THE EFFECTS OF 5E LEARNING CYCLE MODEL BASED ON CONSTRUCTIVIST THEORY ON TENTH GRADE STUDENTS' UNDERSTANDING OF ACID-BASE CONCEPTS

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ABSTRACT

THE EFFECTS OF 5E LEARNING CYCLE MODEL BASED ON CONSTRUCTIVIST THEORY ON TENTH GRADE STUDENTS' UNDERSTANDING OF ACID-BASE CONCEPTS

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

Sixty tenth grade students from two classes of a chemistry course taught by the same teacher in Ankara Atatürk Anatolian High School 2004-2005 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 constructivist approach caused significantly better acquisition of scientific conceptions related to acid-base. Students in both groups showed statistically equal development in attitude toward chemistry as a school subject. 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, Acids-Bases, Attitude Towards Chemistry as a School Subject, Science Process Skill.

ÖZ

YAPILANDIRICI YAKLAŞIM TEORİSİNE DAYALI 5E ÖĞRENME DÖNGÜSÜ MODELİNİN ONUNCU SINIF ÖĞRENCİLERİNİN ASİT VE BAZLARLA İLGİLİ KAVRAMLARI ANLAMALARINA ETKİSİ

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Bu çalışmanın amacı yapilandirici yaklaşım teorisine dayalı 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 Ankara Atatürk Anadolu Lisesi'nde 2004-2005 bahar döneminde gerçekleştirilmiştir. Çalışmaya, aynı kimya öğretmeninin iki ayrı onuncu sınıfındaki altmış öğrenci katılmıştır. Sınıflar kontrol grubu ve deney grubu olarak rastgele seçilmiştir. Kontrol grubunda geleneksel yöntem kullanılırken deney grubunda 5E öğrenme döngüsü modeli kullanılmıştır. Öğrencilerin 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 yapılandırıcı yaklaşım teorisine dayali 5E öğrenme döngüsü modelinin asit-bazlarla ilgili kavramların anlaşılmasında daha grouptaki öğrenciler etkili oldugunu göstermiştir. İki grouptaki öğrenciler de kimya dersine yönelik istatiksel olarak eşit gelişim göstermiştir. Bilimsel işlem becerisinin de öğrencilerin asit-bazlarla ilgili kavramlari anlamalarına istatiksel olarak anlamlı katkısı olduğu belirlenmiştir.

Anahtar Kelimeler: 5E Öğrenme Döngüsü Modeli, Geleneksel Yöntem, Asitler ve Bazlar, Kimya Dersi Tutum Ölçeği, Bilimsel İşlem Becerisi.

To my family, thank you for your love and support.

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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
$\overline{X}$	: Mean of the sample
P	: Significance level
F	: F statistic
t	: t statistic

CHAPTER I

INTRODUCTION

The major aim of science teaching is to promote the understanding of the concept being taught with a view to applying the knowledge of such understanding to real life situations. Inspite of the much focus on teaching strategies in science, students' performance in science subjects continued to record a persistent and depressing downward trend. 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. Moreover, the traditional teaching method in which 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. In addition, 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.With the emphasis on the learner, we see that learning is an active process occurring within and influenced by the learner as much as by the instructor and the school. From this perspective, learning outcomes do not depend on what the teacher presents. Rather, they are an interactive result of what information is encountered and how the student processes it based on perceived notions and existing personal knowledge.

Constructivism is not really a new concept. It has its roots in various disciplines such as education, psychology, philosophy and the history of science. John Dewey, Jean Piaget, Edmund Husser and Thomas Kuhn are only handful of theorists whose work impacts constructivist thought. As its name implies, constructivism emphasizes building or constructing the knowledge. All learning takes place in the brain of the learner, which is constructed as connections are made with previously made constructions. Giambatista Vico commented in a treatise in 1710 that "one only knows something if one can explain it." (Yager, 1991). Immanual Kant further elaborated this idea by asserting that human beings are not passive recipients of information. Learners actively take knowledge, connect it to previously assimilated knowledge and make it theirs by constructing their own interpretation (Cheek, 1992).

Learning cycle which is an inquiry- based teaching model is useful to teachers in designing curriculum materials and instructional strategies in science. The model is derived from constructivist ideas of the nature of science, and the developmental theory of Jean Piaget (Piaget, 1970) and developed by Robert Karplus with the Science Curriculum Improvement Study (SCIS) in 1964. The learning cycle of Karplus has three phases. These are exploration, term introduction and concept application. Over the years the learning cycle is revised and added several phases. So, 5E learning cycle is formed. It is developed by the Biological Sciences Curriculum Study (BSCS). It consists of the following phases: engagement, exploration, explanation, elaboration and evaluation.The 5E learning cycyle has been shown to be an extremely effective approach to learning (Lawson 1995; Guzzetti et al. 1993).

For this reason, in the present study we aimed to examine the effectiveness of "acid- base concepts" instruction based on 5E learning cycle model and attitudes toward science as a school subject. Students' attitudes, feelings and perceptions of science are also important for science achievement.

This study investigates also the effect of treatment on students' attitudes toward chemistry. Chang (2002) and Parker (2000) stated in their studies that the type of instruction affected students' attitudes toward science as a school subject Students' attitudes, feelings and perceptions of science play an important role for their science achievement and their selection of career related to science in the future.

In this study, science process skills that are important for understanding scientific concepts are also investigated. In science education, Lazarowitz (2002) indicated that learning science requires high cognitive skills. The present research study examines the contribution of students' science process skills to their understanding of acids-bases concepts.

1.1 Significance of the Study

Students are unable to successfully integrate memorized facts and formulate with real life application in chemistry concepts. The concept "Acid-Base" is one of them. This is because its abstract nature. Also teaching methods of acid-base concept play very importantant role. The old methods used in science curriculum do not develop student interest in the subject mattter. 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.In the constructivist approach, students construct their knowledge by making links between their ideas and new concepts through experience they acquire in school or daily life.

Learning cycle instructional technique based on the constructivist approach can result in greater achievement in science, better retention of concepts, improved attitudes toward science and science learning, improved reasoning ability, and superior process skills than would be the case with traditional instructional approaches (Abraham&Renner, 1986; Raghubir, 1979; Renner, Abraham&Birnie, 1985). This study deals with 5E learning cycle model, and its effectiveness. It tries to compare instruction based 5E learning cycle model with traditional chemistry instruction.Therefore this study will provide some information about the instruction based on 5E learning cycle model, its application into the classroom situation.

CHAPTER II

REVIEW OF LITERATURE

Science educators focus on improving students' 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 in their studies. 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. Students must relate concepts to the ideas they already have so that meaningful learning occurs. From this point of view, learning is the restructuring of existing ideas rather than merely adding information to existing structure. 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. Learner forget quickly when memorized facts or information that has not been connected with the learner's prior experiences. 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 (Bybee) will be explained.

2.1 Constructivist Approach:

2.1.1. Constructivism

Constructivism is defined as a set of beliefs about knowledge that begins with the assumption that reality exists but cannot be known as a set of truth (Tobin et al, 1994). Constructivists believes that objective knowledge cannot exist, rather all of us are involved in constructing our own words, part of which we take as being shared by others. Constructivist believes in truth but not in a truth that has been constructed by somebody. 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. Knowledge is acquired through involvement with content instead of imitation or repetition. Constructivism is not accepting what you are told but your prior knowledge about what you are taught and your perceptions about it. The new idea is not imposed on the learner. The learner is actively re-structuring his past and present experiences. Students' active involvement is emphasized in constructivism; the knowledge is then rooted into their memory.

