EFFECTIVENESS OF 5E LEARNING CYCLE MODEL ON STUDENTS' UNDERSTANDING OF ACID-BASE CONCEPTS

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ELVAN AKAR

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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.

____

Assis. Prof. Dr. Hüsniye Demircioğlu

Supervisor

Examining Committee Members

Prof. Dr. Ömer Geban	(METU, SSME)	
Assis. Prof. Dr. Hüsniye Demircioğlu	(METU, SSME)	
Assis. Prof. Dr. Jale Çakıroğlu	(METU, ELE)	
Assis. Prof. Dr. Esen Uzuntiryaki	(METU, SSME)	
Assis. Prof. Dr. Yezdan Boz	(METU, SSME)	

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Name, Last name: Elvan Akar

Signature :

ABSTRACT

EFFECTIVENESS OF 5E LEARNING CYCLE MODEL ON STUDENTS' UNDERSTANDING OF ACID-BASE CONCEPTS

AKAR, Elvan

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

Supervisor: Assis. Prof. Dr. Hüsniye DEMİRCİOĞLU

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The main purpose of this study was to compare the effectiveness of instruction based on 5E learning cycle model over traditionally designed chemistry instruction on tenth grade students' understanding of acid-base concepts.

Fifty- six tenth grade students from two classes of a chemistry course taught by the same teacher in Atatürk Anatolian High School 2003-2004 spring semester were enrolled in the study. The classes were randomly assigned as control and experimental groups. Students in the control group were instructed by traditionally designed chemistry instruction whereas students in the experimental group were taught by the instruction based on 5E learning cycle model. Acid-Base Concepts Achievement Test was administered to both groups as a pre-test and post-test in order to assess their understanding of concepts related to acid-base. Students were also given Attitude Scale Toward Chemistry as a School Subject at the beginning and end of the study to determine their attitudes and Science Process Skill Test at the beginning of the study to measure their science process skills.

The hypotheses were tested by using analysis of covariance (ANCOVA) and t-test. The results indicated that instruction based on 5E learning cycle model caused a significantly better acquisition of scientific conceptions related to acid-base produced significantly higher positive attitudes toward chemistry as a school subject than the traditionally designed chemistry instruction. In addition, science process skill was a strong predictor in understanding the concepts related to acid-base.

KEYWORDS: 5E Learning Cycle, Traditionally Designed Chemistry Instruction, Acid-Base, Attitude Towards Chemistry as a School Subject, Science Process Skill.

ÖZ

5E ÖĞRENME DÖNGÜSÜ MODELİNİN ÖĞRENCİLERİN ASİT VE BAZLARLA İLGİLİ KAVRAMLARI ANLAMALARINA ETKİSİ

AKAR, Elvan

Yüksek Lisans, Ortaögretim Fen ve Matematik Alanlari Egitimi Bölümü

Tez Yöneticisi: Yrd.Doç.Dr. Hüsniye DEMİRCİOĞLU

Ocak 2005, 112 sayfa

Bu çalışmanın amacı 5E öğrenme döngüsü modelinin onuncu sınıf öğrencilerinin asit ve bazlarla ilgili kavramları anlamalarına etkisini geleneksel yöntem ile karşılaştırmaktır. Aynı zamanda, öğretim yönteminin öğrencilerin kimya dersine yönelik tutumlarına etkisi de araştırılmıştır.

Bu çalışma Atatürk Anadolu Lisesi'nde 2003-2004 bahar döneminde gerçekleştirilmiştir. Çalışmaya, aynı kimya öğretmeninin iki ayrı onuncu sınıfındaki ellialtı öğrenci katılmıştır. Sınıflar kontrol grubu ve deney grubu olarak rastgele seçilmiştir. Kontrol grubunda geleneksel yöntem kullanılırken deney grubunda 5E öğrenme döngüsü modeli kullanılmıştır. Öğrecilerin asit-bazlarla ilgili kavramları anlama düzeylerini ölçmek için Asit-Baz Kavramları Başarı Testi her iki gruba ön-test ve son-test olarak uygulanmıştır. Ek olarak, öğrencilerin kimya dersine yönelik tutumlarını belirlemek için Kimya Dersi Tutum Ölçeği ve bilimsel işlem becerilerini belirlemek için Bilimsel İşlem Beceri Testi her iki gruba da uygulanmıştır.

Araştırmanın hipotezleri ortak değişkenli varyans analizi (ANCOVA) ve t-test kullanılarak test edilmiştir. Sonuçlar 5E öğrenme döngüsü modelinin asit-bazlarla ilgili kavramların anlaşılmasında daha etkili oldugunu ve kimya dersine yönelik daha olumlu tutuma yol açtığını göstermiştir. Bilimsel işlem becerisinin de öğrencilerin asit-bazlarla ilgili kavramlari anlamalarına istatiksel olarak anlamlı katkısı olduğu belirlenmiştir.

ANAHTAR SÖZCÜKLER: 5E Öğrenme Döngüsü Modeli, Geleneksel Yöntem, Asit ve Bazlar, Kimya Dersi Tutum Ölçeği, Bilimsel İşlem Becerisi.

To my family;

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LIST OF SYMBOLS

IBLCM	: Instruction based on 5E Learning Cycle Model
TDCI	: Traditionally Designed Chemistry Instruction
ABCAT	: Acid-Base Concepts Achievement Test
ASTC	: Attitude Scale Towards Chemistry as a School Subject
SPST	: Science Process Skill Test
df	: Degrees of freedom
SS	: Sum of squares
MS	: Mean square
$\bar{X}$	: Mean of the sample
P	: Significance level
F	: F statistic
t	: t statistic

CHAPTER I

INTRODUCTION

In Turkey, studies show that students are unable to successfully integrate or contrast memorized facts and formulate with real-life applications outside the science classroom. Practical knowledge and school knowledge are becoming mutually exclusive; many students see little connection between what they learn in the science classroom with real life. Additionally, the traditional teaching method of teacher as information-giver to passive students appears outdated. They emphasize the learning of answers more than the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understanding in context. They fail to encourage students to work together, to share ideas and information with each other, or to use modern instruments to extend their intellectual capabilities. One solution for this problem is to prepare students to become good adaptive learners. That is, students should be able to apply what they learn in school to the various situations in real-life. Obviously, the traditional teacher-as-information-giver, textbook guided classroom has failed to bring about the desired outcome of producing thinking students. An alternative is to change the focus of the classroom from teacher-centered to student-centered using a constructivist approach.

Constructivism is not a new concept. It has its roots in philosophy and has been applied to sociology and anthropology, as well as cognitive psychology and education. Perhaps the first constructivist philosopher, Giambatista Vico commented in a treatise in 1710 that "one only knows something if one can explain it." (Yager,1991). Learners actively take knowledge, connect it to previously assimilated knowledge and make it theirs by constructing their own interpretation (Cheek, 1992).

The main purpose of this study is to examine effectiveness of “acid-base concepts” instruction based on constructivist approach and attitudes toward science as a school subject. Students’ attitudes, feelings and perceptions of science are also important for science achievement.

1.1 Significance of the Study

One of the concepts of chemistry which students are unable to successfully integrate memorized facts and formulate with real-life applications outside the chemistry classroom is Acid- Base concepts. The old methods used in science curriculum do not develop student interest in the subject matter. The old methods also do not empower students to become deep thinkers who are capable of making new discoveries and solving complex problems.

Constructivism is a theory that gives hope to the development of the deep understanding of the sciences in students of all ages.

CHAPTER II

REVIEW OF LITERATURE

Improving science achievement through the use of more effective instructional strategies, promoting the active role of the learner, and promoting the facilitative role of the teacher has long been an aspiration of science educators. Students come into a classroom with their own experiences and a cognitive structure based on those experiences. These preconceived structures are valid, invalid or incomplete. The learner will reformulate his/her existing structures only if new information or experiences are connected to knowledge already in memory. Inferences, elaborations and relationships between old perceptions and new ideas must be personally drawn by the student in order for the new idea to become an integrated, useful part of his/her memory. Memorized facts or information that has not been connected with the learner's prior experiences will be quickly forgotten. In short, the learner must actively construct new information onto his/her existing mental framework for meaningful learning to occur. On this ground, we shall begin discussion with constructivist approach. Next, a teaching strategy based on constructivist approach, 5E Learning Cycle will be discussed.

2.1 Constructivist Approach:

2.1.1. Constructivism

Constructivism is an epistemology, a learning or meaning-making theory that offers an explanation of the nature of knowledge and how human beings learn. It maintains that individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe and the ideas, events, and activities with which they come in contact (Cannella and Reiff, 1994; Richardson, 1997). Knowledge is acquired through involvement with content instead of imitation or repetition (Kroll and LaBoskey, 1996). Learning activities in constructivist settings are characterized by active engagement, inquiry, problem solving, and collaboration with others. Rather than a dispenser of knowledge, the teacher is a guide, facilitator, and co-explorer who encourage learners to question, challenge, and formulate their own ideas, opinions, and conclusions. "Correct" answers and single interpretations are de-emphasized.

Von Glasersfeld (1993) indicates that constuctivism is a way of knowing that recognizes the real world as a source of knowledge. There is an external world made up of objects and events, which we want students to laern about. However students as well as scientists can never fully know reality. They can form approximations of reality, but never a true picture of it. What we can aim for is to build useful ideas about the world that are viable and can be used to understand and explain nature. Viable knowledge can be applied to further our purposes and the quality of life. This notion implies that reality is dependent upon the mind for its existence, hence knowledge is constructed by the mind rather than being a facsimile of reality (von Glasersfeld, 1995).

The theory that the mind constructs useful ideas of reality has implications for instruction. If people have to conceptualize reality, they need to process, organize, and reflect upon it. Thus learning becomes an active process that builds upon prior knowledge. What the learners know becomes as important as what we want them to know. Teaching and learning must be an interactive process that engages the learners in constructing knowledge. Negotiaiton takes place between the teacher and students, whereby the teacher moves students toward greater understanding of reality. Often these interactions take time, requiring many small steps toward reforming and building new ideas (Driver, Asoko, Leach, Mortimer, and Scott, 1994). Through this approach, students' ideas become more differentiated and more closely resemble scientific concepts.

In general, two broad interpretations can be found among contemporary educators--psychological constructivism, most notably articulated by Piaget, and social constructivism, associated with Vygotsky. Two major issues shape these interpretations: (1) education for individual development versus education for social transformation and (2) the degree of influence that social context has on individual cognitive development (Richardson, 1997; Vadeboncoeur, 1997).

Psychological or Piagetian constructivists generally regard the purpose of education as educating the individual child in a fashion that supports the child's interests and needs; consequently, the child is the subject of study, and individual cognitive development is the emphasis. Learning is primarily an individualistic enterprise. This is a child-centered approach that seeks to identify, through scientific study, the natural path of cognitive development (Vadeboncoeur, 1997). This approach assumes that students come to classrooms with ideas, beliefs, and opinions that need to be altered or modified by a teacher who facilitates this alteration by devising tasks and questions that create dilemmas for students. Knowledge construction occurs as a result of working through these dilemmas. Characteristic instructional practices include "discovery learning" and hands-on activities, such as using manipulative; student tasks that challenge existing concepts and thinking processes; and questioning techniques that probe students' beliefs and encourage examination and testing of those beliefs (Richardson, 1997). Social or Vygotskian constructivism emphasizes education for social transformation and reflects a theory of human development that situates the individual within a sociocultural context. Individual development derives from social interactions within which cultural meanings are shared by the group and eventually internalized by the individual (Richardson, 1997). Individuals construct knowledge in transaction with the environment, and in the process both the individual and the environment are changed. The subject of study is the dialectical relationship between the individual and the social and cultural milieu.

Ausubel (1963) also promoted a cognitive approach to learning, except he focused on the conceptual rather than the operativ eforms of the knowledge that are stressed by Piaget. He advocated that reception learning is directed toward discipline-based concepts that can be learned by students, and, in fact most of what is learned, both in and out of school, is acquired through the transmission of ideas rather than through discovering them. However, he advised that reception learning must be meaningful in order for it to be effective. He cautioned educators that discovery as well as reception learning can be rote, and that they must avoid this situation and take every measure to make learning meaningful. However, he pointed out that students must relate the material under study to their existing cognitive structures of organized information. When students learn in a meaningful manner, they form mental connections between new ideas and the relevant elements within their existing cognitive strucutres.

Brooks and Brooks (1999) suggest that constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. Each of us generates our own "rules" and "mental models," which we use to make sense of our experiences. Learning, therefore, is simply the process of adjusting our mental models to accommodate new experiences. Constructivism calls for the elimination of a standardized curriculum. Instead, it promotes using curricula customized to the students' prior knowledge. Also, it emphasizes hands-on problem solving. Under the theory of constructivism, educators focus on making connections between facts and fostering new understanding in students. Instructors tailor their teaching strategies to student responses and encourage students to analyze, interpret, and predict information. Constructivism calls for the elimination of grades and standardized testing. Instead, assessment becomes part of the learning process so that students play a larger role in judging their own progress.

