. (2001). Building The Structural Concepts of Chemistry: Some Considerations from Educational Research. *Chemistry Education: Research and Practice in Europe,* 2(2), 123-158. Published on the web at http://www.uoi.gr/conf_sem/cerapie

Tan, K. C. D.; Goh, N. K.; Chia, L. S.; Treagust, D. F. (2003). Students' Understanding of Acid, Base and Salt Reactions in Qualitative Analysis. *School Science Review,* 84(308), 89-97.

Tobin, K. (1990). Social Constructivist Perspectives on The Reform of Science Education. *Australian Science Teachers Journal,* 36(4), 29-35.

Treptow, R. S. (1986). The Conjugate Acid-Base Chart. *Journal of Chemical Education,* 63(11), 938-941.

Vosniadou, S. (1991). Designing Curricula for Conceptual Restructuring: Lessons from The Study of Knowledge Acquisition In Astronomy, *Journal of Curriculum Studies,* 23(3), 219-237.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes.* London: Harvard University Press.

Ward, C. R., & Herron, J. D. (1980). Helping Students Understand Formal Chemical Concepts. *Journal of Research in Science Teaching*, 17, 387-400.

Webb, N. (1983). Predicting Learning from Student Interaction: Defining The Interaction Variables. *Educational Psychologists,* 18 (1), 33-41.

Webb, N. (1982b). Peer Interaction and Learning in Cooperative Small Groups. *Journal of Educational Psychology,* 74 (5), 642-655.

West, L. H. T., & Pines, A. L. (1983). How “Rational” is Rationality? *Science Education,* 67, 37-39.

Whittemore, M. J., & Mecca, P. M. (2003). Learning Together. *The Science Teacher,* 70 (3), 60-63.

Wiser, M. & Kipman, K. (1988). Paper presented at The American Educational Research Association, New Orleans.

Zoller, U. (1990). Students' Misunderstandings and Misconceptions in College Freshman Chemistry (General and Organic). *Journal of Research in Science Teaching,* 27(10), 1053-1065.

APPENDIX A

INSTRUCTIONAL OBJECTIVES

1. To identify acid and base.
2. To explain the properties of an acid.
3. To explain the properties of a base.
4. To explain the characteristics of acids and bases.
5. To state the relationship between acids and bases.
6. To identify pH and pOH terms.
7. To give examples for strong acids and bases.
8. To explain neutralization.
9. To explain hydrolysis.
10. To clarify the strength of an acid and a base.
11. To define indicator.
12. To state that strength of an acid decreases with increasing pH.
13. To state that strength of a base decreases with increasing pOH.
14. To explain that the strength of an acid solutions increases with the amount of H^+ ions in the solution.
15. To explain that the strength of a base solutions increases with the amount of OH^- ions in the solution.
16. To show that acids change blue litmus paper to red.
17. To show that bases change red litmus paper to blue.
18. To show that acids do not change phenolphthalein color.
19. To show that bases change phenolphthalein to pink.
20. To explain that a solution with pH=7 is a neutral solution.
21. To clarify that the acid-base reactions are neutralization reactions.

22. To explain that solutions with a pH less than 7 are acids and a solutions with a pH more than 7 are basic.

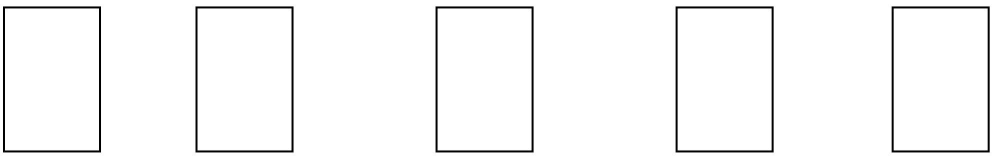
APPENDIX B

ACID-BASE CONCEPTS TEST

This test consists of questions that examine your knowledge of acids and bases. Questions are in the multiple-choice format. On the answer sheet, please circle only one choice for each question.

1. Which of the following beaker contains the strongest acid?

I	II	III	IV	V



pH= 2	pH= 3	pH=5,5	pH=7	pH=13

a) I   b) II   c) III   d) IV   e) V

2. Choose the better statement about the nature of acids and bases.

a) pH of a solution only determines the acidity of a solution
b) Acids and bases give decomposition reaction
c) Acids and bases neutralize each other
d) All substances containing H^+ is acidic
e) All bases contain OH^- ions