Von Glasersfeld (1993) argues 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 learn 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. Absolute truth is not possible. 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, 1993).

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, &

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.

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. According to this approach 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. Working through these dilemmas results in construction of knowledge. "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 are included in instructional practices. 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. 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 (1968) 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. Ausubel (1968) differentiated meaningful learning and rote learning. He stated that the new knowledge should be related with the students' relevant prior knowledge to occur meaningful learning in learners' cognitive structure. With respect to this, Ausubel noted, "the most important single factor influencing learning is what the learner already knows".Science learning is a process of knowledge construction, and its construction start from prior knowledge (Posner et al. 1982, Gil, 1983; Osborn & Wittrock, 1983; Driver, 1985; Novak, 1987). Hewson and Hewson (1984) stated that learning a new idea requires the learner to relate the new idea to his or her current concepts. Ausubel (1968) 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. Ausubel, however, 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 (Ausubel, 1968). Students form mental connections between new ideas and the relevant elements within their existing cognitive structures when the students learn in a meaningful manner.

One way to make sense of how stıdents learn is through constructivism (Lorsbach and Tobin 1997). Constructivism is used increasingly as a theoretical rationale for research and teaching. Many current reform efforts also are associated with the notion of constructivism. Constructivism is an epistemology, a theory of knowledge used to explain how we know what we know. If it is used as a referent, constructivist epistemology is useful to teachers.

In the literature, there are researches where constructivist approach was used; it has been showed that constructivist teaching strategies were effective in enhancing students understanding and achievement. Treagust (1996), 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) 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. They had significantly better exam grades. In the study of Hand et al. (1997), junior secondary school students' perceptions of implementation of constructivist approach to the teaching of science was investigated. Students were more actively involved, had more discussions, practical work, and more fun. As a result of this, constructivist teaching and learning approaches lead greater understanding of concepts. It was concluded that students were more active in the learning process. Students had opportunity to see and control their thinking and they constructed correct knowledge more confidently and became more confident in their understanding of science. In addition to these, Akkuş et all. (2003) examined the effectiveness of the instruction based on the constructivist approach by focusing on the in-class teacher- student and student-student interaction within small groups over traditional method. It is indicated by the results that students instructed by constructivist approach acquired chemical equilibrium concepts better than the students instructed by traditional method. This research study also determined that students' previous knowledge and science process skills had an influence on their understanding of the concepts related to chemical equilibrium.

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. 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. Constructivist teachers of science promote group learning, where two or three students discuss approaches to a given problem with little or no interference from the teacher. What happens to and with such small groups of students can be used as a whole class arrives at consensus of the various small group analysis.

Insofar as learning and knowledge are instrumental in establishing and maintaining the student's equilibrium, they are adaptive. Once this way of thinking takes hold, teachers change their view of problems and solutions. It is not linger possible to cling to the notion that a given problem has only one solution. It is also difficult to justify conceptions of right and wrong answers. Constructivist teachers would rather explore how students see the problem and why their paths towards solutions seem promosing to them.

The role of the constructivist teacher can be seen as quite different from that of “traditional” teachers. So 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).

- become one of many resources that the student may learn from, not the primary source of information.
- engage students in experiences that challenge previous conceptions of their existing knowledge.
- allow student responses to drive lessons and seek elaboration of students' initial responses. Allow student some thinking time after posing questions.
- encourage the spirit of questioning by asking thoughtful, open-ended questions. Encourage thoughtful discussion among students.

- use cognitive terminology such as "classify," "analyze", and "create" when framing tasks.
- encourage and accept student autonomy and initiative. Be willing to let go of classroom control.
- use raw data and primary sources, along with manipulative, interactive physical materials.
- don't separate knowing from the process of finding out.
- insist on clear expression from students. When students can communicate their understanding, then they have truly learned.

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. During the small group interaction time, the role of the teacher 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 (this means frequently altering teachers' plans).
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 carriers related to scienc and technology.

18. Provide opportunities for students to perform in citizenship roles as they attempt to resolve issues they have identified.

19. Demonstrate that sience and technology are major factors that will affect the future.

Also offered by Yager (1991) are these strategies for implementing a constructivist lesson.

1. Starting the lesson:

- Observe surroundings for points to question
- Ask questions.
- Consider possible responses to questions.
- Note unexpected phenomena.
- Identify situations where student perceptions vary.

2. Continuing the lesson:

- Engage in focused play.
- Brainstorm possible alternatives.
- Look for information.
- Experiment with materials.
- Observe a specific phenomenon.
- Design a model.
- Collect and organize data.
- Employ problem-solving strategies.
- Select appropriate resources.
- Students discuss solutions with others.
- Students design and conduct experiments.
- Students evaluate and debate choices.
- Students identify risks and consequences.

- Define parameters of an investigation.

3. Proposing Explanations & Solutions:
   - Communicate information and ideas.
   - Construct and explain a model.
   - Construct a new explanation.
   - Review and critique solutions
   - Utilize peer evaluation.
   - Assemble appropriate closure.
   - Integrate a solution with existing knowledge and experiences

4. Taking action:
   - Make decisions
   - Apply knowledge and skills.
   - Transfer knowledge and skills.
   - Share information and ideas.
   - Ask new questions.
   - Develop products and promote ideas.
   - Use models and ideas to illicit discussions and acceptance by others.

The constructivist teacher sets up problems and monitors student exploration, guides the direction of student inquiry and promotes new patterns of thinking. Classes can take unexpected turns as students are given the autonomy to direct their own explorations. A May 1990 article in Phi Delta Kappan recounts the story of a fourth-grade teacher who challenged her students to experiment with the idea of heat. Convinced that their hats, sweaters, blankets, and rugs all produced heat on a cold winter day, the children placed thermometers inside the garments and recorded the results. After three days the clothes still showed no rise in temperature. Although some of the students began to realize that they needed alternative explanations, many clung to their belief that the clothing generated heat. They were willing to continue testing the garments until their hypothesis was proven-the entire year, if necessary.

The teacher had to set limits for the task and guide the students' examination of the evidence.

Students come to science lessons with ideas about the natural world. Effective science teaching takes account of these ideas and provides activities which enable students to make the journey fom their current understanding to a more scientific view. 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.

Designed primarily by science educators for secondary science teaching, the 5E model has a classic constructivist approach. In the subsequent part, we discuss the 5E learning cycle approach which is based on constructivist approach.

2.1.3. 5E Learning Cycle Approach

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, concept introduction and concept application) proposed by Karplus and Thier (1967). In the exploration phase of the learning cycle, students discover new concepts with guie of the teacher. The students confront with their previous experiences and existing knowledge in this phase. During concept introduction, students are introduced to a new concept. In this phase teachers can use a textbook, a film, a CD to introduce the concept. Students develop relationships between the concepts in this phase. In the concept application phase, student applies their new concept into new situations. Many examples of learning cycles have been described in the literature (Osborne and Wittrock, 1983). The 5E Learning Cycle (Bybee) is used in the new BSCS science programs as well as in other texts and materials.