According to Lorsbach and Tobin (1997) one way to make sense of how students learn is through constructivism. Constructivism is a word used frequently by science educators lately. It is used increasingly as a theoretical rationale for research and teaching. Many current reform efforts also are associated with the notion of constructivism. But what exactly is constructivism and how can it be useful to the practicing teacher? Constructivism is an epistemology, a theory of knowledge used to explain how we know what we know. We believe that a constructivist epistemology is useful to teachers if used as a referent; that is, as a way to make sense of what they see, think, and do.

Driver (1989) has used a constructivist epistemology as a referent in her research on children's conceptions in science. Children's prior knowledge of phenomena is an important part of how they come to understand school science. Often the interpretation of phenomena from a scientific point of view differs from the interpretation children construct; children construct meanings that fit their experiences and expectations. This can lead children to oftentimes construct meanings different from what was intended by a teacher. Teachers that make sense of teaching from an objectivist perspective fail to recognize that students often resolve this cognitive conflict by separating school science from their own life experiences. In other words, students distinguish between scientific explanations and their "real world" explanations (the often cited example- that forces are needed to keep a ball in motion versus Newton's explanation is one such example). Children's conceptions are their constructions of reality, ones that are viable in the sense that they allow a child to make sense of his/her environment. By using a constructivist epistemology as a referent teachers can become more sensitive to children's prior knowledge and the processes by which they make sense of phenomena.

In studies where constructivist approach was used, it has been showed that constructivist teaching strategies were effective in enhancing students understanding and achievement. Treagust (1991), after his studies concluded that constructivism allow for greater greater learning success. Active participation has been showen to lead both greater understanding and greater interest in the subject. Caprio (1994) is another researcher who examined the effectiveness of the constructivist approach compared with the traditional lecture-lab method. It was concluded that students taught by constructivist methodology seemed more confident of their learning.

Hand et al. (1997) examined junior secondary school students' perceptions of implementation of constructivist approach to the teaching of science. Students were more actively involved, had more discussions, practical work, and more fun. So, constructivist teaching and learning approaches lead greater understanding of concepts. It was seen that students were more active in the learning process. They had opportunity to see and control their thinking. And they constructed correct knowledge more confidently and became more confident in their understanding of science.

Cho (2002) studied the effects of a science-technology-society (STS) in-service programme, designed to change teachers' awareness and practice of STS/constructivist approaches, while also focusing on students' understandings and changes of perceptions of the constructivist learning environments. The STS in-service programme was developed to achieve the following features: teacher-oriented, teaching in a social context, emphasis on a 'constructivist' approach, developing STS units and their use in classrooms. A total of 20 middle and high school science teachers participated in the in-service programme in 1998; and three of the middle school teachers were selected to gain information from their implementation of a Reactions of Acids and Bases unit in their respective classrooms. The Science Education Reform Inventory was administered to all the teachers at both the opening and the end of the programme. One hundred twenty-five students of the three teachers experienced about 16 class hours of lessons comprising the new STS unit. At the beginning and the end of the unit, they completed the Constructivist Learning Environment Survey. In order to assess student understanding, teachers administered the creativity test before and after the unit; and the concept acquisition test and the application test after the unit. Students made more relevant and creative responses on unfamiliar situations on the post-test than on the pre-test. Through several tasks including a short essay, students showed their abilities to apply various concepts related to acids and bases to daily life situation. It was found that the STS programme improved the teachers' awareness and practices of the science education reforms characterized by STS and constructivism. The results showed that the STS in-service programme and constructivism was effective and could be implemented successfully with Korean science teachers.

2.1.2. Characteristics of Constructivist Learning and Teaching

In a constructivist setting, knowledge is not objective; mathematics and science are viewed as systems with models that describe how the world might be rather than how it is. These models derive their validity not from their accuracy in describing the real world, but from the accuracy of any predictions, which might be based on them (Postlewaite, 1993). The role of the teacher is to organize information around conceptual clusters of problems, questions and discrepant situations in order to engage the student's interest. Teachers assist the students in developing new insights and connecting them with their previous learning. Ideas are presented holistically as broad concepts and then broken down into parts. The activities are student centered and students are encouraged to ask their own questions, carry out their own experiments, make their own analogies and come to their own conclusions.

Becoming a constructivist teacher may prove a difficult transformation since most instructors were prepared for teaching in the traditional, objectivist manner. It "requires a paradigm shift" and "requires the willing abandonment of familiar perspectives and practices and the adoption of new ones" (Brooks and Brooks, 1993, p. 25). The following represent a summary of some suggested characteristics of a constructivist teacher (Brooks and Brooks, 1993):

1. Become one of many resources that the student may learn from, not the primary source of information.
2. Engage students in experiences that challenge previous conceptions of their existing knowledge.
3. Allow student responses to drive lessons and seek elaboration of students' initial responses. Allow student some thinking time after posing questions.
4. Encourage the spirit of questioning by asking thoughtful, open-ended questions. Encourage thoughtful discussion among students.
5. Use cognitive terminology such as "classify," "analyze", and "create" when framing tasks.
6. Encourage and accept student autonomy and initiative. Be willing to let go of classroom control.
7. Use raw data and primary sources, along with manipulative, interactive physical materials.
8. Don't separate knowing from the process of finding out.
9. Insist on clear expression from students. When students can communicate their understanding, then they have truly learned.

A teacher may structure a lesson in the following format, which was condensed from current constructivist literature and is not intended to be a rigid set of rules. The first objective in a constructivist lesson is to engage student interest on a topic that has a broad concept. This may be accomplished by doing a demonstration, presenting data or showing a short film. Ask open-ended questions that probe the students' preconceptions on the topic. Next, present some information or data that does not fit with their existing understanding. Let the students take the bull by the horns. Have students break into small groups to formulate their own hypotheses and experiments that will reconcile their previous understanding with the discrepant information. The role of the teacher during the small group interaction time is to circulate around the classroom to be a resource or to ask probing questions that aid the students in coming to an understanding of the principle being studied. After sufficient time for experimentation, the small groups share their ideas and conclusions with the rest of the class, which will try to come to a consensus about what they learned.

Constructivist teaching offers a bold departure from traditional objectivist classroom strategies. The goal is for the learner to play an active role in assimilating knowledge onto his/her existing mental framework. The ability of students to apply their school-learned knowledge to the real world is valued over memorizing bits and pieces of knowledge that may seem unrelated to them. The constructivist approach requires the teacher to relinquish his/her role as sole information-dispenser and instead to continually analyze his/her curriculum planning and instructional methodologies. Perhaps the best quality for a constructivist teacher to have is the "instantaneous and intuitive vision of the pupil's mind as it gropes and fumble to grasp a new idea" (Brooks and

Brooks, 1993, p. 20). Clearly, the constructivist approach opens new avenues for learning as well as challenges for the teacher trying to implement it. The following procedures for teachers are suggested by Yager (1991):

1. Seek out and use student questions and ideas to guide lessons and whole instructional unit.
2. Accept and encourage student initiation of ideas.
3. Promote student leadership, collaboration, and location of information and taking actions as a result of the learning process.
4. Use student thinking, experiences and interests to drive lessons.
5. Encourage the use of alternative sources for information both from written materials and experts.
6. Encourage students to suggest causes for event and situations and encourage them to predict consequences.
7. Seek out student ideas before presenting teacher ideas or before studying ideas from textbooks or other sources.
8. Encourage students to challenge each other's conceptualizations and ideas.
9. Encourage adequate time for reflection and analysis; respect and use all ideas that students generate.
10. Encourage self-analysis, collection of real evidence to support ideas and reformulation of ideas in light of new knowledge.
11. Use student identification of problems with local interest and impact as organizers for the course.
12. Use local resources (human and material) as original sources of information

that can be used in problem resolution.

13. Involve students in seeking information that can be applied in solving real-life problems.
14. Extend learning beyond the class period, classroom and the school.
15. Focus on the impact of science on each individual student.
16. Refrain from viewing science content as something that merely exists for students to master on tests.
17. Emphasize career awareness--especially as related to science and technology.

Constructivist teachers refer to raw data, primary sources, and interactive materials to provide experiences for their students rather than relying solely on another's set of data. For teachers who have used only one printed text, a shift to other sources may take some adjustment. For example, rather than read about the census, students examine and interpret census data. Or better yet, they plan a mini-census, gather their own data, and interpret the results.

Constructivism is not about teaching at all. It is about knowledge and learning. It might be asked about the teaching, which results from such a view of learning. It is possibly this, which is meant when the term 'constructivist teaching' is coined, it is not pedantic to question its use. And the constructivist view involves two principles: Knowledge is actively constructed by the learner, not passively received from the environment; coming to know is a process of adaptation based on and constantly modified by a learner's experience of the world (Jaworski,1993).

Pupils come to science lessons with ideas about the natural world. Effective science teaching takes account of these ideas and provides activities which enable pupils to make the journey fom their current understanding to a more scientific view (Driver, Squires, Rushworth and Robinson, 1994). At present, constructivism is a popular idea associated with teaching and learning science. This notion is used to explain learning, guide instructional practices, and conduct research. The central point is that humans construct knowledge being transmitted into their minds. Constructivism stressses the importance of considering what is already in the learner’s mind as a place to initiate instruction. Learning is regarded as an active process whereby students construct personal meaning of the subject matter through their interactions with the physical and social world. It is the student who makes sense out of the experiences. Knowledge is not just out there in textbooks and in teachers’ heads ready to be transferred into the minds of the students. Instead, “out there” is where one finds information and experinces, which are formed by the mind into durable knowledge. The learning process is facilitated by the skilled teacher who engages students in thinking, questioning, testing ideas, explaining, and representing ideas. As stated in the quote above, effective science teaching must take into account what students know, then modify this knowledge so that it reflects scientific views.

2.1.3. 5E Learning Cycle Approach

The philosophy about learning, that proposes learners need to build their own understanding of new ideas, has been labeled constructivism. Much has been researched and written by many eminent leaders in the fields of learning theory and cognition. Scholars such as Jean Piaget, Eleanor Duckworth, George Hein, and Howard Gardener have explored these ideas in-depth. The Biological Science Curriculum Study (BSCS), a team whose Principal Investigator is Roger Bybee developed an instructional model for constructivism, called the "Five Es". Briefly, this learning approach as it relates to science can be summarized as follows: Learning something new, or attempting to understand something familiar in greater depth, is not a linear process. In trying to make sense of things we use both our prior experience and the first-hand knowledge gained from new explorations.

Designed primarily by science educators for secondary science teaching, the 5E model has a classic constructivist structure. Trowbridge, Bybee and Powell (1990) envision a five-phase model in which learners begin to investigate phenomenon and eventually complete the learning cycle by creating conceptions, theories and generalizations based on their work. First used as an inquiry lesson-planning model in the Science Curriculum Improvement Study (SCIS) program, a K-6 science program in the early 1970s, the early learning cycle model had 3 stages (exploration, invention, and discovery) proposed by Karplus and Thier (1967). Using the learning cycle approach, the teacher "invents" the science concept of the lesson in the 2nd stage (rather than defining it at the outset of the lesson as in the traditional approach). The introduced concept subsequently enables students to incorporate their exploration in the 3rd stage and apply it to new examples. Many examples of learning cycles have been described in the literature (Barman, 1989; Ramsey, 1993; also see Osborne and Wittrock, 1983). The 5E Learning Cycle is used in the new BSCS science programs as well as in other texts and materials.

The five phases, whose titles capture the essence of the students' actions, are listed as follows:

- **ENGAGEMENT**
- **EXPLORATION**
- **EXPLANATION**
- **ELABORATION**
- **EVALUATION**

1.Engagement: In most instances the teacher will want to begin with "Engagement". In this stage teacher want to create interest and generate curiosity in the topic of study; raise questions and elicit responses from students that will give teacher an idea of what they already know. This is also a good opportunity for the teacher to identify misconceptions in students' understanding. During this stage students should be asking questions (Why did this happen? How can I find out?) Examples of engaging activities include the use of children's literature and discrepant events.

Learner	**Teacher**
calls up prior knowledge	poses problems
has an interest	asks questions
experiences doubt or disequilibria	reveals discrepancies
has a question(s)	causes disequilibria or doubt
identifies problems to solve, decisions to be made, conflicts to be resolved	assess prior knowledge

2. Exploration: During the "Exploration" stage students should be given opportunities to work together without direct instruction from the teacher. Teacher should act as a facilitator helping students to frame questions by asking questions and observing. Using Piaget's theory, this is the time for disequilibria. Students should be puzzled. This is the opportunity for students to test predictions and hypotheses and/or form new ones, try alternatives and discuss them with peers, record observations and ideas and suspend judgment.

Learner	**Teacher**
hypothesizes and predicts	questions and probes
explores resources and materials	models when needed
designs and plans	makes open suggestions
collects data	provides resources
builds models	provides feedback
seeks possibilities	assesses understandings and processes
self reflects and evaluates	

3. Explanation: During explanation, teacher should encourage students to explain concepts in their own words, ask for evidence and clarification of their explanation, and listen critically to one another's explanation and those of the teacher. Students should use observations and recordings in their explanations. At this stage teacher should provide definitions and explanations using students' previous experiences as a basis for this discussion.