3. On a pH scale, determine the correct orientation of acids and bases

a) $0 < pOH < 7$ => base
$7 > pH > 14$ => acid

b) $0 \leq pOH < 7$ => base
$14 > pH > 7$ => base

c) $0 \leq pH \leq 7$ => acid
$7 < pOH < 14$ => base

d) $0 \leq pH < 7$ => acid
$7 < pOH \leq 14$ => acid

e) $0 \leq pOH \leq 7$ => base
$14 \geq pOH > 7$ => acid

4. Which of the following statements is true?

a) 100 g of H_2SO_4 solution in 200 ml. H_2O is more acidic than 10 g of H_2SO_4 solution in 20 ml. H_2O
b) Acids are always bitter taste
c) Acids and bases give composition reaction since a salt is composed
d) There is no water production after a reaction of an acid and NH_3
e) Dissociation of water is exothermic

5. Think that you have a solution having a pOH of 8. Which of the following notification gives the correct pH of the solution?

a) $pH = 8$
b) $pH = 6$
c) $6 < pH < 8$
d) $pH = (pOH\ 8 - 14) / 2$
e) We cannot calculate the pH without knowing the type of solution

6. Which of the following is common for both acid and base solutions?

a) They both have sour taste
b) They both have bitter taste
c) They conduct electricity
d) They turn blue litmus paper into red
e) They are both slippery

7. What would be the color of the red litmus paper, if you immerse into;

i. Soap + water
ii. Vinegar + water
iii. Lemon + water

a) I: blue, II: red, III: red
b) I: red, II: blue, III: red
c) I: red, II: red, III: blue
d) I: red, II: blue, III: blue
e) I: blue, II: red, III: blue

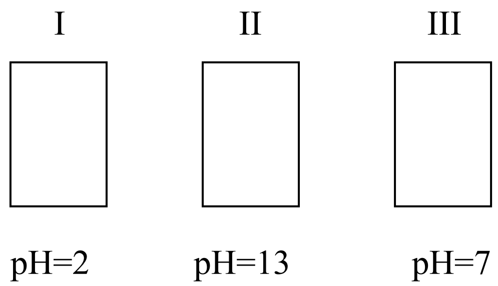
8. The strength of an acid is related with;

a) the volume of the solution
b) the mass of the solution
c) the number of OH^{-} ions in the solution
d) the number of H^{+} ions in the solution
e) the total number of ions in the solution

9. Which of the following statement is correct for all acid and base solutions?

a) The pH of a solution only gives the acidity of the solution
b) The pOH of a solution only gives the basicity of the solution
c) pH is less than 7 in acid solutions and more than 7 in base solutions
d) The pH of a solution only gives the basicity of the solution
e) pH and pOH refer to the same number in both acid and base solutions

10. The following test tubes contain different solutions with different pH's. Choose the answer that gives the correct type of the solution.



I	II	III .
a) weak acid	strong acid	neutral solution
b) strong base	neutral solution	acid
c) strong base	strong acid	neutral solution
d) strong acid	strong base	neutral solution
e) strong base	weak base	neutral solution

11. Which of the following statements about strong acids is / are true?

I. They conduct electricity well

II. Their molecules contain always more than one H^+ ions

III. They can ionize in water well

a) I b) II c) III d) I, III e) I, II, III

12. Which of the following statement about bases is / are anytime true?

i. They form a neutral solution by combining acids

ii. They have bitter taste

iii. Fruits have always basic characteristics since we can eat them

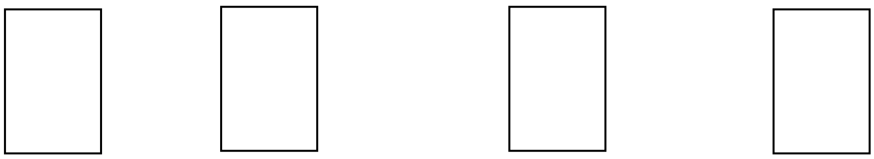
a) I b) II c) I, II d) I, III e) I, II, III

13. Which of the following statements is true?

a) A gas is released after a reaction of an acid and a base
b) Acidity increases by increasing pH
c) Basicity increases by increasing pOH
d) H_2 is released after a reaction of HCl and Mg
e) A food contains any kind of an acid is not eaten since it is toxic

14. What will be the color change of red litmus paper if you immerse it into the following solutions?

I	II	III	IV



Ammonia solution	Vinegar solution	Lemon solution	Water with soap

	I	II	III	IV
a)	blue	red	red	blue
b)	red	red	blue	blue
c)	red	blue	blue	red
d)	blue	blue	red	red
e)	blue	red	blue	blue

15. Which of the following is true if a solution have a pOH > 7 at 25 ^0C ?

a) $[OH^{--}] = 10^{-7}$

b) It turns blue litmus paper into red

c) It's a basic solution

d) $K_w=1*10^{-14}$ at all temperature

e) It has a bitter taste

16. Which of the following statements is / are true?

I. Flammable substances have acidic characteristics
II. Solutions of strong acids conducts electricity well
III. Acidic substances should not be eaten
IV. All substances containing H have acidic characteristics

a) I b) II c) III d) IV e) I, II, IV

17. Which of the following statement is true for salt formed at the end of a neutralization reaction?

a) It is always acidic
b) It is always neutral
c) After some neutralization rxn, no salt product is formed
d) It is always basic
e) The information given is not enough for state the salt is acidic, or basic, or neutral