The 5E learning cycle includes the following phases: Engagement, Exploration, Explantion, Elaboraiton, and Evaluation are listed as follows:

1. Engagement: In this stage teacher create interest and generate curiosity in the topic of study. For this reason activities are made. These activities help students to make connections with the previous knowledge. Teacher raises questions and elicits responses from students that will give you an idea of what they already know. Teacher has also a good opportunity 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.

Table 2.1 The Role of Student and Teacher in the Engagement Phase of 5E Learning Cycle Model

Student	**Teacher**
calls up prior knowledge	poses problems, generates curiosity
Shows interest in the topic.	raises questions, creates interest

Table 2.1 (continued)

experiences doubt or disequilibria	reveals discrepancies
ask questions such as: “Why did this happen? “What can I foun abot this?”	causes disequilibria or doubt
identifies problems to solve, decisions to be made, conflicts to be resolved	Elicits responses that uncover what the students know or think about the concept/topic.

2. Exploration: In exploration stage, students should be given opportunities to work together without direct instruction from the teacher. Students get directly involved with phenomena. The teacher’s role in the exploration phase is that of guide, coach and facilitator.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.

Table 2.2 The Role of Student and Teacher in the Exploration Phase of 5E Learning Cycle Model

Student	**Teacher**
Tests predictions and hypotheses.	Encourages students to work without direct instruction from the teacher.
Tries alternatives and discusses them with others.	Ask probing questions to redirect students’ investigations when necessary.
Thinks freely, but within the limits of the activity.	Provides time for students to puzzle through problems.
Forms new predictions and hypotheses.	Acts as a consultant for students.

Table 2.2 (continued)

Records observations and ideas.	Observes and listens to students as they interact.
Suspends judgement.	Provides time for students' investigations when necessary.

3. Explanation: During explanation, teacher help students make sense of their observations and questions arise from their observations. The teacher encourages 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. Then, the teacher introduced a scientific explanation for the event through formal and direct instruction. The teacher connected the scientific explanation with the physical evidence from exploration and engagement and also relates it to the explanations that the children have formed. Besides the verbal methods, the teacher might also use videos, books, multiemedia presentations, and computer courseware.

Table 2.3 the Role of Student and Teacher in the Explanation Phase of 5E Learning Cycle Model

Student	Teacher
Explains possible solutions or answers to the others.	Provides feedback
Shares understandings for feedback	Ask questions, poses new problems and issues
Seeks new explanations.	Enhances or clarifies explanations
Forms generalizations	Uses students' previous experience as the bases for explaining concepts.

Table 2.3 (continued)

Uses recorded observations in explanations.	Evaluates explanations
Reflects on plausibility	Offers alternative explanations

4. Elaboration: During "Elaboration" students should apply concepts and skills in new (but similar) situations and use formal labels and definitions. Students expand on the concepts they have learned, make connections to other related concepts, and apply their understanding to the real world around them. 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. This phase often involves experimental inquiry; investigate projects, problem solving and decision making. The teacher may decide to recycle through different phases of the 5E learning cycle to improve students' understanding or move on to new science lessons.

Table 2.4 The Role of Student and Teacher in the Elaboration Phase of 5E Learning Cycle Model

Student	Teacher
Draw reasonable conclusions from evidence.	Encourouges students to apply or extend the concepts and skills in new situations.
Records observations, explanations, and reasonable conclusions from evidence.	Refers students to existing data and evidence and asks: "Why do you think…?" "What do you already know?"
Check for understanding among peers.	Expects students to use formal labels, definitions, and explanations provided previously.
Applies new labels, definitions, explanations, and skills in new, but similar, situations.	Reminds students of alternative explanations.

5. Evaluation: Evaluation should take place at all points along the continuum of the instructional process.Teacher observe students' knowledge and/or skills, application of new concepts and a change in thinking. Teacher may be using also rubrics, student interviews, portfolios designed with specific purposes, project and prolem-based learning products, and concept maps. Students should assess their own learning. Teacher asks open-ended questions and look for answers that use observation, evidence, and previously accepted explanations. Students are also asked questions that would encourage future investigations.

Table 2.5 The Role of Student and Teacher in the Evaluation Phase of 5E Learning Cycle Model

Student	Teacher
Evaluates her own progress and knowledge	Assesses students' knowledge and/ or skils.
Answers open-ended questions by using observations, evidence, and previously accepted explanations.	Allow students to assess their own learning and group- process skills.
Asks related questions that would encourage future investigations.	Observes students as they apply new cncepts and sklls.
Demonstrates an understanding or knowledge of the concept or skill.	Looks for evidence that students have changed their thinking or behaviours
	Ask open-ended questions such as: "What do you know about x?", "Why do you think...?", "How would you explain x?"

According to several researches, 5E learning cycle is an effective teaching strategy and enhances students' understanding and achievement. In their study, Bevenino, Dengel and Adams (1999) stated that 5E learning cycle encourages students to develop their own frames of thought. Similar results can be seen in the study of Colburn and Clough (1997).They examined that 5E learning cycle is an effcitive way to help students enjoy science, understand concept and apply scientific process and concepts to authentic situations. Pavelich & 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).

Formal operational students learn equally well with learning cycle or traditional approaches (Ward & 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.

Another researchers Ward & 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.

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. 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 5E Learning Cycle Model Teaching vs. Traditional Teaching

Students distinguish the Learning Cycle Approach from traditional approaches in the following ways (Abraham, 1982):

- The Learning Cycle Approach emphasizes the explanation and investigation of phenomena, the use of evidence to back up conclusions, and the designing of experiments.
- Traditional approaches emphasize the development of skills and techniques, the receiving of information, and the knowing of the outcome of an experiment before doing it.

2.4 Misconception

Learning is the result of the interaction between what the student is taught and his current ideas or conceptions. This is by no means a new view of learning. Its roots can be traced back to early Gestalt psychologists.

During the last decade there has been an increasing interest in science misconceptions. In their studies, Dykstra, Boyle, and Monarch (1992) summarized the meaning of misconceptions as:

- The mistaken answer students give when confronted with a particular situation.
- The ideas about particular situaiton students have which invoke the mistaken answer.
- The fundamental beliefs students have about how the world works, which they apply to a variety of different situaitons. These are beliefs in an explanatory sense about causality.

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

Most of the work dealing with students' misunderstandings, learning difficulties, and misconceptions in chemistry has been focused on relatively "classical" examples, such as mole concept (Duncan & Johnstone, 1973; Novik & Mannis, 1976), entropy (Campbell, 1978; Frazer, 1980), and chemical equilibrium (Camacho & Good, 1989; Gussarsky & Gorodetsky, 1990).

Nakhleh (1992) stated some implications about misconceptions. First, apparently there are profound misconceptions in the minds of many students from a wide range of cultures concerning the particulate and the kinetic nature of matter. Second, apparently students do not spontaneously visualize chemical events as dynamic interactions. Many topics in chemistry do not make conceptual sense and are learned by rote without an understanding of the kinetic behavior of particles. Third, the cognitive model of learning implies that misconceptions can occur when students come for instruction holding meanings for everyday words that differ from the scientific meaning. Fourth, learning is much more difficult if student must master different definitions for the same phenomenon. For example, if students who take both chemistry and physics at the same time, they may confound some concepts.

Nakhleh (1992) also indicated that students would have a better chance of becoming meaningful learners of chemistry if educators would have a more accurate estimate of students' actual cognitive structures, and students might give more serious thought to understandings the concepts.