Learner	Teacher
clarifies understandings	provides feedback
shares understandings for feedback	asks questions, poses new problems and issues
forms generalizations	models or suggests possible modes
reflects on plausibility	offers alternative explanations
seeks new explanations	enhances or clarifies explanations
employs various modes for explanation (writing, art, etc)	evaluates explanations

4. Elaboration: During "Elaboration" students should apply concepts and skills in new (but similar) situations and use formal labels and definitions. Remind students of alternative explanations and to consider existing data and evidence as they explore new situations. Elaboration strategies apply here as well because students should be using the previous information to ask questions, propose solutions, and make decisions, experiment, and record observations.

5. Evaluation: Evaluation should take place throughout the learning experience. Teacher should observe students' knowledge and/or skills, application of new concepts and a change in thinking. Students should assess their own learning. Ask open-ended questions and look for answers that use observation, evidence, and previously accepted explanations. Ask questions that would encourage future investigations.

The learning cycle is an inquiry approach originating with the Science Curriculum Improvement Study (Trowbridge and Bybee, 1990). Robert Karplus and his colleagues based the learning cycle format on Piaget's cognitive development principles. Students "learn through their own involvement and action…the goal is to allow students apply previous knowledge, develop interests, and initiate and maintain a curiosity toward the materials at hand" (Trowbridge and Bybee, 1990).

Bevevino, Dengel and Adams (1999) implies that using the learning cycle format, the teacher can create a series of activities that are personally meaningful for students and give students opportunities to practice critical thinking skills. In this inquiry format, the students first tackle a teacher-created problematic situation by conceptualizing questions, constructing hypotheses, and reaching consensus on solutions. Next, they discuss and debate their proposed solutions with the class. Finally they apply their contextualized insights to an important historical issue, researching and analyzing events and societal conditions of the time, proposing solutions to the controversial issue and deciding on the best solutions. The teacher acts as a catalyst, encouraging students to propose hypotheses and to analyze the validity of previously gained personal and academic knowledge. By offering suggestions for problem solving and for shaping the learning cycle itself, he or she also encourages the students to reflect on the process. The teacher's job is to nurture divergent solutions and to help students to recognize and expand their ability to think critically. Bybee (1990) observed that many educators are confronted with the task of facilitating development from concrete to formal levels of thought. To do so requires educators to understand the major differences between the two stages. Since both concrete and formal periods are concerned with logical thought, what are some basic differences between the periods? There are two differences. In the formal operational period, mental action no longer requires actual objects, events or situations. For students (at the concrete level), the realm of the possible is real.

Several key studies have compared the learning cycle approach with traditional approaches. Pavelich and Abraham (1979) concluded that the learning cycle approach more accurately reflects scientific inquiry processes than traditional approaches. Students distinguish the learning cycle approach from traditional approaches in the following ways: (a) the learning cycle approach emphasizes the explanation and investigation of phenomena, the use of evidence to back up conclusions, and the designing of experiments. (b) Traditional apprroaches emphasze the development of skills and techniques, and receiving of information, and the knowing of the outcome of an experiment before doing it (Abraham, 1982).

Another researchers Ward and Herron (1980) summarized their studies as using the learning cycle approach, formal operational students learn both concrete and formal concepts better than concrete operational students. For concrete operational students, the learning cycle approach is superior to traditional approaches in content achievement.

Formal operational students learn equally well with learning cycle or traditional approaches (Ward and Herron, 1980). Schneider and Renner (1980) also have studies about learning cycle approach. They concluded that for concrete operational students, learning cycle approach is superior to traditional approaches in intellectual development gains. The learning cycle approach is superior to traditional approaches in the retention of gains of content achievement.

Studies show that 5E Learning Cycle approach is also an effective teaching strategy in enhancing students understanding and achievement. Bevenino, Dengel and Adams (1999) have explored 5E learning Cycle approach in their study. After their study they conclude that 5E Learning Cycle approaches encourage students to develop their own frames of thought and it is effective in the classroom. Colburn and Clough also supports the 5E learning cycle as an effective way to help students enjoy science, understand content, and apply scientific processes and concepts to authentic situations. The 5E learning cycle is a great strategy for middle school and high school science teaching because it works, is flexible, and places realistic demands on teachers and students.

Lord (1999) published a study that compared two classes taught by traditional methods with two classes taught with 5E Learning Cycle method. The traditional classes were teacher-centered and taught in lecture fashion. 5E Learning Cycle method used involved small heterogeneous groups who worked on thought-provoking scenarios and critical thinking questions or constructed concept maps. The study showed that the experimental groups had much greater understanding of the information covered especially on questions that required interpretation. "The students taught with the 5E Learning Cycle method understood the course material in a much deeper, more comprehensive way" (Lord, 1999, 26). There was a significant difference in the feedback from the students. In the experimental group the vast majority of the students wrote positive comments about the course. In the control group only about half of the students wrote any response, and of the comments that were written few were positive.

Caprio (1994) published a study that compared a class which he taught with traditional (lecture) methodology in 1985 to one in which he taught with 5E Learning Cycle method in 1994. The students in both groups had the same prerequisites, and the same exam was used for comparison. The exam grades were much higher for the class taught with the constructivist methodology. "The control (traditional) group's average grade was 60.8 percent, while the experimental (5E Learning Cycle) group averaged 69.7 percent" (Caprio, 1994, 212). In addition to the test scores, the experimental group had a high energy level and gave positive feedback on the course.

5E Learning cyle is not only effective in enhancing stundents understanding and achievement; it also enhances teachers' classroom behaviors. Marek, Eubanks and Gallaher (1990) examined the relationship that exits between high school science teachers' understanding of the Piagetian developmental model of intelligence, its inherent teaching procedure – the 5E learning cycle – and classroom teaching practices. The teachers observed in the study had expressed dissatisfaction with the teaching methods they used, and, subsequently, attended a National Science Foundation sponsored in-service-program designed to examine laboratory-centered science curricula and the educational and scientific theories upon which the curricula were based. The teachers who exhibited a sound understanding of the Piagetian model of intelligence and the learning cycle were able to successfully integrate their students' laboratory experiences with class discussions to construct science concepts.

2.2 Traditional Instruction

What are the underpinnings for a constructivist learning setting and how do they differ from a classroom based on the traditional model (sometimes referred to as the objectivist model)? Classes are usually driven by "teacher-talk" and depend heavily on textbooks for the structure of the course. There is the idea that there is a fixed world of knowledge that the student must come to know. Information is divided into parts and built into a whole concept. Teachers serve as pipelines and seek to transfer their thoughts and meanings to the passive student. There is little room for student-initiated questions, independent thought or interaction between students. The goal of the learner is to regurgitate the accepted explanation or methodology expostulated by the teacher (Caprio, 1994). It is becoming a common idea that traditional method is ineffective in qualitative learning.

2.3 Constructivist Teaching vs. Traditional Teching

The following is a checklist that a teacher can utilize to determine the degree of constructivist learning in their classroom vs. a more traditional, objectivist approach (Yager, 1991, p. 56).

More Objectivist		More Constructivist
Teacher	Identifies the issue/topic	Student
No	Issue is seen as relevant	Yes
Teacher	Asks the questions	Student
Teacher	Identifies written and human resources	Student
Teacher	Locates written resource	Student
Teacher	Contacts needed human resource	Student
Teacher	Plans investigation and activities	Student
No	Varied evaluation techniques used	Yes
No	Students practice self-evaluation	Yes
No	Concepts and skills applied to new situations	Yes
No	Students take action(s)	Yes
No	Science concepts and principles emerge because they are needed	Yes
No	Extentions of learning outside the school is evidence	Yes

After the related literature, it can be easily seen that students shoud be given the freedom to understand and construct meaning at their own pace through challenging personal experiences as they develop through individual developmental process and peer interactions and social negotiations should be encouraged in the classroom. The acid-base topic includes the concepts which seem to be difficult for students, because this topic includes both abstract and theoretical concept. So, 5E learning Cycle should be applied as an instructional method for better understanding in chemistry classes. In this study, we aimed to determine the effect of constructivist approach on students' understanding of acid-base concepts and their attitudes toward chemistry as a school subject when their science process skill was taken as a covariate.

CHAPTER III

PROBLEMS AND HYPOTHESES

3.1 The Main Problem and Subproblems

3.1.1 The Main Problem

The purpose of this study is to compare the effectiveness of 5E learning cycle model over traditionally designed chemistry instruction on 10th grade students' understanding of acid-base concepts and attitudes toward chemistry as a school subject.

3.1.2 The Subproblems

1. Is there a significant mean difference between the effects of instruction based on 5E learning cycle model and traditionally designed chemistry instruction on students' understanding of acid-base concepts when science process skill is controlled as a covariate?

2. What is the contribution of students' science process skills to their understanding of acid- base concepts?

3. Is there a significant mean difference between students taught through instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to their attitudes toward chemistry as a school subject?

3.2 Hypotheses

$H_0$1: There is no significant difference between post-test mean scores of the students taught with instruction based on 5E learning cycle model and students taught with traditionally designed chemistry instruction in terms of acid-base concepts when science process skill is controlled as a covariate.

$H_0$2: There is no significant contribution of students' science process skills to understanding of acid-base concepts.

$H_0$3: There is no significant mean difference between students taught with instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to their attitudes toward chemistry as a school subject.

CHAPTER IV

DESIGN OF THE STUDY

4.1 The Experimental Design

In this study, the quasi experimental design was used (Gay,1987).

Table 4.1 Research design of the study

Groups	**Pre-test**	**Treatment**	**Post-test**
Experimental Group	ABCAT ASTC SPST	IBLCM	ABCAT ASTC
Control Group	ABCAT ASTC SPST	TDCI	ABCAT ASTC

Here, ABCAT represents Acid-Base Concepts Achievement Test. IBLCM is Instruction based on 5E Learning Cycle Model and TDCI is Traditionally Designed Chemistry Instruction. SPST refers to Science Process Skill Test. ASTC represents Attitude Scale Toward Chemistry.

4.2 Subjects of the Study

This study consisted of 56 10th grade students (27 male and 29 female) from two classes of a Chemistry Course from Atatürk Anatolian High School taught by the same teacher in the 2003-2004 spring semester. Two instruction methods used in the study were randomly assigned to groups. The data analyzed for this research were taken from 28 students participating instruction based on 5E learning cycle model and 28 students participating in the traditionally designed chemistry instruction.

4.3 Variables

4.3.1 Independent Variables:

The independent variables were two different types of treatment; instruction based on 5E learning cycle model and traditionally designed chemistry instruction, gender and science process skill.

4.3.2 Dependent Variables:

The dependent variables were students' understanding of acid-base concepts and their attitudes toward chemistry as a school subject.

4.4 Instruments

4.4.1 ACID-BASE Concepts Achievement Test (ABCAT):

This test developed by the researcher. The test contained 30 multiple choice questions. Each question had one correct answer and four distracters.

The items used in the test were related to acid-base concepts. They were selected from the previous questions of OSS which was prepared by OSYM. During construction of items, care was taken to eliminate any extraneous factors that might prevent the students from responding. We tried to get the items that measure achievement of the specific learning outcomes. Table of specification of the ABCAT is given in Appendix G. The language of the test was Turkish, because chemistry course was instructed in Turkish.

During the developmental stage of the test, the instructional objectives of acid-base concepts were determined (See Appendix A) to find out whether the students achieved the behavioral objectives of the course and present study. The items in the test were chosen according to the instructional objectives and were designed in such a manner that each of them examine students' knowledge of acid-base concept. A pilot study was conducted in two 10th grade classrooms of Yüce College in Ankara.

The reliability of the test was found to be 0.72. This test was given to students in both groups as a pre-test to control students' understanding of acid-base concepts at the beginning of the instruction. It was also given to both groups as a post-test to compare the effects of two instructions (IBLCM & TDCI) on understanding of acid-base concepts. (See Appendix B)

The items were assessed by the classroom teacher, a group of experts in science education and chemistry and for the appropriateness of the items for the purpose of the investigation and representativeness of the acid-base unit of chemistry course.

4.4.2 Attitude Scale Toward Chemistry (ASTC)

This scale was developed by Geban et al. (1994) to measure students' attitudes toward chemistry as a school subject. This instrument consisted of 15 items in 5 point likert type scale (fully agree, agree undecided, partially agree, fully disagree). The reliability was found to be 0.83. It was given to all students in both groups as a pre-test and post-test. (see Appendix C).

4.4.3 Science Process Skill Test (SPST)

The test was originally developed by Okey, Wise and Burns (1982). There are 36 items in the test. It includes five subsets designed to measure the different aspects of science process skills. These are intellectual abilities of students related to identifying variables, identifying and stating the hypotheses, operationally defining, designing investigations and graphing and interpreting data. It was translated and adapted into Turkish by Geban, Aşkar and Özkan (1992). It was given to all students in the study. The reliability coeficient of the test was found to be 0.81. (see Appendix D).