18. Which of the following statement will be true after 1 moles of NaCl ionizes in water?

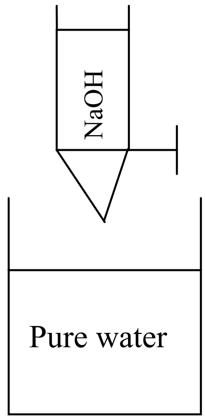
a) Solution will not contain neither H_3O^+ nor OH^- ions
b) Solution will contain more H_3O^+ ions than OH^- ions
c) Solution will contain more OH^- ions than H_3O^+ ions
d) Solution will contain same amount of OH^- ions and H_3O^+ ions
e) We can give information about H_3O^+ ions or OH^- ions if amount of salt added is stated

19. After mixing the 100 ml 0.1M NaOH solutions with 100 ml 0,1M HCN solutions, what do you expect the approximate pH value?

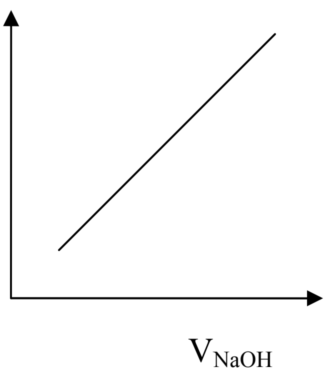
a) 3 b) 4 c) 6 d) 7 e) 13

20.

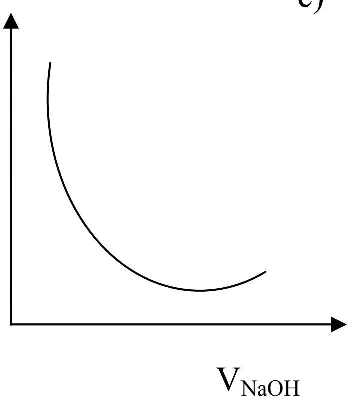
NaOH is added little by little to the pure water. Which of the following graphics represent the volume of NaOH added vs. change of pH of the mixture correctly?



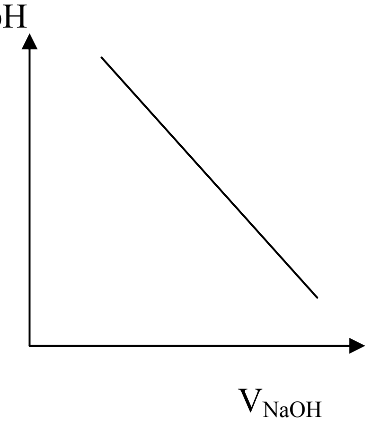
a) pH



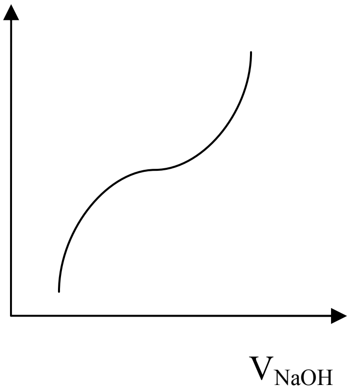
b) pH



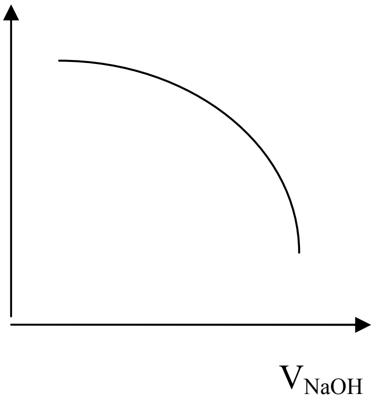
c) pH



d) pH



e) pH



APPENDIX C

CONCEPTUAL CHANGE TEXT EXAMPLES

Acid-base concept is one of the topics that students have many misunderstandings. The following text clarifies the misunderstandings about acid-base concepts. Please try to answer the questions in the text straightforwardly, then check and correct your misunderstanding(s) if there is / are.

1. The Relationship of Strength of Acids with The Volume of The Solution

Do you think that the more volume the solution has the stronger the acid is?

For example; you have two solutions, the first one including 100 g of H_2SO_4 in 200 ml. H_2O, and the second one including 50 g of H_2SO_4 in 100 ml. H_2O.

Do you think that the first solution is more acidic than the second one since the first one includes much H_2SO_4?

In fact it is not; they have the same acidity. On the other hand, if mass decrease with a constant volume, the strength does not increase or decrease. That is, the acidity does not always change by increasing or decreasing amount of the mass if the same type of acid is used. This is also true for bases.