2.5 Acids and Bases

In chemistry education, as in daily life, acids and bases have a special importance. Since Liebig defined acids as substances that form hydrogen when they react with metals in 1838, many studies have been conducted about ways of teaching acids and bases. While defining acids and bases systematically, Sumfleth (1989) used concept maps; Schmidkunz (1985) used curriculum spirals; Weisenhorn (1994) and Hilbing and Barke (2000) used thinking and visual models. While teaching acids and bases, demonstrations (Meyer et al., 2003), and carrying out experiments play an important role. Instead of theoretical learning, learning by doing improves students' performance. In the aplications, there are techniques that use constructivism (Hand and Treagust, 1991), problem based learning inductive approach and learning cycle In the analogy applications, acids and bases taught by football analogy.

In chemistry, students must deal with stoichiometry and gas law problems which involve proportions, variables, and mass conservation; with intensive properties such as concentration, density, and pressure; with abstract concepts such as chemical bonds and molecular orbitals; as well as a whole host of generalized variables, including reaction rates, energy, force and entropy.

In his article, Treptow (1986) mentioned that beginning students are often confused by the many subleties of acid- base chemistry. The topic of acids, bases and pH is particularly challenging within high school chemistry since the student must possess a deep understanding of atoms, molecules, ions and chemical reactions. In literature, several studies found that students have difficulties in understanding the reactions in the topic of acids, bases and salts. First of all, Butts and Smith (1987) determined in their studies that students could not relate the formation of precipitate in a double decomposition reaction to the low solubility of salt. Then, Boo (1994) examined that students believed the driving force for a double decomposition reaction was the difference in reactivity between the metallic elements present in the compounds involve. In another research, Schmidt (2000) indicated that students believed the reaction between magnesium oxide/hydroxide and hydrochloric acid was a redox reaction since there is oxygen in the oxide and hydroxide.

In the light of the related literature, we can see that, students should 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 in chemistry includes the concepts which seem to be difficult for students, because this topic includes both abstract and theoretical concept. Nakhleh and Krajcik (1994) and Zoller (1990) pointed out that from high school to the university chemistry curriculum, the topic of acids, bases and pH is considered a challenging topic for students to understand. This, in turn, has led to the creation of several different teaching models to address the concepts of acids and bases, such as: including various learning tecnologies (Nakhleh and Krajcik, 1994), integrating multiple teaching methods (Francisco, Nicoll and Trautmann, 1998), and emphasizing epistemological reasoning. 5E learning cycle model based on constructivism play also an important role in understanding acids and bases concept, but research in this area has been relatively sparse. 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 5E learning cycle model based on constructivism 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 instruction based on 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

In this table, 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

The subjects of the study consisted of 60 10^{th} grade students (33 male and 27 female) from two classes of a Chemistry Course from Ankara Atatürk Anatolian High School taught by the same teacher. This study was carried out during the spring semester 2004-2005. Two instruction methods used in the study were randomly assigned to the groups. The data analyzed for this research were taken from 30 students participating instruction based on 5E learning cycle model and 30 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. 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.

The reliability of the test was found to be 0.72. This test was administered 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 administered 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 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. The classroom teacher also examined the test items to check whether they are appropriate to the instructional objectives or not.

4.4.2 Attitude Scale Toward Chemistry (ASTC)

This scale was developed by Geban, Ertepınar, Yılmaz, Altın and Şahbaz (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). Its language is Turkish. The reliability was found to be 0.83. This test was administered 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). It was translated and adapted into Turkish by Geban, Aşkar and Özkan (1992). This instrument consists of 36 four-alternative multiple choice questions. 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 given to all students in the study. The reliability coeficient of the test was found to be 0.85. (see Appendix D).

4.5 Treatment

This study was conducted approximately four weeks during the 2004-2005 spring semesters at Ankara Atatürk Anatolian High School. 60 10^{th} grade students (33 male and 27 female) from two classes of a Chemistry Course were involved in the study.

There are two goups in the study. One of the classes was assigned as the experimental group applied 5E learning cycle model, and the other class was assigned as the control group applied traditionally designed instruction. The instructional methods were randomly assigned to the classes. Both of the groups were instructed by the same science teacher and students in two groups were exposed to same content of the chemistry course for the same duration. The classroom instruction of the groups was regularly scheduled as three times per week in which each teaching session lasted 40 minutes. The topics related with acid base concepts were covered as a part of the regular curriculum.

The teacher was trained about the implementation of the constructivist strategy before the treatment. In order to verify the treatment, the researcher observed instructions in both groups randomly.

This study was done using a pre-test and post-test control group design (Campbell & 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. In addition to this, at the beginning of the treatment all students in this study received Science Process Skill Test to assess their science process skills.

In the control group, traditionally designed instruction was administered as regular chemistry courses. 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 during the lesson, answered some questions and made suggestions when needed. Worksheets were corrected and scored in the classroom.Then the students investigated their sheets after correction.

Student in the experimental group were instructed with the 5E learning cycle model. The strategy used was based on Bybee’s (1990) 5E Learning Cycle. A sample Lesson based on Bybee’s 5E learning cycle model teaching strategy is presented in Appendix E. According to this strategy, Bybee’s 5E phases were arranged in a manner that meaningful learning occurs for the acid-base concepts. Before beginning the instruction the teacher was informed about the 5E learning cycle in three one hour sessions. The teacher divided the classroom into groups at the beginning of the instruction. So the interaction between the students was maximized.

The instruction began with the “Engagement” part. 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. The teacher gave enough time to the students to discuss the questions with their friends. The teacher also let them write their answers to their notebooks. During the discussion, the teacher didn’t interfere with the students. She was the facilitator and observed and listened to students as they interact. After the students discussed, each group gave a common answer to the teacher. So, the teacher had an opportunity to view the students’ previous ideas.

In the explanation part, based on the students’ answers, the teacher explained the concept using students' previous experiences. She presented scientifically correct explanation by using analogies and 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.

In the elaboration part, the fourth phase of cycle, 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.

In the last part called evaluation, the teacher encouraged students to assess understanding and abilities; and evaluated their learning**.** Assessment occurred at all points along the instruction. 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. The teacher also asked questions to the students during the lesson and observed them through discussions and hands-on activities. Moreover, the students are asked several open-ended and multiple-choice questions at the end of the instruction. The students had enough time to think about the anwers of the questions. Later, the answers of the questions were discussed in the classroom.

4.6 Analysis of Data

In this study, Analysis of Covariance (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. On the other hand, 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 encountered during the study are listed below:

4.7.1 Assumptions:

1. Students in experimental group did not interact with students in control group.
2. The teacher who applied the treatment was not biased.
3. The tests were administered under standard conditions.
4. All students gave accurate and sincere responses to all items in the instruments used in the study.

4.7.2 Limitations:

1. The subjects of the study were limited to 10^{th} grade students of a Anatolian high school in Ankara.
2. The study was limited to the unit of "Acid-Base" concept.
3. This study was limited to 60 students in two classes.

CHAPTER V

RESULTS AND CONCLUSIONS

This chapter presents the results of analyses of hypotheses stated in Chapter III. The hypotheses were tested at a significance level of α=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) (Norsis, 1991).

5.1 Results

The results showed that there was no significant difference at the beginning of the treatment between the IBLM group and the TDCI group in terms of students' achievement of acid-base concepts (t = -1,134, p>0.05) and attitudes toward chemistry as a school subject (t =- 0,015 p >0.05) before treatment.