4.5 Treatment

This study was conducted approximately four weeks during the 2003-2004 spring semester. One of the classes was assigned as the experimental group instructed through 5E learning cycle model, and the other group was assigned as the control group instructed through traditional instruction. Both groups were instructed by the same teacher on the same content of the chemistry course. The teacher was trained about the implementation of the constructivist strategy before the treatment. The researcher observed classes in the control and experimental groups randomly.

During the instruction, the acid-base concepts were covered as conducted in the Ministry of National Education's curriculum. The classroom instruction of the groups was regularly scheduled as three times per week in which each teaching session lasted 40 minutes.

This study was done using a pre-test and post-test control group design (Campbell and Stanley, 1966) with Acid-Base Concepts Achievement Test and Attitude Scale Toward Science, which was distributed to measure students' attitudes toward chemistry as a school subject. Also, at the beginning of the treatment Science Process Skill Test was given to all students in the study to determine whether there would be a significant difference between the groups with respect to their reasoning abilities.

In the control group, the teacher directed strategy represented the traditional approach used on the course. The students were instructed with traditionally designed chemistry texts. During the classroom instruction, the teacher used lecture and discussion methods to teach science subjects. Also, the students in the control group were provided with worksheets. Each worksheet consisted of one or two pages that included questions to be answered, tables to be completed or space for students to make sketches. The teacher roamed the room, answered some questions and made suggestions when needed. Worksheets were corrected and scored and the students investigated their sheets after correction.

The experimental group was instructed by using the 5E learning cycle model. According to this strategy, Bybee's 5E phases were arranged in a manner that meaningful learning occurs for the acid-base concepts. As a first phase (engagement), the teacher made demonstrations and asked students some questions at the beginning of the instruction in order to create interest and generate curiosity in the topic of study; raise questions and elicit responses from students that will give you an idea of what they already know. As a second phase (exploration), students were allowed to discuss the question in groups by using their previous knowledge related to acid-base concepts. During these discussions the teacher let the student manipulate materials to actively explore concepts, processes or skills. She was the facilitator and observed and listened to students as they interact.Each group gave a common answer to the teacher after discussion. In this way, the teacher had an opportunity to view the students' previous ideas. As a third phase (explanation), based on the students' answers, she explained the concept using students' previous experiences. She presented scientifically correct explanation by using examples from daily life in order to make concepts more concrete. For example, she explained "The Uses of Acid, Alkali and Neutralisation in Daily Life" in a session. As a fourth phase (elaboration) students worked in groups again and in laboratory. The purpose of the teacher was to extend conceptual understanding; practice desired skills; deepen understanding. For example, students compared acid and base solutions in a laboratory activity. As a fifth phase (evaluation) the teacher encouraged students to assess understanding and abilities; and evaluated their learning**.** Before presenting each new concept, the teacher asked questions which students could answer by using their previous knowledge. Some questions were: Sometimes people suffer from heartburn and they take a medicine called 'antacid'. Can you guess how antacids help the stomach? We have observed some properties of acids. Can you think of how we can use this knowledge in practice? Can it be useful in our daily life? What would happen if we dropped acid without water onto the same samples? Would you be able to observe the same properties? Why does red litmus paper change to blue in some of the solutions and not in the others? What are the characteristics of the solutions that change red litmus paper to blue? At the end of the sessions all the students always got the answers of the questions.

4.6 Analysis of Data

ANCOVA was used to compare the effectiveness of two different instructional methods related to acid-base concepts by controlling the effect of students' science process skills as a covariate. Also this statistical technique identified the contribution of science process skills to the variation in achievement. Independent t-test statistics was used to compare the effect of treatment on students' attitudes toward chemistry as a school subject.

4.7 Assumptions and Limitations

The assumptions and limitations of the study are listed below:

4.7.1 Assumptions:

1. There was no interaction between the students in the IBLCM and those in TDCI.
2. The teacher who administered the treatment was not biased.
3. The tests were administered under standard conditions.
4. All subjects' responses to the items in the instruments used in the study were sincere.

4.7.2 Limitations:

1. This study was limited to the unit of acid-base subject.
2. This study was limited to 10th grade students of an Anatolian high school.
3. This study was limited to 56 students in two classes.

CHAPTER V

RESULTS AND CONCLUSIONS

5.1 Results

This chapter presents the results of analyses of hypotheses stated in Chapter 3. The hypotheses were tested at a significance level of 0.05. Analysis of covariance (ANCOVA) and t-test were used to test the hypotheses. In this study, statistical analyses were carried out by using the SPSS/PC (Statistical Package for Social Sciences for Personal Computers) (Noruis, 1991).

The results showed that there was no significant difference at the beginning of the treatment between the IBLCM group and the TDCI group in terms of students' achievement of acid-base concepts ($t = -1,136$, $p>0.05$). With respect to students' attitudes toward chemistry, no significant difference was found between the two groups, either ($t =- 0,015$ $p >0.05$).

Table 5.1 Means of the Instruments

	Groups	N	$\overline{X}$ pre-test	post-test
Achievement	IBLCM	28	11.964	19.286
	TDCI	28	13.857	18.036
Attitude	IBLCM	28	56.892	57.750
	TDCI	28	56.928	57.214
Science Process Skill	IBLCM	28	24.286	
	TDCI	28	25.321	

Hypothesis 1:

To answer the question posed by hypothesis 1 stating that there is no significant difference between the post-test mean scores of the students taught by IBLCM and those taught by TDCI with respect to achievement related to acid-base concepts, when science process skill is controlled as a covariate, analysis of covariance (ANCOVA) was used. The measures obtained are presented in Table 5.2.

Table 5.2 ANCOVA Summary (Achievement)

Source	df	SS	MS	F	P
Covariate (Science Process Skill)	1	27.796	27.796	4.062	0.048
Treatment	1	26.590	26.590	1.016	0.032
Error	51	1334,206	26.161		

The result showed that there was a significant difference between the post-test mean scores of the students taught by IBLCM and those taught by TDCI with respect to the acid-base concepts. The IBLCM group scored significantly higher than TDCI group ($\overline{X}$ (IBLCM) = 19,286 $\overline{X}$ (TDCI) = 18.036).

Table 5.3 shows the percentages of students' correct responses in the post-test.

Table 5.3 Percentages of students' correct responses in the post-test

Item	Experimental Group Post-test (%)	Control Group Post-test (%)
1	89.3	85.7
2	75	67.9
3	92.9	89.3
4	85.7	96.4
5	100	92.9
6	92.9	92.9
7	100	89.3
8	92.9	100
9	96.4	85.7
10	75	60.7
11	71.4	50
12	82.1	60.7
13	71.4	35.7
14	53.6	25

Table 5.3 Continued

Item	Experimental Group Post-test (%)	Control Group Post-test (%)
15	71.4	60.7
16	82.1	46.4
17	78.6	50
18	78.6	57.1
19	78.6	85.7
20	82.1	53.6
21	57.1	42.9
22	76.6	71.4
23	67.9	39.3
24	60.7	39.3
25	53.6	35.7
26	82.1	60.7
27	53.6	35.7
28	50	35.7
29	28.6	25
30	57.1	32.1

As seen in the table, there were differences in responses between the two groups to the items in ABCAT. The differences in responses of questions, 13, 14, 16, 23 and 27 were greater among the other questions after the treatment. In question 13, students were asked to identify the properties of the acids and bases by using the amount of $[OH^-]$ in the solutions. They were supposed to find the pH of the solutions, decide the strength of the solutions and the colour change in litmus paper when immersed into these solutions.

Before treatment, 25% of the experimental group students and 50% of the control group students responded this question correctly. After treatment, 71.4% of the students taught by the IBLCM, seemed to develop their critical thinking. On the other hand, 35.7% of the students taught by TDCI responded this question correctly.

In question 14, students were asked to choose the correct by using the amount of $[H^+]$ in the solutions. Before treatment, 7.1% of the experimental group students and 21.4% of the control group students responded correctly to this question. After treatment, 53.6% of the students in the IBLCM group responded this question correctly which means that they had a better sense of understanding in the conductivity of the acid and base solutions, the strength of acid solutions and the acid-base reactions.

Question 16 was related to neutralization reactions. Although TDCI group students showed high achievement for this question before the treatment, IBLCM group students showed higher achievement after the treatment. Before treatment, 60.7% of the control group students and 35.7% of the experimental group students responded it correctly. And the average correct response percentage after the treatment was 82.1% in the experimental group and 46.4% in the control group. So, we can conclude that the experimental group students undestood the neutralization reactions better than the control group. One reason why control group students' achievement decreased may be that there is a possibility of selecting the correct alternative by purely guessing.

In question 23, before treatment, 39.3% of the experimental group students and 25% of the control group students responded it correctly. After treatment, 39.3% of the control group students responded this question correctly. On the other hand, 67.9% of the control group students responded it correctly. This shows that students in experimental group were able to identify and acid or a base by using their physical and chemical properties and give examples of acids and bases.

In question 27, problem solving skills were again assessed. Before treatment, the average correct response percentage was 21.4% in the experimental group and 35.7% in the control group. And the average correct response percentage after the treatment was 53.6% in the experimental group and 35.7% in the control group. As it's seen there is no difference in the control groups' response percentage after the instruction. Most students in the experimental group increased their achievement in problem solving skills. The percentages of students' correct responses in the pre-test and post-test for questions 13, 14, 16, 23 and 27 is given in Table 5.4:

Table 5.4 Percentages of students' correct responses in the pre-test and post-test for questions 13, 14, 16, 23 and 27

Item	Experimental Group		Control Group	
	Pre-test (%)	**Post-test (%)**	**Pre-test (%)**	**Post-test (%)**
13	25	71.4	50	35.7
14	7.1	53.6	21.4	25
16	35.7	82.1	60.7	46.4
23	39.3	67.9	25	39.3
27	21.4	53.6	35.7	35.7

In IBLCM group, the average correct response percentage was 39.2% before treatment and 74.6% after treatment. The greatest improvement was observed in questions 2, 5, 7 and 14. In question 2, the average correct response percentage was 3.6% before instruction and 75% after instruction. The question was related with the examples of acid-base reactions. Question 5 was related with pH orientation of solutions. Before treatment 67.9% of the students responded it correctly and after treatment 100% of the students responded the question correctly. Question 7 was also related with pH orientation of solutions. The average correct response percentage was 64.3% before instruction and 100% after instruction. This shows that the experimental group students understood pH orientation of the solutions very well. Question 14 was related with strength of the acids. And the average correct response percentage increased from 7.1% to 53.6% after treatment. Poorer students' results were obtained in question 29. In question 29, students were supposed to answer the sub-alternatives about acidity constant, molarity and strength of acids. Before treatment 14.3% of the students responded it correctly and after treatment 28.6% of the students responded it correctly. The percentages of experimental group students' correct responses in the pre-test and post-test for questions 2, 5, 7, 14 and 29 is given in Table 5.5:

Table 5.5 Percentages of experimental group students' correct responses in the pre-test and post-test for questions 2, 5, 7, 14 and 29

	Experimental Group	
Item	**Pre-test (%)**	**Post-test (%)**
2	3.6	75
5	67.9	100
7	64.3	100
14	7.1	53.6
29	14.3	28.6

In the TDCI group, the average correct response percentage was 46.2% before treatment and 60% after treatment. It is seen that the average correct response percentage improvement between pre-test and post-test is not as much as in the experimental group. The greatest improvement was observed in questions 2, 8, 10, 18 and 28, which were related with type of solutions, examples of acid-base reactions and pH orientation of a solution. And, poorer student results were obtained in questions 13, 14, 16, 17, 20, 25 and 29, which were related with strength of acids and bases, conductivity of acid and base solutions and neutralization reactions. The percentages of control group students' correct responses in the pre-test and post-test for questions 2, 8, 10, 13, 14, 16, 17, 18, 20, 25, 28 and 29 are given in Table 5.6:

Table 5.6 Percentages of experimental group students' correct responses in the pre-test and post-test for questions 2, 8, 10, 13, 14, 16, 17, 18, 20, 25, 28 and 29

	Control Group	
Item	**Pre-test (%)**	**Post-test (%)**
2	7.1	67.9
8	75	100
10	39.3	60.7
13	50	35.7
14	21.4	25
16	60.7	46.4
17	64.3	50
18	17.9	57.1
20	57.1	53.6
25	39.3	35.7
28	-	35.7
29	32.1	25

So, we can conclude that the instruction based on 5E learning cycle model group students understood the acid-base concepts significantly better than the traditionally designed chemistry instruction group students. The IBLCM group and TDCI group students' correct response percentages of each question in ABCAT is presented in Appendix F

Hypothesis 2:

To analyze hypothesis 2 stating that there is no significant contribution of science process skill to variation in students' achievement related to acid-base concepts, science process skill was used as a predictor and covariate in ANCOVA model. Table 5.1 also represents the contribution of science process skill to achievement. F value indicated that there was a significant contribution of science process skills on students' understanding of acid-base concepts ($F = 4.062$; $p < 0.05$).

Hypothesis 3:

To answer the question posed by hypothesis 3 stating that there is no significant mean difference between the students taught with instruction based on constructivist approach and traditionally designed chemistry instruction with respect to their attitudes toward chemistry as a school subject, t-test was used. Table 5.7 summarizes the result of this analysis.