2. Heat of The Dissociation of Water

Another confusion is related with the heat of the reaction.

Do you think that the dissociation of water is exothermic since weather is too hot when water evaporates?

If you say ‘yes’, it means you confuse the terms of ‘evaporation’ and ‘dissociation’. The reason of heat of the weather is not because of the evaporation of the water. Reversely, it supplies the needed energy for water to evaporate. In fact, the dissociation of water is endothermic.

Also K_w increases with increasing temperature.

3. Tastes and Appearances of Acids

Are you one of the people who believe that acids are always yellow colored and they have a bitter taste?

Or what do you think about the physical properties, such as taste and appearance, of acids and bases?

Of course, it’s not true to make generalization to distinguish acids and bases by looking at their colors. On the other hand, most of the students think that acids have a bitter taste. In fact, they have a sour taste like vinegar and lemon. Bases have a bitter taste like soaps.

4. Reactions of Acids and Bases

What kind of reaction do you think that acids and bases give?

Most of the students think that acid-base reaction as composition reaction since they give a reaction and a salt is one of the productions; that is, salt is composed. Actually, they give neutralization reaction in which the cation of the acid replaces with the anion of the bases.

5. Reaction of An Active Metal and An Acid

An active metal and an acid give a reaction. After this reaction, a salt and Hydrogen gas are produced as a product. What kind of reaction is this?

Some of the students think that replacement reaction occurs when acid reacts with active metals since H^+ ion in the acid is left alone after a reaction occurred. Actually, after a reaction of an acid and active metal; such as Mg, Zn, and Al; H_2 is released. For example;

$$Mg_{(s)} + 2HCl_{(aq)} \longleftrightarrow MgCl_{2(aq)} + H_{2(g)}$$

Well, do metals have an ability to give a reaction with bases?

Some students think that any metals do not react with bases since active metals in groups IA and IIA shows more basic characteristics than the other elements placed in righter columns in periodical table. But it is not true to say none of the metals can react with the bases. In fact, bases can react with amphoteric metals, such as Al, Zn, and Sn.

6. pH and pOH Concept

How can you decide the acidity of a solution, by pH or/and by pOH?

It's sometimes thought that only the pH of a solution gives the acidity of the solution, and similarly only the pOH of a solution gives the basicity of the solution since people relates H^+ with acidity and so does pH; similarly they relates OH^- with basicity and so does pOH. This generalization is wrong since we use both pH and pOH to express both acidity and basicity.

	ACID	**BASE**
pH	**$0 \leq pH < 7$**	**$7 < pH \leq 14$**
pOH	**$7 < pOH \leq 14$**	**$0 \leq pOH < 7$**

Acids have a range **$0 \leq pH < 7$** in pH scale and **$7 < pOH \leq 14$** in pOH scale whereas bases have a range $7 <$**$pH \leq 14$** in pH scale and **$0 \leq pOH < 7$** in pOH scale. According to this scale, a solution with a pH=13 (pOH=1) is a strong base not an acid.

Well, does the acidity increase by increasing pH or does the basicity increase by increasing pOH?

Another misunderstanding of students is increasing acidity or basicity with increasing pH or pOH since the generalization of values are increases when the numerical values increase. This is not always true. For example; an acid with pH=2 is stronger than an acid with pH=5. Similarly, a base pOH=3 is stronger base than a base with pOH=8. It's related with the amount of H^+ ion (or OH^- ion) in the solution.

Another important point is that when **pH=pOH=7,** solution is a neutral, neither an acidic nor a basic.

7. Productions of Acid-Base Reactions

Well, what do you think about the release of gas after a reaction of an acid and a base?

Do you think gases are released after a reaction or not?

Generally, you tend to think like this because of maybe your childhood experiences with cartoons. Generally, a reaction of an acid with anything results in a production of a gas in cartoons. In fact, this is not true. The products of an acid and a base are a salt and water (except of reaction of an acid and NH_3).

What are the products of an acid and a base reaction?

Some of the students think that the products of all neutralization reactions are salt and water. This is true but there is an exception like a reaction of a weak base of NH_3 with an acid. Its production is only salt, there's no water as a product.

$$NH_3 + HCl \longrightarrow NH_4Cl$$

8. Indicator

How does a color of an acidic or a basic solution change after adding cabbage water?

Do you think that the color of acidic solution will turn into red; whereas the color of basic solution will turn into blue?

Red cabbage water is an indicator of pH. Although it can't be used to determine exact pH, it can distinguish between acid (pH of 0 to 6), neutral (pH near 7), and base (pH of 8 to 14).

If the indicator turns the solution red or pink, the solution is an acid. A purple solution indicates that it is neutral, neither an acid nor a base. If the indicator turns the solution blue or green, the solution is a base.