Table 5.1 Means of the Instruments

	Groups	N	$\overline{X}$	
			pre-test	post-test
Achievement	IBLCM	30	10.961	20,386
	TDCI		11.644	18.642
Attitude	IBLCM	30	57.656	58.666
	TDCI		57.742	58.123
Science Process Skill	IBLCM	30	25.343	
	TDCI		26.434	

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	26.679	26.679	4.042	0.034
Treatment	1	25.320	25.320	1.012	0.030
Error	42	1211,103	21.128		

The result of the analysis presented in the Table 5.1 showed that there was a significant difference between the post-test mean scores of the students taught by IBLCM and those taught by TDCI with respect to the acid-base concepts. The IBCLM group scored significantly higher than TDCI group ($\overline{X}$ (IBLCM) = 20,386; $\overline{X}$ (TDCI) = 18.642).

Table 5.3 shows the percentages of correct responses from the students in both IBLCM and TDCI group to the questions in the post-test 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	87.2	83.2

Table 5.3 (continued)

2	78	69.4
3	70.2.	34.4
4	88.5	92.6
5	77	62.9
6	100	93.8
7	96.9	92.2
8	90.1	90.1
9	100	92.8.
10	78.7	60.6
11	71.4	38.6
12	100	89.7
13	79.7	52
14	79.7	58.8
15	83.2	44.8
16	78.6	46.4
17	68.8	70.1
18	54.9	42.4
19	29.6	26
20	65.2	32.0
21	57.1	42.9
22	52.8	32.1
23	58.8	46.9
24	62.8	37.6
25	77.4	72.3

As seen in the table above, there were differences in responses between the two groups to the items in ABCAT. After the treatment, the differences in responses of questions, 3, 11, 15, 20, 22, and 24 were greater among the other questions. In question three, students were asked to classify the definition of base. Most of the students were chosen the correct alternative, the Arrhenius base, which gives hydroxide iyons (OH^-) in their aqeous solutions. Before treatment, 26% of the experimental group students and 48% of the control group students responded this question correctly. After treatment, 70.2% of the students taught by the IBLCM seemed to develop their critical thinking. On the other hand, 34.4% of the students taught by TDCI responded this question correctly. The students were answered mostly the Lewis Base alternative,which was false. They didn't understand completely the acid-base definitions.

In question 11, students were asked to choose the false statement by using the pH and pOH. The correct answer was the alternative C,which was pH is smaller than seven, when the molarity of OH^- iyons are greater than the molarity of H^+ iyons. 10.2% of the experimental group students and 20.2% of the control group students responded correctly to this question. After treatment, 71.4% of the students in the IBLCM group responded this question correctly which means that they had a better sense of understanding the pH and pOH. And 38,6% of the students in control group gave the correct statement, after the treatment.Wee see that the students in control group confused this concept, because they didn't understand the pH and POH concept. They gave different alternatives to these questions, which were false.

Question 15 was related to characteristics of strong acids. Although TDCI group students showed high achievement for this question before the treatment, IBLCM group students showed higher achievement after the treatment. Most of the students in IBLCM group said that strong acids ionize in their aqeous solutions and conduct electricity very well, which was the true statement of the question after the instruction. On the other hand most of the students in TDCI group added those true statement mentioned before the false statement, which was strong acids have always more than H^+ ions in their structure. This was a confusing statement. 63.2. % of the control group students and 36.8% of the experimental group students responded it correctly before treatment. And the average correct response percentage after the treatment was 83.2% in the experimental group and 44.8% in the control group. We can conclude that the experimental group students understood the strong acids and their characteristics better than the control group.

In question 20, 38.2% of the experimental group students and 25.3% of the control group students responded it correctly before treatment. After treatment, 32% of the control group students responded this question correctly. On the other hand, 65.2% of the experimental group students responded it correctly, that is they chosen only the true statement, which was strong acids conduct electricity very well in their aqeous solutions. The other staments were false for the properties of acids. Most students in control group chosen also false, confusing statements. They answered that, we don't eat the acidic foods, burning substance have acidic characteristics and All substance, in which structure have H, have acidic characteristics. This shows that students in experimental group were able to understand the properties of acid solutions exactly.

Question 22 was about the strength of bases.The students were asked that on which statement depent the the stegth of base. Before the treatment, 26.9% of the experimental group students and 15.6% of the control group students responded it correctly, so they answered that the strength of the base depent on the number of the OH^- ions in solutions. After the treatment, 52.8% of the experimental group students responded this question correctly, whereas only 32.1% of the control group students responded it correctly. It can be concluded that the experimental group students had a better sense of understanding the strength of base.

In question 24, students were asked about pH and pOH concept again. They were going to choose the true pH/pOH interval. Before treatment, the average correct response percentage was 22.8% in the experimental group and 37 % in the control group. And the average correct response percentage after the treatment was 62.8% in the experimental group and 37.6 % in the control group. From these results wee see that most of the students in the experimental group increased their understanding of pH and pOH. The students in experimental group know that acids have a pH value between zero and seven or have a pOH value between 7 and 14 or vice versa. The percentages of students' correct responses in the pre-test and post-test for questions 3, 11, 15, 20, 22 and 24 are given in Table 5.4:

Table 5.4 Percentages of students' correct responses in the pre-test and post-test for questions 3, 11, 15, 20, 22 and 24

Item	Experimental Group		Control Group	
	Pre-test (%)	**Post-test (%)**	**Pre-test (%)**	**Post-test (%)**
3	26	70.2	48	34.4
11	10.2	71.4	20.2	38.6
15	36.8	83.2	63.2	44.8
20	38.2	65.2	25.3	32
22	26.9	52.8	15.6	32.1
24	22.8	62.8	38	37.6

Before the treatment, the average correct response percentage was 45.7% in IBLCM group and 75.5% after the treatment. And we can see the greatest improvement in questions 7, 9, 10 and 15. First of all in question 7, the average correct response percentage was 17.5% before the instruction and 96.9% after the instruction. This question was about pOH orientation. The students were asked to calculate the pOH value of the 0,00001 M HCl solution. Most of the students calculated as 5, which was false, before the instruction. They confused with pH value of this solution. After the instruction most of the students gave the correct answer, which was 9. They could calculate the pH value from the molarity of solution and than translate it to pOH value.

Then in question 9, the average correct response percentage was 33.9% before the instruction and 100% after the instruction. The question 9 was related with the type of solutions. Before the instruction, most of the students answered that CH_3COOH is acidic, as a false statement. This statement was true. The students supposed that CH_3COOH is base, because there is an OH in its structure. They knew that all substance, in which structure there is an OH, are bases.That is false. CH_3COOH is a weak acid although there is an OH in its structure.

When we look question 10, 5.3% of the students responded the question correctly before the treatment and 78.7% of the students responded the question correctly after the treatment. This question was about also pH orientation. The students were asked classify tree solutions having the molarity 0,1 as strong acid, base or neutral according to their pH values given.To give the correct answer students must know the pH interval exactly. Before the instruction, most of the students confused pH interval, and because of thie they gave the false answer. On the other hand when we look the results, after the instruction, most of the students could chosen the correct alternative. So, we can understand that the experimental group students understood the pH orientation of solutions very well. They said that solution having the pH value of one is a strog acid but solution having a pH value of eight is a weak acid. A solution is strong base when its pH value is 13.