Table 5.7 The Result of t-test Analysis for Group Comparison with Respest to Attitude Scale Toward Science as a School Subject

Group	n	X	s	df	t-value	p
IBLCM	28	57.75	8.20		0.253	0.801
TDCI	28	57.21	7.62	54		

The results showed that there was no significant mean difference between students taught through instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to attitudes toward chemistry as a school subject. Students in both groups showed statistically equal development in attitude toward science as a school subject.

5.2 Conclusions

The following conclusions can be drawn from the results:

1. The instruction based on 5E learning cycle model caused a significantly better acquisition of scientific conceptions related to acid-base concepts than traditionally designed chemistry instruction.
2. No statistically significant mean difference was found between the experimental and control group in terms of attitude.
3. Science process skill was a strong predictor for the achievement of acid-base concepts.

4. The pre and post scores of Acid-Base Concepts Achievement Test shows that both IBLCM and TDCI group's achievement was increased. Thus, it can be concluded that the growth in understanding of acid-base concepts is statistically significant. However, the increase in IBLCM group is higher.

CHAPTER VI

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

6.1 Discussion

The main purpose of this study was to compare the effectiveness of the instruction based on 5E learning cycle model and traditionally designed chemistry instruction on 10^{th} grade students' understanding of acid-base concepts.

The results of the study layed that the instruction based on 5E learning cycle model caused a significantly better acquisition of scientific conceptions related to acid-base concepts than traditionally designed chemistry instruction.

In this research, acid-base unit are studied. This topic includes abstract and theoretical concepts; therefore students have difficulty in understanding the acid-base concepts. So, it can be concluded that while teaching acid-base concepts, the teachers should make the scientific concepts as concrete as possible. Children's prior knowledge of phenomena is an important part of how they come to understand school science. Therefore, the teachers also should be more sensitive to children's prior knowledge. For this purpose, the present study used 5E Learning Cycle Model in the experimental group. By restructuring traditional learning activities into a 5E learning cycle sequence, students are motivated to find correct answers rather than convenient answers; engaged in a topic; explore that topic; are given an explanation for their experiences; elaborate on their learning and are evaluated. The main advantage of the constructivist instruction was that the students derived the scientific facts after long discussions with their peers; scientific facts were not narrated by the teacher as in the traditional instruction. Since students cannot discover all important ideas on their own, social interaction is a vital part of their educational excursion. Students benefit from discussions with teachers and interactions with peers who can help them to acquire new concepts. Further, students received information that has been organized by others, so long as it is meaningful to their way of thinking and knowing. In this way, the teacher also created a learning environment where students could use their prior knowledge and become aware of their already existing conceptions. During discussion with their peers, the students tried to make a connection between their existing knowledge and the new concept. They analyzed, interpreted, and predicted information. By this way they constructed knowledge actively, instead of receive it from the teacher passively. Teaching and learning was an interactive process that engaged the learners in constructing knowledge.

However, in the control group where traditionally designed chemistry instruction was used, the teacher transferred their thoughts and meanings to the passive students. In this group, the teacher used a lecture method in instruction. She provided information without considering students' prior knowledge and checked whether students have acquired it or not. Students listened to their teacher, took motes, studied their textbooks and completed the worksheets. One reason why the students in this group were not so successful as the experimental group students might be due to the fact that they were not given any opportunity to develop their thinking, reasoning and communication skills. They didn't become more confident in their understanding of science. Meaningful learning occurs if students construct their own knowledge and apply this new knowledge.

The present study is consistent with the literature. Lorsbach and Tobin (1997) believed that one way to make sense of how students learn is through constructivism. Constructivism is an epistemology, a theory of knowledge used to explain how we know what we know. A constructivist epistemology is useful to teachers if used as a referent; that is, as a way to make sense of what they see, think, and do. And Driver, Squires, Rushworth and Wood-Robinson (1994) claims that constructivism stressses the importance of considering what is already in the learner's mind as a place to initiate instruction. Learning is regarded as an active process whereby students construct personal meaning of the subject matter through their interactions with the physical and social world. It is the student who makes sense out of the experiences. Knowledge is not just out there in textbooks and in teachers' heads ready to be transferred into the minds of the students. Instead, “out there” is where one finds information and experinces, which are formed by the mind into durable knowledge. The learning process is facilitated by the skilled teacher who engages students in thinking, questioning, testing ideas, explaining, and representing ideas. So, it can be concluded that the experimental group in this study were provided for meaningful learning to be occur. After the results are assessed, it is seen that there is a significant mean difference between the experimental and control group. Both groups of students increased their understanding in the acid-base concept as expected, but the improvement is greater in the experimental group.

Furthermore, this study investigated the effect of instruction based on 5E learning cycle model and traditionally designed chemistry instruction on students’ attitudes towards chemistry as a school subject. Altough, instruction based on 5E learning cycle model, focused on students’ ideas, encouraged students to think about situations, there was no significant mean difference between the students taught with instruction based on 5E learning cycle model and traditionally designed chemistry instruction with respect to their attitudes toward chemistry as a school subject. One reason why students have not shown more positive attitude toward science from instruction based on 5E learning cycle model may be that instructional time using this tecnique was not sufficient for the students to adapt and be effective in a new technique. In order to have more positive attitude, 5E learning cycle model can be used throughout the whole science concepts.

To sum up, this study showed that 5E learning cycle model is an effective teaching method. 5E learning cycle model can provide teachers with many insights into how students can learn about and appreciate science. 5E learning cycle model is useful not only improving achievement but also they help students construct their views about science and develop thinking ability.

6.2 Implications

Existing knowledge of the students gives a strong idea of students' achievement in science. In order for meaningful learning to occur, students should link between new and existing knowledge. So, this should be taken into account for an effective teaching. Students also should be given the opportunity to discuss the concepts, test predictions, and refine hypotheses. The 5E Learning Cycle Model as a constructivist approach is an effective way in terms of help students enjoy science, understand content, and apply scientific processes and concepts to authentic situations.

Students should be provided with disequilibrium with their existing conceptions, so that, they will have to rethink and try to reconstruct their knowledge.

Teacher should facilitate safe, guided or open inquiry experiences and questioning so students might uncover their misconceptions about the concept.

Teachers must be informed about the usage and importance of 5E Learning Cycle based on constructivist approach and they must plan the instructional activities accordingly. Curriculum programs should be based on the constructivist perspective.

Students' attitudes towards chemistry as a school subject should be considered while teaching science.

6.3 Recommendations

Based on the results, the researcher recommends that:

Similar research studies should be carried out for different grade levels and different science courses to investigate the effectiveness of 5E learning cycle model.

Further research studies can be conducted to investigate the effectiveness of 5E Learning Cycle approach in understanding science concepts in different schools.

This study can be carried out with greater groups to obtain more accurate results.

Other constructivist teaching strategies such as the Driver's constructivist teaching sequence or conceptual change model can be used.

This method can be compared with other instructional methods (problem solving, demonstration etc.)

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APPENDIX A

INSRTUCTIONAL OBJECTIVES

1. To identify an acid by using the physical properties.
2. To identify a base by using the physical properties.
3. To state the relation between acids and bases.
4. To clarify the stregth of acid solutions increases with the amount of H^+ ions in the solutions.
5. To clarify the stregth of base solutions increases with the amount of OH^- ions in the solutions.
6. To give examples for acidic substances in everyday life.
7. To give examples for basic substances in everyday life.
8. To explain that solutions with a pH less than 7 are acids and a solution with a pH more than 7 are bases.
9. To state that strength of an acid increases with a decrease in pH.
10. To state that strength of a base increases with a increase in pH.
11. To show that acids change blue litmus paper to pink and pink litmus paper remains the same.
12. To show that bases change pink litmus paper to blue and blue litmus paper remains the same.
13. To clarify that a solution with a pH = 7 is neither an acid nor a base but a neutral solution.
14. To identify that a acid-base reactions are neutralization reactions.

APPENDIX B

ACID- BASE CONCEPTS ACHIEVEMENT TEST

1. Amonyağın, NH_3, baz özelliği gösterdiğini açıklayan denklem aşağıdakilerden hangisidir?

A) $NH_{3(gaz)} \rightleftarrows NH_{3(sıvı)}$

B) $N_{2(gaz)} + 3H_{2(gaz)} \rightleftarrows 2NH_{3(gaz)}$

C) $2NH_{3(gaz)} + 5/2\ O_{2(gaz)} \rightleftarrows 2NO_{(gaz)} + 3H_2O_{(gaz)}$

D) $NH_{3(gaz)} + H_2O_{(sıvı)} \rightleftarrows NH^{+}_{4(suda)} + OH^{-}_{(suda)}$

E) $4NH_{3(suda)} + Cu(OH)_{2(suda)} \rightleftarrows [Cu(NH_3)_4]^{+2}_{(suda)} + 2OH^{-}_{(suda)}$

2. I. $2NH_3 + H_2S \rightarrow (NH_4)_2S$

II. $CO^{-2}_3 + 2H^+ \rightarrow H_2O + CO_2$

III. $Ag^+ + HCl \rightarrow AgCl + H^+$

tepkimelerinden hangisi asit-baz tepkimesidir?

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

3. Sulu çözeltilerinin özellikleri ile ilgili olarak,

I. pH = pOH = 7 ise çözelti nötrdür.

II. $[H^+] > 10^{-7}$ M ise, pH > 7 dir.

III. $[H^+] > [OH^-]$ ise, pH > 7 dir.

yargılarından hangileri doğrudur?

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

4. Aşağıdakilerden hangisinde, maddenin sulu çözeltisinin özelliği yanlış olarak verilmiştir?

Madde	Sulu çözeltisinin özelliği
A) HNO_3	Asidik
B) CH_3COOH	Asidik
C) NaOH	Bazik
D) NaCl	Nötr
E) NH_3	Nötr

5. 0.00001 M HCl çözeltisinin pH'ı kaçtır?

A) 10^{-5} **B)** –9 **C)** –5 **D)** 9 **E)** 5

6.

0.1 M çözelti	pH değeri
X	1
Y	8
Z	13

Tabloda pH değerleri verilen X, Y, Z çözeltileri için aşağıdakilerden hangisinde verilen sınıflandırma doğrudur ?

	X	Y	Z
A)	Kuvvetli asit	Zayıf baz	Kuvvetli baz
B)	Kuvvetli asit	Zayıf asit	Kuvvetli baz
C)	Kuvvetli baz	Zayıf baz	Kuvvetli asit
D)	Kuvvetli baz	Zayıf asit	Kuvvetli asit
E)	Kuvvetli asit	Nötr	Kuvvetli baz

7. Bir çözeltinin pH değeri 7'den 0'a doğru küçüldükçe asit özelliği, 7'den 14'e doğru büyüdükçe baz özelliği artar.X, Y, ve Z çözeltilerinden birinin kuvvetli asit, birinin zayıf asit, birinin de baz olduğu bilinmektedir. X'in pH değeri Y ninkinden küçük Z ninkinden ise büyüktür.

Buna göre X, Y ve Z çözeltileri kuvvetli asit, zayıf asit, baz olarak nasıl sınıflanabilir?

	Kuvvetli Asit	Zayıf Asit	Baz
A)	Z	X	Y
B)	Z	Y	X
C)	Y	X	Z
D)	Y	Z	X
E)	X	Y	Z

8. 25 ^{O}C de sulu bir çözelti için aşağıdaki ifadelerden hangisi yanlıştır ?

A) $[H^+] = [OH^-]$ ise, pH = 7 dir.

B) $[H^+] > 10^{-7}$ ise, pH < 7 dir.

C) $[OH^-] > [H^+]$ ise, pH < 7 dir.

D) $[OH^-] > 10^{-7}$ ise çözelti baziktir.

E) $[H^+] > [OH^-]$ ise çözelti asidiktir.

9. Aşağıdakilerden hangisi asitlerin genel özelliklerinden biri değildir?

A) Mavi turnusol kağıdının rengini kırmızıya çevirir.

B) Sulu çözeltilerinde OH^- iyonu bulundururlar.

C) Çözeltileri elektrolittir.

D) Seyreltik çözeltilerinin tadı ekşidir.

E) Sulu çözeltileri aktif metallerle tepkime verir.

10. I. $Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$

II. $Al_2O_3 + 6NaOH \longrightarrow 2Na_3AlO_3 + 3H_2O$

Al_2O_3 ün I ve II denklerimlerinde gösterilen tepkimelerine benzer tepkime veren metal oksitleri için aşağıdakilerden hangisi kesinlikle doğrudur?

A) Asitler ile indirgenirler.

B) Bazlar ile yükseltgenirler.

C) Asitlerle kompleks tuz oluştururlar.

D) Hem asidik hem bazik özellik gösterirler.

E) Peroksitler sınıfındadırlar.

11. Tablodaki X, Y, Z çözelti örneklerinden birinin kuvvetli asit, birinin zayıf asit, diğerinin ise kuvvetli baz olduğu bilinmektedir.