9. Properties of Acids

Are the acids toxic and flammable substances since some of them can be dangerous if used carelessly?

Most of the students think that acids are toxic and flammable substances since some strong acids such as H_2SO_4 and toxic materials are dangerous if they're used careless. But it's not true to say acids are toxic materials since some of them can be dangerous if used with careless.

Well, is it true to eat if a food contains an acid?

Also they think that foods that contain acids aren't eaten since they think that they're toxic so fruits must have basic characteristics. In fact, this is not true.

For example, apple contains maleic acid; yoghurt contains lactic acid. Also some students think that soil has a basic characteristic since plants are grown in the soil. In fact, soil can show acidic or basic characteristics according to other materials in it.

10. Arrhenius and Bronsted-Lowry Definition of Acids and Bases

Some students neglect that Arrhenius definition is limited to aqueous solutions.

Actually, Arrhenius definition is limited the discussion of an acid or a base to aqueous solutions.

Looking at acid-base reactions only in aqueous solutions, it singles out the OH^- ion as the source of base character, when other species can play a similar role.

By the Arrhenius definition, the dissociation of HCl in water may be written as;

$$HCl \longrightarrow H^+ + Cl^-$$

In terms of Bronsted-Lowry definition, the solvent water cannot be ignored because a proton transferred from HCl to H_2O

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

proton transfer

APPENDIX D

ACTIVITY SHEET RELATED TO CONCEPTUAL CHANGE INSTRUCTION

1. Please define the acids and bases according to Arrhenius and Bronsted-Lowry acid-base concept.

	ACID	BASE
ARRHENIUS		
BRONSTED-LOWRY		

2. Please check and if needed correct the following characteristics of acids and bases and fill in the blanks with appropriate characteristics.

ACID	BASE
tastes...........................	tastes sour
turns litmus paper .... to	turns litmus paper .... to ....
(conducts / doesn't conduct) electricity	(conducts / doesn't conduct) electricity
reacts with acids to form salt and water	reacts with bases to form salt and water

3. Calculate the molar concentration of H^+ and OH^- ions in a solution of

a) 0,01M HCl

b) 0,0001M NaOH

4. Please circle the correct expression(s) about acids and bases and correct the false expression(s)

a) $[H^+] > 1*10^{--7}$ => Acidic solution

b) pH > 7 => Basic solution

c) $[OH^-] < 1*10^{-}7$ => Basic solution

d) pOH < 7 => Acidic solution

e) $[H^+] = [OH^-]$ => Neutral solution

f) If $[H^+]$ increases acidity of solution decreases

g) Strong bases 100% ionized in solution

h) In terms of Bronsted-Lowry definition the solvent water can be ignored for notification of proton transfer reaction

$$HCl \longrightarrow H^+ + Cl^{--}$$

i) Arrhenius definition is limited to aqueous solution

j) 100g HNO_3 in 200ml water is stronger than 50g HNO_3 in 100ml water

k) The dissociation of water is endothermic

l) Pure water contains equal concentrations of H^+ and OH^- ions, so it's neutral

m) Pure water is a good electrolyte

n) The products of all neutralization reactions are salt and water

o) At end point pH=7

p) Bases do not give any reaction with any metals

r) Fruits show basic characteristics since we can eat them.

APPENDIX E

KİMYA DERSİ TUTUM ÖLÇEĞİ

AÇIKLAMA: Bu ölçek, 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 ile 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 F

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.

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

a. Her oyuncunun almış olduğu günlük vitamin miktarını.

b. Günlük ağırlık kaldırma çalışmalarının miktarını.

c. Günlük antrenman süresini.

d. Yukarıdakilerin hepsini.

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

a. Arabaların benzinleri bitinceye kadar geçen süre ile.

b. Her arabanın gittiği mesafe ile.

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

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

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

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

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

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

c. Büyük evlerin ısınma giderleri fazladır.

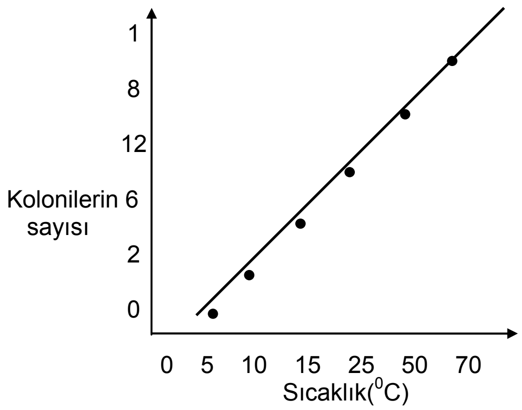
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