Finally in question 15, the average correct response percentage was 36.8% before instruction and 83.2% after the instruction. This question is about the strength of acids. Before the instruction, the students supposed to answer that all strong acids have more than H in their structures. This was false. For example H_2CO_3 (carbonic acid) is not a strong acid although it has two H in its structure. It is weak acid. On the other hand HNO_3 is a strong acid, although there is one H in its structure. The strength of acids/bases depents on the ionization percentage in water. After the the instruction, we see that most of the students understood the strength of acids and they gave the correct answer. We mentioned the correct answer of question 15 before.

The poorest results were obtained in question 19. In this question, how is the calculation of pOH value of a solution from the pH value of a solution was asked. 20% of the students responded this question correctly before the instruction and 29.6% of the students responded it correctly after the instruction.They calculated that the pOH value of a solution is eight when the pH value of thie solution is six. So, they could translate the pH value to the pOH value. But most of the students couldn't calculate the pOH value. They didn't understand exactly the calculation of pH and pOH values. Mostly, they chosen the false statement which was we cannot calculate the pOH value of a solution unless we don't know the type of solution. Calculation of pH or pOH values is not depent on the type of solution. In Table 5.5 below, the percentages of experimental group students' correct responses in the pre-test and post-test for questions 7, 9, 10, 15 and 19 are given:

Table 5.5 Percentages of experimental group students' correct responses in the pre-test and post-test for questions 7, 9, 10, 15 and 19.

	Experimental Group	
Item	**Pre-test (%)**	**Post-test (%)**
7	17.5	96.9
9	33.9	100
10	5.3	78.7
15	36.8	83.2
19	20	29.6

On the other hand in the TDCI group, the average correct response percentsge was 46.3% before the instruction and 60.2% after the instruction. We can see from the results that the average correct response percentage improvement between pre-test and post test is not as much as in the experimental group. According the results, the greatest improvement was observed in questions 5, 6, 9, 17 and 25. These questions are related with pH and pOH concept, pH orientation, characteristics of acids and base solutions, neutralization and types of solutions.

In question 5, students were asked neutralization. Students were going to obtain a solution having the pH value of seven (which is neutral) from the given solutions. So they were asked a neutralization reaction. In neutralization reaction the number of H^+ ions is equal to the number of OH^- ions. Before the treatment since they didn't know how a neutralization reaction occurs, they couldn't answer the question. But after the treatment, most of the students gave the correct answer.

In Question 6 there was figure about strong acid (HCl) soluiton and strong base (NaOH) solution. Students were asked true staments according to the figure.These statement were about pH concept and molarity of H^+ ions. Most of the students were answered correctly after the treatment. They understood pH orientation well. Students who couldn't answer this question confused the pH orientation.

When wee look question 9, it is about types of given solutions. Students were asked to choose the false statement. Before the treatment, most of the students answered that CH_3COOH is an acidic, as a false statement. But after the treatment most of the students answered that NH_3 is neutral, which was the correct answer of the question. NH_3 solution is a weak base, it is not neutral.

Question 17 was about pH and pOH concept. Before the instruciton, most of the student answered that pH value of a solution give only the acidic characteristic of that solution, which was false. After the treatment most of the students gave the correct answer which was in acidic solutions pH values is smaller than seven and in basic solutions it is higher than seven.

Finally in question 25, students were asked about the general characteristics of acids and bases. Most of the students answered that pH value of a solution give only the acidity of that solution. That is false statement. After the treatment, most of the students chosen the true statement. The students answered that strong acids and strong bases neutralizes each other.

The poorest results were obtained in questions 3, 14, 16, 19, 21, 23 and 24. These questions were related with pH or pOH orientation, characteristics of acid-base solutions, definitions of acids and bases, calculation the pOH value of a solution from the pH value of a solution, types of solutions from daily life and strength of acids and bases.

Question three was about Arrhenius definition of bases. Most of the students in control group answered that substance that gives OH^- ions in their solutions is Lewis base.They gave the false answer.This definition was about Arrhenius base. A few students answered this question correctly before the treatment and after the treatment. We can understand from this result that thay confuse the various definitions of acids and bases. They didn't understand this concept completely.

In question 14 there were figures about solutions. Students were chosen the correct alternative according to the given values of the solutions in figures. A few students understood the type of solutions from the given molarities.They knew that first solution of which OH^- ion molarity is 1.10^{-12} is acidic, and the other having the OH^- ion molarity is 1.10^{-2} is basic. The false alternative, chosen by most of the students in control group was first solution is strong base and second solution is weak base.

When we look question 16, it was about the type of solutions from daily life. Students were asked how these solutions change the colour of the red litmus paper. A few students answered that in basic solutions (Amonium solution and soapy water) change red litmus paper in to blue and in acidic solutions (vinegar and lemon juice) there is no colour change. That is a few students gave correct answer. Most of the students in control group didn't know the types of given solutions. They mostly suppose that amonium solution is an acid or they confuse the colour change of red litmus paper. They didn't undersood how the colour of red litmus paper in acidic and basic solutions.

Then question 19 was related about the calculation the pOH value of a solution from the pH value of a solution.Students were asked the calcualtion of pOH value from the pH value of six. Also in IBLCM group had the poorest in this question.We mentioned it before. Most of the students in control group gave the false answer. They couldn't translate the pOH value from the pH value. A few students in control group calculated that pOH value is eight when the pH value is six. There is a little increase in the percentage of control group students' correct responses. (see Table 5.6)

Question 21 was about the general characteristics of acids and bases. A few of the students gave the correct answer.They said that when HCl reacts with Mg metal, H_2 gas is released after the reaction. Wee see from the results that the percentages of control group students' correct responses decreases from pre-test to post-test. (see Table 5.6). Before the instruction, most of the students answered this question that we don't eat all acidic foods bcause they are toxic. This is false. There are acidic foods we eat. Not all acidic foods are toxic. After the instruction, most of the students answered that when the pH value of a solution increases, its acidic characterisitics increases. So, the students didn't understand the pH concept exactly in control group.

In question 23, students were asked information about a solution having pH value higher than seven. Almost half of the students in control gave the cırrect answer before the instruction. But then after the instruction, the number of the students responded question 23 correctly decreased. These students answered that solution having pH value higher than seven is basic and changes the red litmus paper to blue. Most of the students didn't determine that the given solution is basic and they gave the various false answers.

And finally, question 24 was related about pH and pOH interval. Students were asked to choose the correct pH or pOH interval. There are few students answering this question correctly. Also in this question, the percentages of control group students' correct responses decreases from pre-test to post-test (see Table 5.6) But as we mentioned earlier in IBLCM group, the percentages of students' correct responses for this question increases very much.(see Table 5.4). The percentages of control group students' correct responses in the pre-test and post-test for questions 3, 5, 6, 9, 14, 16, 17, 19, 21, 23, 24 and 25 are given in the Table 5.6:

Table 5.6 Percentages of control group students' correct responses in the pre-test and post-test for questions 3, 5, 6, 9, 14, 16, 17, 19, 21, 23, 24 and 25.

	Control Group	
Item	**Pre-test (%)**	**Post-test (%)**
3	48	34.4
5	5.5	62.9
6	60.3	93.8
9	49.2	92.8
14	50.7	58.8
16	52.0	46.4
17	35.2	70.1
19	20.9	26
21	49.2	42.9
23	57.1	46.9

24	38.0	37.6
25	23.7	72.3

Accordingly, 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 are presented in Appendix F.