Çözelti	Elektrik iletkenliği	Birbiriyle etkileşimi
X	az	Y ile tepkime veriyor
Y	iyi	Z ile tepkime veriyor
Z	iyi	X ile tepkime vermiyor

Tablodaki bilgilere gore, bu çözeltiler aşağıdakilerden hangisinde doğru olarak sınıflandırılmıştır?

	Kuvvetli asit	Zayıf asit	Kuvvetli baz
A)	Z	X	Y
B)	Z	Y	X
C)	Y	X	Z
D)	X	Y	Z
E)	X	Z	Y

12. Bromtimol mavisi bir boyar maddedir ve asidik ortamda sarı, bazik ortamda mavi, nötr ortamda ise yeşil renk verir.

Bir kaptaki bromtimol mavisi damlatılmış 10 ml 0.1 M HCl çözeltisine 0.2 M NaOH çözeltisi azar azar ekleniyor.Bu işlemde kaptaki çözeltinin rengi ile ilgili aşağıdaki ifadelerden hangisi yanlıştır?

A) NaOH eklenmeden önce sarı

B) 2 ml NaOH eklendiğinde sarı

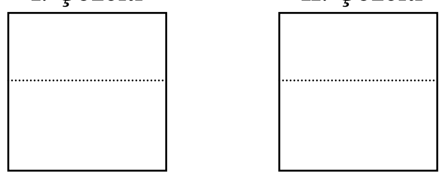
C) 5 ml NaOH eklendiğinde yeşil

D) 10 ml NaOH eklendiğinde yeşil

E) 20 ml NaOH eklendiğinde mavi

13. Şekilde verilen çözeltilerle ilgili aşağıdaki ifadelerden hangisi doğrudur?

I. Çözelti II. Çözelti



$[OH^-] = 1.10^{-12}$ M $[OH^-] = 1.10^{-2}$ M

A) I. çözelti asit, II. çözelti bazdır.

B) I. çözelti kuvvetli baz, II. çözelti zayıf bazdır.

C) I. çözeltinin pH değeri 12 dir.

D) I. çözeltide turnusolun rengi kırmızıdan maviye döner.

E) II. çözeltide turnusolun rengi maviden kırmızıya döner.

14. HX ve HY asitlerinin oda sıcaklığında eşit derişimli sulu çözeltileri hazırlanmıştır. HX çözeltisindeki H^+ derişimi, HY çözeltisindeki H^+ derişiminden büyüktür.

Bu çözeltilerle ilgili,

I. HX'in asitliği HY'ninkinden büyüktür.

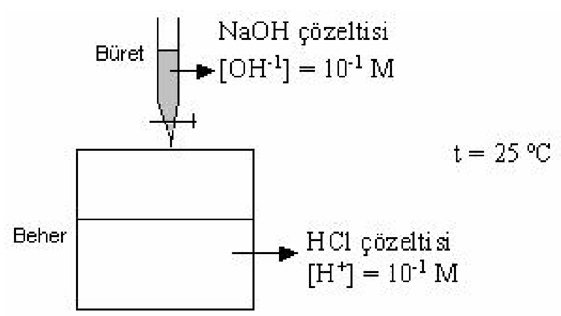
II. Elektrik iletkenliği aynıdır.

III. Eşit hacimlerini NaOH ile tamamen tepkimeye girmesi için eşit miktarlarda NaOH gerekir.

yargılarından hangileri doğrudur?

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

15.



H^+ iyonu derişimi 10^{-1}M olan HCl'in sulu çözeltisine, OH^- iyonu derişimi10^{-1}M olan NaOH nin sulu çözeltisi, şekildeki gibi damla damla katılıyor. Bu olay ile ilgili olarak;

I. Büretteki NaOH çözeltisinin pH değeri 1 dir.

II. Beherdeki çözeltinin pH değeri zamanla küçülür.

III. Beherdeki çözeltinin hacmi başlangıçtakinin iki katına ulaştığında H^+ iyonu derişimi 10^{-7} olur.

yargılarından hangileri doğrudur?

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

16. X çözeltisinde OH^- derişimi 10^{-3} M, Y çözeltisinde ise 10^{-11} M dir. X ve Y nin eşit hacimleri karıştırılınca pH değeri 7 olan bir karışım oluşuyor.

Bu çözeltiler için,

I. X zayıf, Y ise kuvvetli bazdır.

II. X in pH değeri 11, Y ninki ise 3 tür.

III. Oluşturdukları karışımda OH^- derişimi 10^{-7} M dir.

yargılarından hangileri doğrudur?

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

17. I. 50 mililitre 2.0 M NaOH

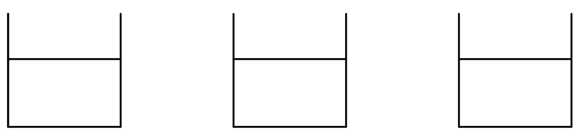
II. 50 mililitre 1.0 M NaOH

III. 100 mililitre 0.5 M NaOH

Çözeltilerinden hangileri, derişimi 1.0 M olan HCl çözeltisinin 50 şer mililitresi ile karıştırılırsa, pH değeri 7 olan çözelti elde edilir?

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

18.



0.1 M HCl 0.1 M NaOH 0.1 M NaCl

Şekildeki üç kabın her birinde sırasıyla HCl, NaOH ve NaCl nin 100 er mililitre eşit derişimli sulu çözeltisi vardır. Bu çözeltilere HCl nin 100 er mililitre 0.1 M sulu çözeltisi katılıyor.(t = 25 ^oC)

Bu çözeltilerin son durumdaki pH değerleri,

I. de 1 dir.

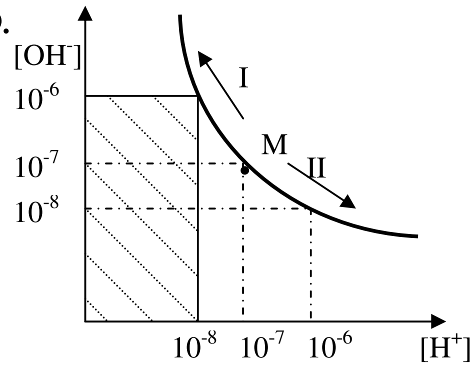
II. de 7 dir.

III. de 0.05 tir.

yargılarından hangileri doğrudur?

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

19.



Sulu çözeltilerin oda sıcaklığında H^+ ve OH^- molar derişimleri grafikteki gibidir. Bu grafiğe göre, aşağıdaki yargılardan hangisi yanlıştır? (Grafik ölçeksiz çizilmiştir.)

A) M noktasında çözeltiler nötr özellik gösterir.

B) I. ok yönünde çözeltilerin bazik özellikleri artar.

C) II. ok yönünde çözeltilerin asidik özellikleri artar.

D) Kesikli çizgi ile belirlenmiş taralı bölgenin alanı Ksu ya eşittir.

E) II. ok yönünde çözeltilerin pH değerleri artar.

20. Genel formülleri HX ve MOH olan asit ve bazların eşit derişimli çözeltilerinden, eşit hacimlerde alınarak aşağıdaki karışımlar oluşturuluyor.

Karışım	Özellik
I. Zayıf asit + Kuvvetli baz	bazik
II. Kuvvetli asit + Zayıf baz	asidik
III. Kuvvetli asit + Kuvvetli baz	nötr

Bu karışımlardan hangileri, karşısında verilen özelliği gösterir ?

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

21. Sulu çözeltilerinde CrO^{-2}_4 ve $Cr_2O^{-2}_7$ iyonları aşağıdaki denklemlerde görüldüğü gibi birbirlerine dönüşürler.

$2CrO^{-2}_4 + 2H^+ \longrightarrow Cr_2O^{-2}_7 + H_2O$

sarı renkli

$Cr_2O^{-2}_7 + 2OH^- \longrightarrow 2CrO^{-2}_4 + H_2O$

Turuncu renkli

Buna gore aşağıdakilerden hangisinde verilen maddelerin eşit derişimli sulu çözeltilerinin eşit hacimleri karıştırılırsa bir renk değişimi gözlenir?

A) K_2CrO_4; NaOH; KOH **B)** K_2CrO_4; H_2SO_4; HCl **C)** K_2CrO_4; NaOH; HCl

D) $K_2Cr_2O_7$; NaOH; H_2SO_4 **E)** $K_2Cr_2O_7$; H_2SO_4; HCl

22. HB ve XOH bileşiklerinin, sulu çözeltilerinde %100 iyonlaştıkları bilinmektedir. H^+ iyonları derişimi bu bileşiklerden,

HB ile hazırlanan çözeltide $1,0.10^{-3}$ M

XOH ile hazırlanan çözeltide ise $1,0.10^{-13}$ M dır.

Bu iki çözeltinin eşit hacimleri karıştırıldığında oluşan çözelti için aşağıdakilerden hangisinde verilen bilgi doğrudur?

A) pH = 7 dir.

B) $[H^+] = 5{,}0.10^{-4}$ M dır.

C) $[OH^-] = 1{,}0.10^{-10}$ M dır.

D) Baziktir

E) Nötrdür.

23. Asit ya da baz olduğu bilinen, eşit derişimli, I, II, III çözeltilerinin bazı özellikleri tabloda verilmiştir.

	Çözelti I	Çözelti II	Çözelti III
Cu'ya etkisi	Etkir	Etkimez	Etkimez
Elektrik iletkenliği	İyi iletken	Zayıf iletken	İyi iletken
Kendi aralarındaki tepkimeler	III ile tepkime verir.	I ile tepkime verir.	II ile tuz oluşturur.

I, II ve III sırasıyla aşağıdakilerden hangisinde verilen maddelerin çözeltileri olabilir?

A) H_2SO_4, NaOH, CH_3COOH

B) NaOH, H_2SO_4, CH_3COOH

C) H_2SO_4, CH_3COOH, NaOH

D) CH_3COOH, H_2SO_4, NaOH

E) CH_3COOH, NaOH, H_2SO_4

24. Bir HA asidi için $K_A = 4.10^{-7}$ dir. Bu asidin 0,1 M çözeltisinde $[H^+]$ kaç M dır?

A) 2.10^{-3} **B)** $6,3.10^{-4}$ **C)** 2.10^{-4} **D)** 4.10^{-6} **E)** 1.10^{-8}

25. 0.01 mol katı NaOH x gram NaOH

10 ml 2 M HCl 1 lt H_2O

I. kapta 10 mililitre 2 M lık HCl içersinde 0,01 mol katı NaOH çözünmektedir. II. kapta 1 litre suda X gram NaOH çözünmektedir. I. ve II. deki çözeltiler karıştırıldığında son çözeltinin pH'ı 7 olduğuna gore II. kapta kaç gram NaOH çözünmüş olur?

A) 0,2 **B)** 0,4 **C)** 0,6 **D)** 0,8 **E)** 0,1

26. Aşağıdaki tepkime denklemleri verilen maddelerin eşit derişimli sulu çözeltilerinden hangisinin pH si en yüksektir?

A) $HCl_{(suda)} \longrightarrow H^+_{(suda)} + Cl^-_{(suda)}$ (Kuvvetli asit)

B) $HF_{(suda)} \rightleftarrows H^+_{(suda)} + F^-_{(suda)}$ (Zayıf asit)

C) $CO_{2(suda)} + H_2O \rightleftarrows H^+_{(suda)} + HCO^-_{3(suda)}$ (Zayıf asit)

D) $NH_{3(suda)} + H_2O \rightleftarrows NH^+_{4(suda)} + OH^-$ (Zayıf baz)

E) $NaOH_{(suda)} \rightleftarrows Na^+_{(suda)} + OH^-_{(suda)}$ (Kuvvetli baz)

27. Bir zayıf asidin 0,01 M lik çözltisinin 100 ml. Sinde 10^{-6} mol H^+ iyonu bulunduğu saptanmıştır. Bu asidin iyonlaşma sabiti Ka nın değeri kaçtır?

A) 1.10^{-10} **B)** 1.10^{-8} **C)** 1.10^{-6} **D)** 1.10^{-4} **E)** 1.10^{-2}

28. 0,1 mol CuO yu,

$CuO + 2HNO_3 \longrightarrow Cu(NO_3)_2 + H_2O$

Tepkimesine gore tamamen çözebilmek için, HNO_3 çözeltisinden en az 200 mililitre gerekmektedir. Bu HNO_3 çözeltisinin pH değei kaçtır?

A) 0 **B)** 1 **C)** 2 □□□□□ **D)** 3 **E)** 4

29. H^+ iyonu derişimi a olan zayıf bir asitin sulu çözeltisi, hacmi iki katına çıkarılarak seyreltiliyor.Oluşan çözeltide H^+ iyonu derişiminin a/2 den büyük, a dan küçük olduğu görülüyor. Buna göre,

I. Zayıf asitlerin iyonlaşma oranı, seyreltme ile artar.

II. Maddelerin sulu çözeltilerinin derişimleri, hacimleri ile ters yönde değişir.

III. Zayıf asitlerin Ka değerleri seyreltme ile küçülür.

açıklamalarından hangileri doğrudur?