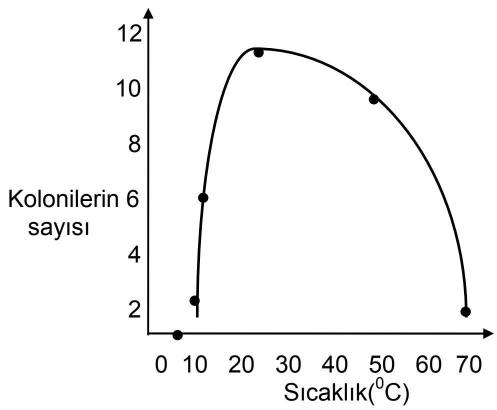
Deney odasının sıcaklığı (^{0}C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

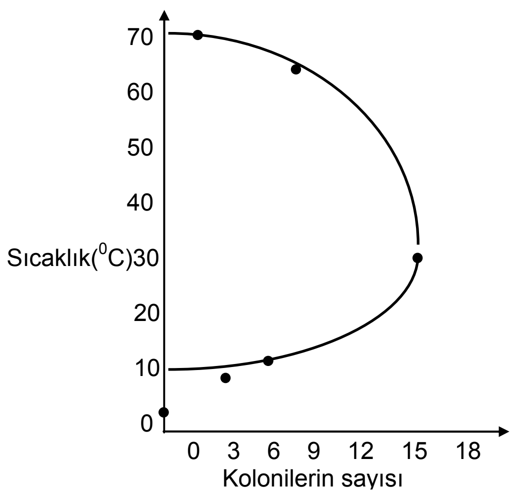
a.



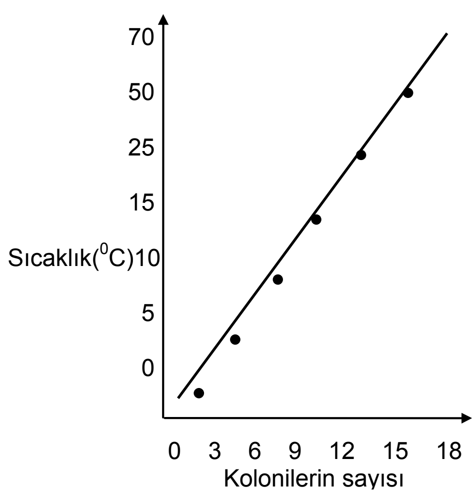
b.



c.



d.



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

a. Daha genç sürücülerin daha hızlı araba kullanma olasılığı yüksektir.
b. Kaza yapan arabalar ne kadar büyükse, içindeki insanların yaralanma olasılığı o kadar azdır.
c. Yollarda ne kadar çok polis ekibi olursa, kaza sayısı o kadar az olur.
d. Arabalar eskidikçe kaza yapma olasılıkları artar.

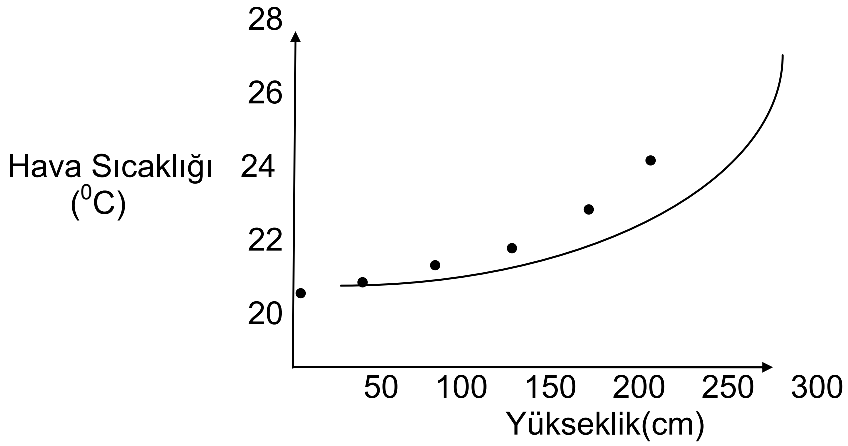
7. Bir fen sınıfında, tekerlek yüzeyi genişliğinin tekerleğin daha kolay yuvarlanması üzerine etkisi araştırılmaktadır. Bir oyuncak arabaya geniş yüzeyli tekerlekler takılır, önce bir rampadan (eğik düzlem) aşağı bırakılır ve daha sonra düz bir zemin üzerinde gitmesi sağlanır. Deney, aynı arabaya daha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

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.
b. Rampanın (eğik düzlem) eğim açısı ölçülür.
c. Her iki deneyde kullanılan tekerlek tiplerinin yüzey genişlikleri ölçülür.
d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

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

a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.
b. Ne kadar çok mısır elde edilirse, kar o kadar fazla olur.
c. Yağmur ne kadar çok yağarsa , gübrenin etkisi o kadar çok olur.
d. Mısır üretimi arttıkça, üretim maliyeti de artar.