Hypothesis 2:

To answer the question posed by hypothesis 2 which states 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 showed that science process skills made a significant contribution to the variation in achievement. F value indicated that there was a significant contribution of science process skills on students' understanding of acid-base concepts ($F = 4.042$; $p < 0.05$).

Hypothesis 3:

To analyze hypothesis 3 stating that there is no significant mean difference between the students taught with instruction based on 5E learning model 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	30	57.62	8.12		0.234	0.800
TDCI	30	57.18	7.42	50		

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 conclusions obtained from the results could be summarized as follows:

1. The 5E learning cycle model based instruction caused a significantly better acquisition of scientific conceptions related to acid-base concepts than traditionally designed chemistry instruction.

2. The instruction based on constructivist approach and traditionally designed chemistry instruction produced significantly equal attitudes towards chemistry as a school subject.

3. There is no statistically significant difference between attitude scale scores of students taught by 5E learning cycle model based instruction and those taught by traditionally designed instruction.

4. Science process skill of the students was a strong predictor for the achievement of acid-base concepts.

5. The pre and post scores of Acid-Base Concepts Achievement Test shows that both IBCLM 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

This chapter involves a discussion and interpretation of the results reported in the Chapter V. It includes also the implications and recommendations for further research.

6.1 Discussion

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

According to the descriptive statistics given in Chapter V, it can be concluded that the instruction based on the 5E learning cycle model caused a significantly better acquisition of scientific conceptions related to acid-base concepts than traditionally designed chemistry instruction.

The unit "Acids and Bases" which is studied in this study includes abstract and theoretical concepts. For this reason 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. Hence, Bybee's 5E Learning Cycle (1990) in the experimental group was used in this study. Through the instruction designed according to 5E learning cycle, the teacher was aware of students' prior knowledge. Since learning is a social process, students worked in groups with their friends. So interaction is maximized through this way. In the learning process, students also made hands-on and minds- on activities. They participated actively in instruction.In this strategy, in the first phase of cycle called “engagement”, students are asked several questions. Here the purpose of teacher was to activate students’ prior knowledge. In the exploration phase, the teacher asked a question for students to explore the phenomena by themselves. In two phases, teacher let the students to discuss with their friends.In this learning environment, students tried to make connections between the new concepts and the existing ones.

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. Discussion was mostly used through all phases to increase student- student and also student-teacher interaction. 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. In the elaboration part, students applied the newly learned concepts into new situations. Evaluation and assessment of students’ knowledge is made through the instruction. In the evaluation phase students are asked several questions. So, the teacher had an idea whether the students gained the necessary concepts or not.

On the other hand, in the control group where traditionally designed chemistry instruction was used. In the light of the results obtained from analysis, it can be concluded that traditional instruction is less effective than instruction based on 5E learning cycle model. There may be some reasons. The traditional instruction was teacher-centered that is the teacher transferred their thoughts and meanings to the passive students. The teacher provided information without considering students' prior knowledge and checked whether students have acquired it or not. Lecture method is generally used by the teacher in instruction. She wrote important notes to the board and distributed work sheets to the students to complete. During instruction students listened to their teacher, took notes, studied their textbooks and completed the worksheets. The students were not given any opportunity to develop their thinking, reasoning and communication skills. They only received the teacher's truth while she lecturing. They were not given opportunity to use problem-solving skills in other situations. Since the teacher instructed the lecture, students in control group did not have so many chances to discuss or share ideas with each other. There was no interaction between teacher and students, and students and and students in control group. They didn't become more confident in their understanding of science. On the ather hand, in 5E learning cycle based instruction students were actively involved in the learning process and constructed their own knowledge. This might be caused the difference in the concept test scores in traditional instruction versus 5E learning cycle instruction.

The present study is consistent with the literature. Anthony Lorsbach, Kenneth 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 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. The learning process is facilitated by the skilled teacher who engages students in thinking, questioning, testing ideas, explaining, and representing ideas. The teacher should have good subject- matter knowledge and be flexible in their teaching methods. Otherwise, they tend to use the tradiotional way of teaching (Smerdon and Burkam, 1999). 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 also investigated the effect of treatment; 5E learning cycle based instruction and traditionally designed chemistry instruction, on students' attitudes towards chemistry as a school subject. There was 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 although instruction based on 5E learning cycle model, focused on students' ideas, encouraged students to think about situations. The treatments developed similar attitude toward science. The reason why no significant difference was found in this study might be due to the fact that 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.

In short, this study showed that 5E learning cycle model is an effective teaching strategy. On the contrary, traditional instruction does not seem effective in developing students' understanding of acid-base concepts. 5E learning cycle model can provide teachers with many insights into how students can learn about and appreciate science. By using this teaching strategy, better acquisition of scientific concepts could be observed. 5E learning cycle model is useful not only improving achievement but also they help students construct their views about science and develop thinking ability. Advance questioning activates relevant prior knowledge and promotes meaningful learning. In addition, this causes students to have more positive attitudes towards chemistry as a school subject.

6.2 Implications

In the light of the findings of the present study the following implications could be offered:

- Since its abstractive nature learning chemistry is difficult. Prospective teachers should be given opportunities to apply their understandings about 5E learning cycle model based on constructivist approach on high school students. Universities and schools should work together to create more fully developed constructivist teachers.

- Teachers should use instructional techniques that promote students' undesstanding such as: 5E learning cycle based instruction since traditional instruction is less effective than 5E learning cycle based instruction. The role of the teacher is facilitate safe, guided or open inquiry experiences and questioning so students uncover their misconceptions about the concept. And also, in universities, teacher education programs especially methods of science courses should include some topics related to 5E learning cycle approach.

- Teachers should create disequilibrium with students' existing conceptions, so that, they will have to rethink and try to reconstruct understanding.

- Teachers should be trained 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.

- Teachers should be aware of students' attitudes towards chemistry as a school subject. They must know that attitudes affect the students' achievement and should seek to improve students' attitudes.

6.3 Recommendations

Based on the results of this study, the followings are made for further researchers:

- A study can be conducted for different grade levels and different science courses to investigate the effectiveness of the 5E learning cycle model.
- Further research studies can be carried out to investigate the effectiveness of 5E learning cycle approach in understanding science concepts in different schools. So, more accrute results can be obtained and a generalization for Turkey can be provided.

- This study can be conducted with larger sample size out in order to obtain more accurate results.

- Other constructivist teaching strategies such as the Driver's constructivist teaching sequence or analogies approach can be used.

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APPENDIX A

INSTRUCTIONAL 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

Aşağıdaki test "Asitler ve Bazlar" ünitesiyle ilgili sorular içermektedir. Bu testteki sorular sizlerin "Asitler ve Bazlar" ünitesine dair bilgilerinizi değerlendirmek için hazırlanmıştır. Sorular çoktan seçmeli formatında oluşturulmuştur. Her soru için doğru olan bir seçeneği yuvarlak içine alınız.

1. Aşağıdakilerden hangisi asitlerin genel özelliklerinden biri değildir?

A) Mavi turnusol kağıdının rengini kırmızıya çevirir.

B) Sulu çözeltilerinde H^+iyonu bulundururlar.