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

30. Sulu çözeltisine hidrojen iyonu (H^+) veren maddeler için aşağıdakilerden hangisi doğru sınıflandırmadır?

A) Arrhenius asidi

B) Lewis bazı

C) Arrhenius bazı

D) Lewis asidi

E) Bronsted asidi

APPENDIX C

KİMYA DERSİ TUTUM ÖLÇEĞİ

AÇIKLAMA: Bu ölçek, Kimya dersine ilşkin 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 D

BİLİMSEL İŞLEM BECERİ TESTİ

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

1. Bir basketbol antrenörü, oyuncuların güçsüz olmasından dolayı maçları kaybettklerini 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 antreman süresini.
d. Yukarıdakilerin hepsini.

2. Arabaların verimliliğini inceleyen bir araştırma yapılmaktadır. Sınanan hipotez, benzine katılan bir katkı maddesinin arabaların verimliliğini artıdığı 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 arabnın 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 değşkenleri araştımaktadırlar. 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 sebeblerini merak etmektedir. Isınma giderlerini etkileyen faktörleri araştırmak için bir hipotez kurar. Aşağıdakilerden hangisi bu araştırmada sınanmaya uygun bir hipotez değildir?

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

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

c. Büyük evlerin ısınma giderleri fazladır.

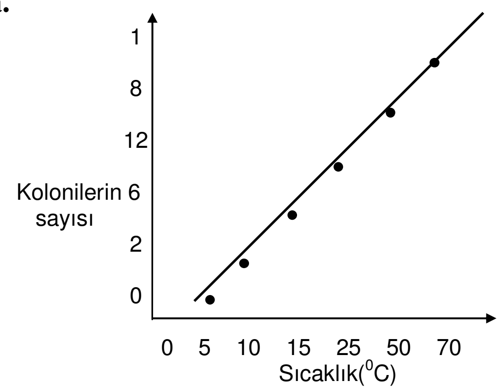
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

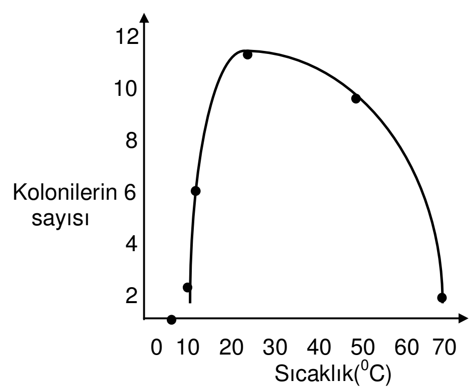
Deney odasının sıcaklığı (^0C) 5	Bakteri kolonilerinin sayısı 0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

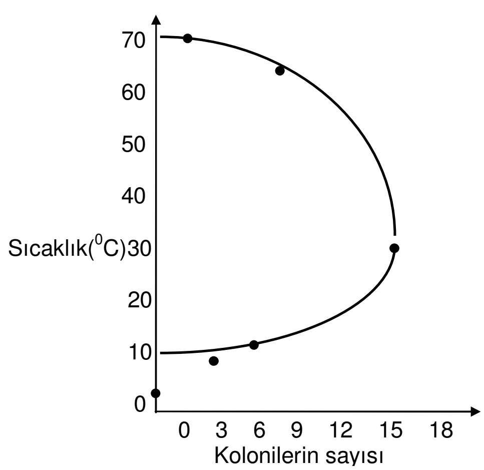
a.



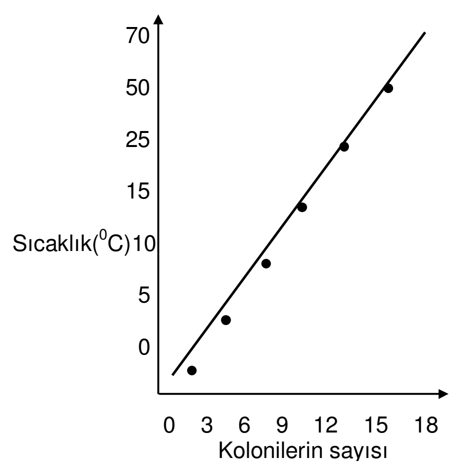
b.



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. Yollarde 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. Br oyuncak arabaya geniş yüzeyli tekerlekler takılır, önce bir rampadan (eğiik 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 genişlkleri 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?

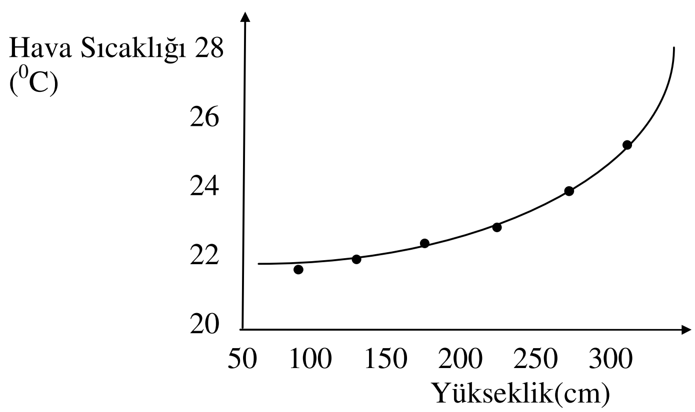
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

b. Ne kadar çok mısır elde edilirse, k**a**r 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 sıçracağını düşünmektedir. Bu hipotezi araştırmak için, birkaç basketbol topu alır ve içlerine farklı miktarda hava pompalar. Ahmet hipotezini nasıl sınamalıdır?

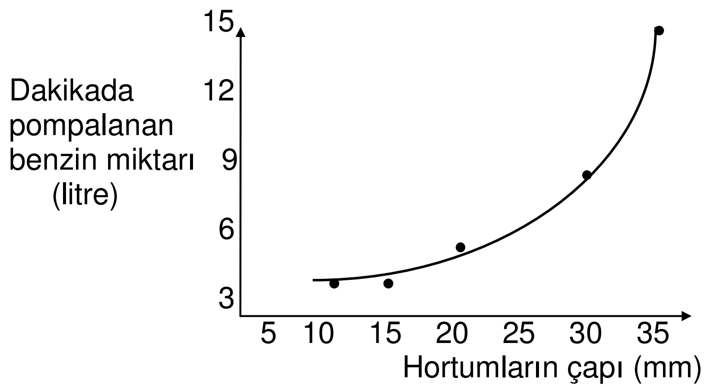
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

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. Bumlardan 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 maddelari farklı derecelerde ısıtır.
d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

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

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

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

16. Can, yedi ayrı bahçedeki çimenleri biçmektedir. Çim biçme makinasıyla her hafta bir bahçedeki çimenleri biçer. Çimenlerin boyu bahçelere göre farklı olup bazılarında uzun bazılarında kısadır. Çimenlerin boyları ile ilgili hipotezler kurmaya nbaşlar. 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 nci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.

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

17. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

d. Kullanolan 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. Araştımanın 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 alnlardaki 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 liter soğuk su koyar ve 10 dakika süreyle ısıtır. Ebru, alevin meydana getirdiği ısı enerjisini nasıl öiçer?

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

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

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

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

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

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

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

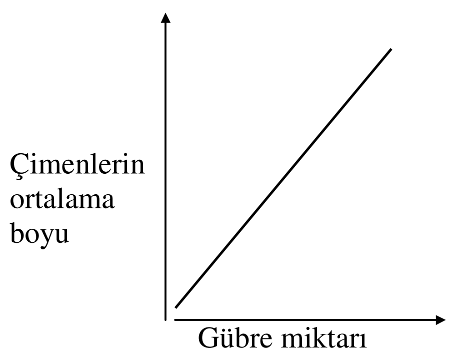
d. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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

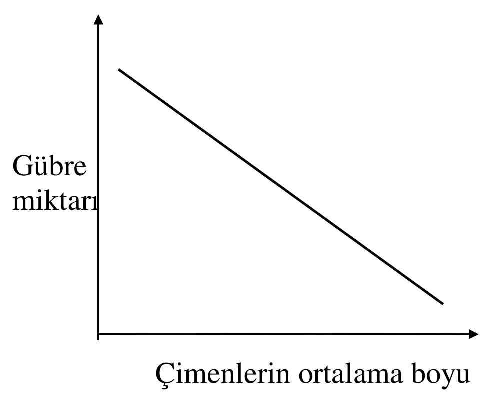
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

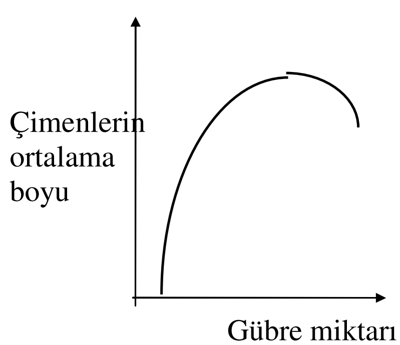
a.



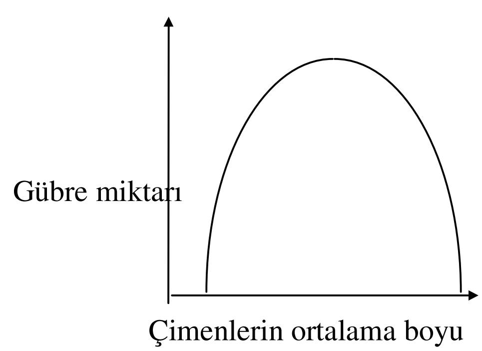
b.



c.



d.



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

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Hergün fareleri tartar.

d. Hergün farelerin yiyeceği vitaminleri tartar.

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

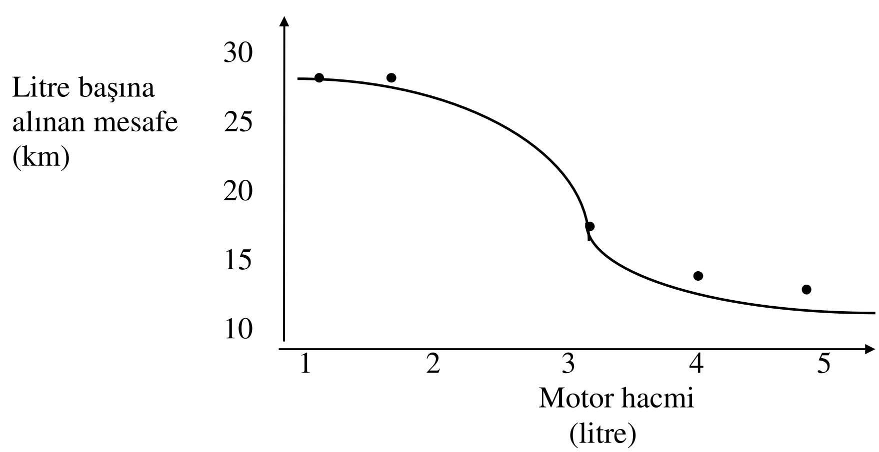
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

b. Su soğudukça, şekeri çözebilmek için daha fazl akarıştırmak gerekir.

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

d. Su ısındıkça şeker daha uzun sürede çözünür.

28. Bir araştıma grubu, değişik hacimli motorları olan arabalaın randımanlarını ölçer. Elde edilen sonuçların garfiği aşağıdaki gibidir:



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

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

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

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

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

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

29. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki 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 mınatısların 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 üle.

b. Demir tozalrını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

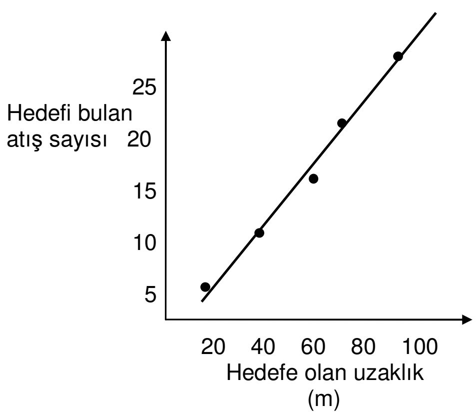
d. Çekilen demir tozlarının ağırlığı ile.

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

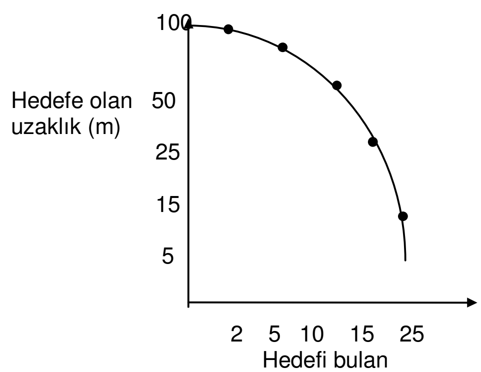
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

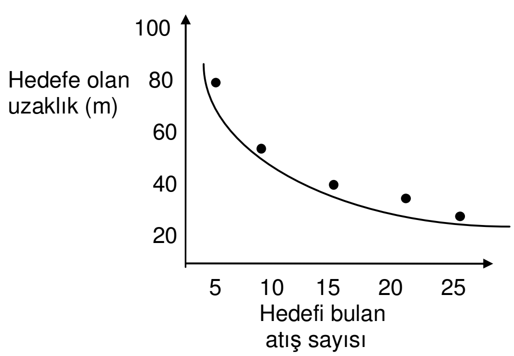
a.