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

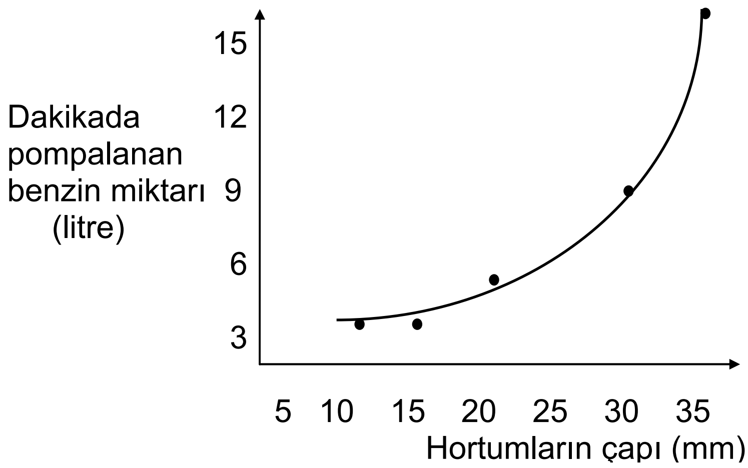


a. Yükseklik arttıkça sıcaklık azalır.
b. Yükseklik arttıkça sıcaklık artar.
c. Sıcaklık arttıkça yükseklik azalır.
d. Yükseklik ile sıcaklık artışı arasında bir ilşki yoktur.

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

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

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

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

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

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

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

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

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

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

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

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?
a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Her bir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?
a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Her bir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?
a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Her bir kovanın güneş altında kalma süresi.

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

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

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

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

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

18. Bu araştırmada kontrol edilebilen değişken hangisidir?
a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?
a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

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

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

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

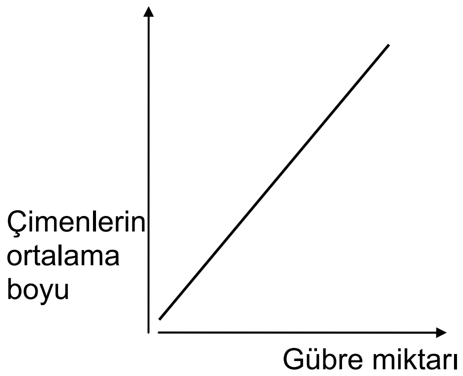
a. Her biri farklı şekil ve ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.
b. Her biri aynı şekilde fakat farklı ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri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

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

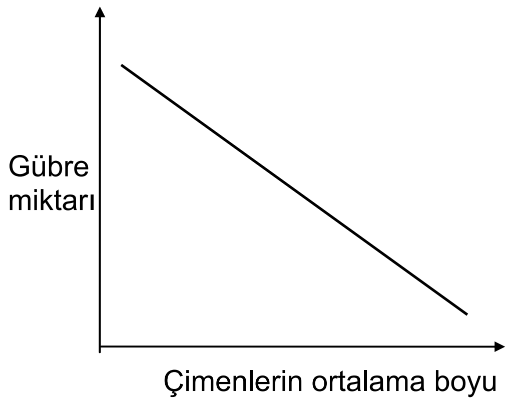
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

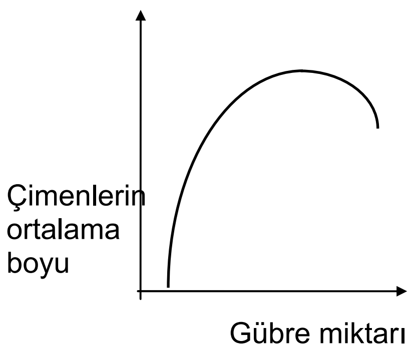
a.



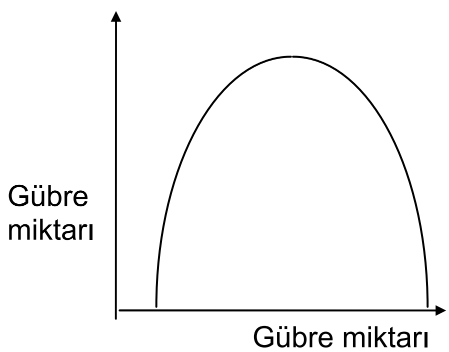
b.



c.



d.



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

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Her gün fareleri tartar.

d. Her gün farelerin yiyeceği vitaminleri tartar.