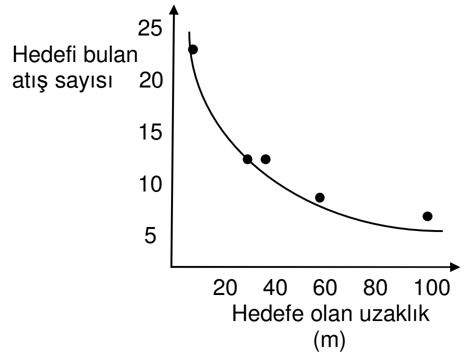
b.



c.



d.



35. Sibel, akvaryumdaki balıkların bazen çok haraketli 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 electrikli alet vardır. Fazla gelen elektrik faturaları dikkatini çeker. Kullanılan elektrik miktarını etkileyen faktörleri araştırmaya karar verir. Aşağıdaki değişkenlerden hangisi kullanılan elektrik enerjisi miktarını etkileyebilir?

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c.

APPENDIX E

SAMPLE LESSONS BASED ON BYBEE'S 5E LEARNING CYCLE TEACHING STRATEGY

SAMPLE 1:

In the sample lessons Bybee's 5E phases are arranged in a manner that meaningful learning occurs for the acid-base concepts.

1.ENGAGEMENT: The teacher made a demonstration. He dipped red litmus paper into vinegar and then water with soap solution.The students observed the color changes of the red litmus paper. Then the teacher asked a question: "Why does the red litmus paper change to blue in some of the solutions and not in the others? What are the characteristics of the solutions that change red litmus paper to blue?" The teacher created groups of four or five students. And, He alowed students 5–7 minutes to think about the question individually and then share it with their group. Then, he informed the students that they will engage in a laboratory activity to help them test their answers. In this stage, the purpose of the teacher is to create interest and generate curiosity in the topic of study; raise questions and elicit responses from students that will give you an idea of what they already know. Students by the end of the teacher's introduction had an idea about the focus of the lesson and what they would be doing.

2. EXPLORATION: The teacher gave some solutions and red litmus paper to each group. The students tried to distinguish these solutions using blue litmus paper and they discussed the question the teacher asked in the previous step with peers. During the discussion, they had opportunity to express their ideas and saw their peers' thoughts. Each group was supposed to record their observations and ideas and give a common answer to the teacher. In this stage the purpose of the teacher is to let the student manipulate materials to actively explore concepts, processes or skills. The teacher was the facilitator and observed and listened to students as they interact.

3.EXPLANATION: The teacher listened to each group's answer. Then he explained the concept using students' previous experiences. He gave examples from daily life in order to make concepts more concrete. For the answer of the question asked in "engagement" phase, he explained the physical properties of the acid and bases emphasizing the differences between them.

"Neutral Solutions, which are neither acidic nor alkaline, and acids, which have pH value of less than 7, do not change the color of the red litmus paper. Bases, which have pH value of more than 7, turn red litmus paper blue. The properties of alkalis are:

They taste bitter, have pH value of more than 7, turn red litmus paper blue, can conduct electricity and have a corrosive effect.Some examples of alkalis are sodium hydroxide (used in making soap and detergent), potassium hydroxide (used as whitening agent or in making soap, dyes and alkaline batteries), calcium hydroxide (used in cement and in medicine as an antacid), barium hydroxide (used making in plastic and soap) and ammonia (used as a refrigerant, as a solvent and in fertilizers). (Teacher brought some examples of bases to the class and after he had shown them he wanted the students give other examples of bases from daily life.)

4. EXPLORATION: In this phase teacher let the students explore if base solutions conduct electricity.

"Some chemical solutions such as acid, base and salt solutions can produce a flow of electrons through a wire. In this experiment, you will explore if base solutions conduct electricity in other words produce electricity. (For this experiment, teacher created groups of four or five students. He gave an activity sheet to each student.)

Conductivity of Base Solutions

Purpose: You will explore if base solutions conduct electricity in other words produce electricity.

Materials: Empty beaker

Distilled water

Copper strip

Zinc strip

Sodium-hydroxide solution

Calcium-hydroxide solution

Procedure:

1. Connect two pieces of wire and ammeter as shown in the figure. One of the free ends of this wire will be connected to a zinc strip. Place the strip of copper and zinc in a beaker half-filled with distilled water and record the amount of current shown on the ammeter.
2. Place the strip of copper and zinc in a beaker half-filled with sodium - hydroxide solution and record the amount of current shown on the ammeter.
3. Place the strip of copper and zinc in a beaker half-filled with calcium-hyroxide solution and record the amount of current shown on the ammeter.

Questions:

1. Which solutions in the beakers produce electricity when the copper and zinc strips are placed in them?

2. In order for a flow of electrons to be produced in the wire, what must occur in the solutions, which produce electiricity when the copper and zinc strips are placed in them?

3. What would happen if we use dry base with the same samples? Would you be able to observe the same properties?

Conclusion:

5.EXPLANATION: Students gave their answer to the previous questions about conductivity of base solutions. They used their observations and recordings in their explanations. The teacher listened critically to all of them. After getting answers, the teacher gave the answer of the question "What would happen if we use dry alkali with the same samples? Would you be able to observe the same properties?"

Base substances react easily with substances that contain water such as meat. They attract water, fat and protein and break the substance into smaller pieces. So base substances have a corrosive effect on substances that contain water. Our skin becomes dry after we use soap because soap is an alkali. It attracts water from the skin and removes fat from the skin and causes dryness. (Teacher asked a new question to explain the uses of bases in daily life?)

Now can you answer the questions: "We have observed that bases react with certain substances and do not react with others. We have also observed that base solutions conduct electricity. Can you think of how we can use this knowledge? Can it be useful in our daily life?

Bases do not react with materials such as iron, plastic, glass and cotton cloth. In addition to certain metals, bases also react with meat. Also bases can make a wooden surface slippery to the touch. Base substances are used with water to clean the dirt from clothes, dishes and other substances. Base solutions conduct electricity. Base batteries use the conductivity of base solutions in practice.

Now can you answer the questions: “What would happen if we use dry base with the same samples? Would you be able to observe the same properties?” Dry bases do not react with substances at all. When we dip blue litmus paper and red litmus paper in solid bases, no colour change will be observed. However, we will observe a colour change when litmus papers are dipped in solid base with water. Since the solution is base, red litmus paper will turn blue and no colour change is observed in the blue litmus paper. In explanation, bases need water to show their base properties.

At the end of this part, students discussed common properties of acid/bases and form a simple definition. Then, teacher summarized the properties of acids and bases in order to make connections what they have already learned. He drew a table that shows the properties of acid and base solutions.

“Let us summarize what we have observed about acid solutions and alkali solutions so that we can compare them.

Base solutions	**Acid solutions**
Taste bitter	Taste sour
Make skin dry Slippery	Burn skin
pH > 7	pH < 7
Turn red litmus paper to blue	Turn blue litmus paper to red
Corrosive effect	Corrosive effect
Conducts electricity	Conducts electricity

Teacher carefully developed a specific questioning sequence that related to the new knowledge that he identified as his purpose of the lesson. The sequence of questions in this portion of the lesson was most important. He moved from concrete to abstract, from the known to the new. He guided children's exploration of acid-base concept while he probed their thinking and provided feedback.

6.ELABORATION: Purpose of this step is extend conceptual understanding; practice desired skills; deepen understanding. Students work in groups again and in laboratory. Teacher gave acid solutions and base solutions, the other necessary materials and wanted students to compare them and them complete the table I.

Table I

Property	**Explanation**	
pH	(Numeric value will be written here)	
Litmus Paper		Changes red litmus into blue
		Changes blue litmus into red
Taste		Sour
		Bitter
Neutralisation Reaction		Neutralise acids
		Neutralise bases
Slippery		

7.EVALUATION: In this phase the purpose of the teacher is to encourage students to assess understanding and abilities; and evaluate learning**.**

What will the predicted pH of water with soap be? Test it with pH paper

a. If we add some vinegar to the water with soap, what will happen?

b. Demonstrate

c. Will the same result be observed if we added ammonia instead of vinegar?

SAMPLE 2:

1.ENGAGEMENT: The teacher asked a question: "We have distinguished acids and bases. What happens when we put the alkali and the acid together?" The purpose was to activate students' existing ideas and to motivate students by creating some mental disequilibrium.

2. EXPLORATION: The same groups discussed the question. Teacher let the students observe what happens when they put the alkali and the acid together in a laboratory activity. He reminded the groups that since acids are very harmful they should add the alkali to the acid. They add same amount of aqoues NaOH solution to aqoues HCl solution and checked the property of the final solution with red and blue litmus paper. The teacher asked new questions after the experiment: "Neither the blue litmus paper nor the red litmus paper changed colour in the final solution. So it is neither acidic nor alkaline. Do you know any other solution that has the same property? Can you tell the pH value of the final solution?"

3.EXPLANATION: The teacher got the answers from each group. Based on their answers, he explained the concept. "In the previous experiment, before exploring the reaction of acids with alkalis, we identified the solutions as acid and alkali using litmus paper. As we previously observed, the product of the acid and alkali reaction was neither acidic nor alkaline. Instead, it is neutral.

Now can you answer these questions: Do you know any other solution that has the same property? Can you tell the pH value of the final solution?

Pure water also does not change the colours of neither the blue litmus paper nor the red litmus paper. Therefore pure water is neutral, which has a pH value of 7. Like pure water, all neutral solutions have a pH value of 7.

Acids and alkalis react with each other in a process called neutralisation. They neutralise each other. The products of this reaction form a neutral solution because both the salt and pure water are neutral.

When we combine equal amounts of acid and alkali, they react with each other and form water and salt. Neutralisation Equation in words:

$\text{Acid} + \text{Alkali} \rightarrow \text{Salt} + \text{Water}$

The products are salt and water. Water and salt are neutral. They have neither acidic nor alkaline properties. The reaction is called neutralisation.

Neutralisation reactions are very important. Many industrial products are produced by neutralisation reactions between acids and alkalis. Neutralisation reaction is used for pH control in the pharmacy and the food industry. Neutralisation reaction is also used in the refinement of petroleum. The chemical processing of metals and mines is another area where we use neutralisation reaction. For example, the soap-making process is the neutralisation reaction of fatty acids with an alkaline substance. The neutralisation process can be used in the cure of insect bites. . In mosquito bites and honeybee stings, the poison is acidic solution. So you should apply dilute ammonia solution, which is an alkali, on the stung area. This will neutralise the acidic poison solution. However, in bumblebee stings, the poison is alkaline. So you should apply vinegar, which is an acidic solution, on the stung area.”

3. ELABORATION: Students work in groups again and in the laboratory. They made soap. While soap-making process, they again observed neutralisation reaction and applied their knowledge to real life situations.

4.EVALUATION: The teacher gave research homework and he wanted them to make presentation about their homework. The homework is “sometimes people suffer from heartburn and they take a medicine called ‘antacid’. Can you guess how antacids help the stomach?”

APPENDIX F

Table F Percentages of Students' Responses on Acid-Base Concepts Achievement Test

Item	Experimental Group Pre-test(%)	Experimental Group Post-test(%)	Control Group Pre-test(%)	Control Group Post-test(%)
1	75	89.3	64.3	85.7
2	3.6	75	7.1	67.9
3	67.9	92.9	53.6	89.3
4	67.9	85.7	82.1	96.4
5	67.9	100	60.7	92.9
6	82.1	92.9	71.4	92.9
7	64.3	100	78.6	89.3
8	46.4	92.9	75	100
9	71.4	96.4	75	85.7
10	53.6	75	39.3	60.7
11	39.3	71.4	60.7	50
12	50	82.1	53.6	60.7
13	25	71.4	50	35.7
14	7.1	53.6	21.4	25
15	46.4	71.4	64.3	60.7
16	35.7	82.1	60.7	46.4
17	39.3	78.6	64.3	50
18	17.9	78.6	17.9	57.1
19	50	78.6	50	85.7
20	42.9	82.1	57.1	53.6
21	7.1	57.1	17.9	42.9
22	46.4	76.6	35.7	71.4
23	39.3	67.9	25	39.3

24	28.6	60.7	17.9	39.3
25	7.1	53.6	39.3	35.7
26	50	82.1	53.6	60.7
27	21.4	53.6	35.7	35.7
28	7.1	50	-	35.7
29	14.3	28.6	32.1	25
30	21.4	57.1	21.4	32.1

APPENDIX G

TABLE OF SPECIFICATION

	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Definition of acids and bases	(12, 13)* (9)**	(1,2)*				
Properties of acids and bases				(4)* (21, 25)**		
Examples of acids and bases	(7, 8)* (4)**					
Acid - Base theories	(3)* (30)**			(1,2)**		
pH and pOH	(9, 14)* (3)**		(5, 8, 16, 18, 22, 28)**	(13, 19)**		
The strength of acids and bases	(10, 11)* (6, 7)**		(5, 6)* (11, 20, 23, 24, 26, 27)**	(14, 29)**		
Neutralization			(17)**	(15)* (12, 15)**		
Amphoteric substances				(16)* (10)**		

( )* Instructional Objectives
( )** Questions of ABCAT