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

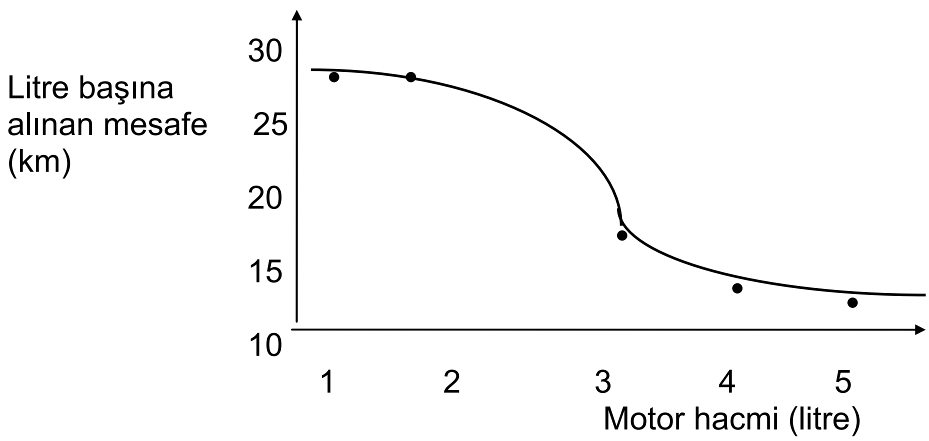
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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

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

d. Su ısındıkça şeker daha uzun sürede çözünür.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

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

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

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

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

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

29. Bu araştırmada sınanan hipotez hangisidir?
a. Bitkiler güneşten ne kadar çok ışık alırlarsa, o kadar fazla domates verirler.
b. Saksılar ne kadar büyük olursa, karıştırılan yaprak miktarı o kadar fazla olur.
c. Saksılar ne kadar çok sulanırsa, içlerindeki yapraklar o kadar çabuk çürür.
d. Toprağa ne kadar çok çürük yaprak karıştırılırsa, o kadar fazla domates elde edilir.

30. Bu araştırmada kontrol edilen değişken hangisidir?
a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki torak miktarı.
d. Çürümüş yapak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?
a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki torak miktarı.
d. Çürümüş yapak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?
a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki torak miktarı.
d. Çürümüş yapak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

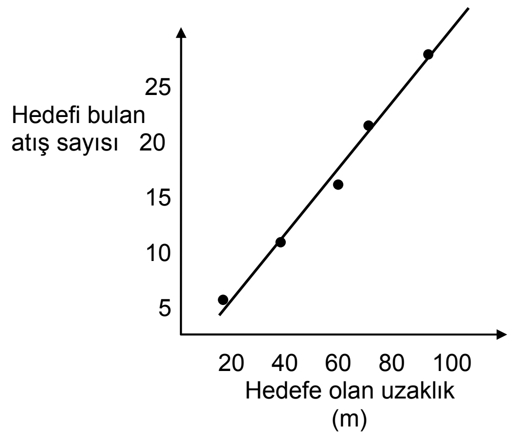
d. Çekilen demir tozlarının ağırlığı ile.

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

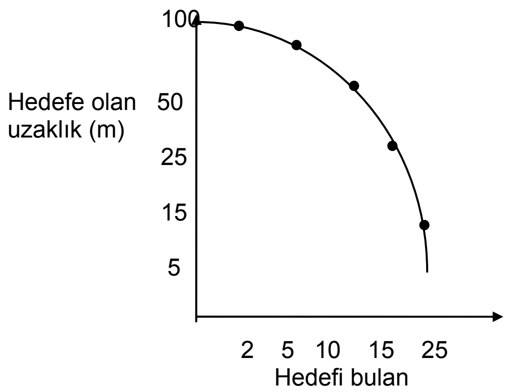
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

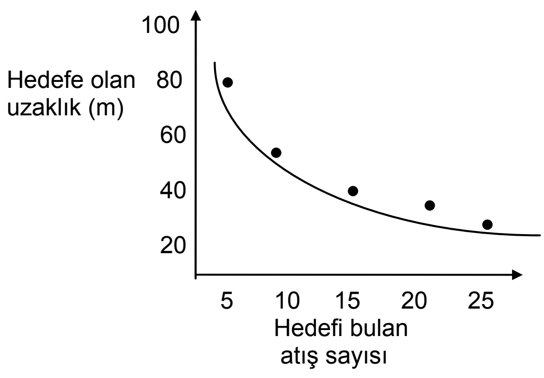
a.



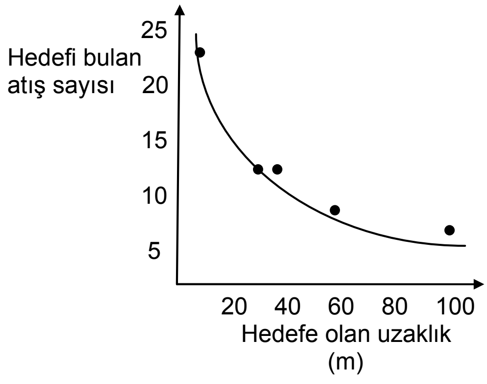
b.



c.



d.



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

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

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

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

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

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

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c.