C) Çözeltileri elektrolittir.

D) Seyreltik çözeltilerinin tadı ekşidir.

E) Sulu çözeltileri aktif metallerle tepkime vermez.

2. 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)

3. Sulu çözeltisine hidroksit iyonu (OH^-) veren maddeler için aşağıdakilerden hangisi doğru sınıflandırmadır?

A) Arrhenius bazı

B) Lewis asidi

C) Arrhenius asidi

D) Lewis bazı

E) Bronsted bazı

4. 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

5. I. 50 mililitre 2.0 M NaOH

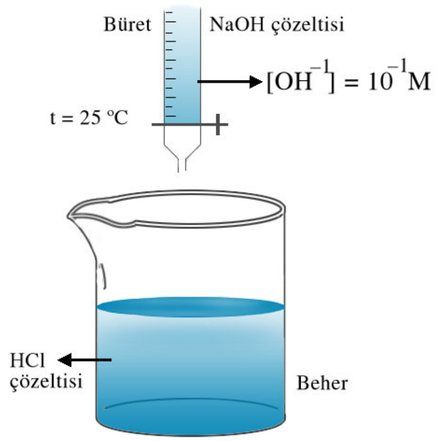
II. 50 mililitre 1.0 M NaOH

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

6.



$[H^+]= 10^{-1}M$

H^+ iyonu derişimi $10^{-1}M$ olan HCl'in sulu çözeltisine, OH^- iyonu derişimi$10^{-1}M$ 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

7. 0.00001 M HCl çözeltisinin pOH'ı kaçtır?

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

8. 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) $4NH_{3(suda)} + Cu(OH)_{2(suda)} \rightleftarrows [Cu(NH_3)_4]^{+2}_{(suda)} + 2OH^-_{(suda)}$

9. 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

10.

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

11. 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.

12. 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

13. Aşağıdaki ifadelerden hangisi asit ve bazların ortak özelliklerindendir?

A) Tadları acıdır.

B) Tadları ekşidir.

C) Ele kayganlık hissi verirler.

D) Elektrik akımını iletirler.

E) Mavi turnusol kağıdını kırmızıya çevirirler.

14. Aşağıda 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.

15. Aşağıda verilen ifadelerden hangisi ya da hangileri kuvvetli asitler için doğrudur ?

I. Suda çok iyi iyonlarına ayrışırlar.

II. Elektrik akımını çok iyi iletirler.

III. Yapılarında her zaman birden fazla H vardır.

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

16. I. Amonyak çözeltisi

II. Sirke çözeltisi

III. Limon suyu

IV. Sabunlu su

Yukarıda bazı çözeltiler verilmiştir. Bu çözeltilerin her birine kırmızı turnusol kağıdı batırıldığında, turnusol kağıdının rengi ne olur ?

	I	II.	III	IV
A)	mavi	kırmızı	kırmızı	mavi
B)	kırmızı	kırmızı	mavi	mavi
C)	kırmızı	mavi	mavi	kırmızı
D)	mavi	kırmızı	mavi	mavi
E)	mavi	mavi	kırmızı	kırmızı

17. Aşağıdaki ifadelerden hangisi bütün asit ve bazlar için doğrudur ?

A) Bir çözeltinin pOH değeri o çözeltinin sadece bazik değerini gösterir.

B) Bir çözeltinin pH değeri sadece o çözeltinin bazik değerini gösterir.

C) pH ve pOH değerleri aynı şeyi ifade ederler.

D) Asidik çözeltilerde pH değeri 7'den küçüktür, bazik çözeltilerde ise 7'den büyüktür.

E) Çözeltinin pH değeri o çözeltinin sadece asidik özelliğini gösterir.

18. 100 ml 0,1 M NaOH çözeltisi ile 100 ml 0,1 M HCl çözeltisileri karıştırılıyor. Oluşan yeni çözeltinin pH değerinin ne olmasını beklersin?

A) 3 **B)** 5 **C)** 6 **D)** 7 **E)** 14

19. pH değeri 6 olan bir çözeltinin, pOH değerinin hesaplanmasını gösteren ifade aşağıdakilerden hangisidir ?

A) pOH= 8

B) 6 < pOH < 8

C) pOH= 6

D) pOH= (pH 6-14)/ 2

E) Çözeltinin türünü bilmeden pOH değerini hesaplayamayız.

20. Aşağıdaki verilen ifadelerden hangisi ya da hangileri doğrudur ?

I. Yapısında H bulunan bütün maddeler asidik özellik gösterirler.

II. Asitli yiyecekler yenilmemelidir.

III. Kuvvetli asitlerin sulu çözeltileri elektrik akımını çok iyi iletirler.

IV. Yanıcı maddeler asidik özellik gösterirler.

A) I B) II C) III D) IV E) I, II, IV

21. Aşağıdaki ifadelerden hangisi doğrudur ?

A) pH değeri arttıkça çözeltinin asitlik karakteri artar.

B) pOH değeri arttıkça çözeltinin asitlik karakteri azalır.

C) Asitle bazın reaksiyonu sonucu gaz açığa çıkar.

D) Tüm asit içeren bir yiyecekler zehirli olduklarından dolayı yenilmezler.

E) Mg metali ile HCl’nin reaksiyonu sonucu H_2 gazı açığa çıkar.

22. Bazın kuvvetliliği aşağıdakilerden hangisine bağlıdır ?

A) Çözeltideki toplam iyonların sayısına

B) Çözeltinin hacmine

C) Çözeltinin kütlesine

D) Çözeltideki H^+ iyonlarının sayısına

E) Çözeltideki OH^- iyonlarının sayısına

23. Bir çözeltinin belirli bir sıcaklıkta pH değerinin 7'den büyük olduğu biliniyor (pH> 7 at 25^o C). Bu çözeltiye ait aşağıdaki ifadelerden hangisi doğrudur ?

A) Çözeltinin ekşi tadı vardır.

B) Asidik bir çözeltidir.

C) Çözeltiye turnusol kağıdı batırdığımızda rengi kırmızıdan maviye döner.

D) $[H^+] = 10^{-7}$

E) Her sıcaklık için $K_w = 1\times 10^{-14}$

24. Aşağıdaki pH/ pOH araliklarından hangisi doğru olarak ifade edilmiştir ?

A) $0 \leq pOH \leq 7 \Rightarrow$ baz
$14 \geq pOH \geq 7 \Rightarrow$ asit

B) $0 \leq pOH < 7 \Rightarrow$ baz
$14 > pH > 7 \Rightarrow$ baz

C) $0 \leq pH < 7 \Rightarrow$ asit
$7 < pOH \leq 14 \Rightarrow$ asit

D) $0 \leq pH \leq 7 \Rightarrow$ asit
$7 < pOH < 14 \Rightarrow$ baz

E) $0 < pOH < 7 \Rightarrow$ baz
$7 > pH > 14 \Rightarrow$ asit

25. Aşağıdaki ifadelerden hangisi doğrudur ?

A) Asit ve bazın reaksiyonuna ayrışma reaksiyonu denir.

B) Yapısında H bulunan bitin maddeler asidik karakter gösterirler.

C) Yapısında OH bulunan bütün maddeler bazik karakter gösterirler.

D) Bir çözeltinin pH değeri o çözeltinin sadece pH'ını (asitliğini) belirtir.

E) Asit ve baz birbirleriyle nötrleşirler.

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.

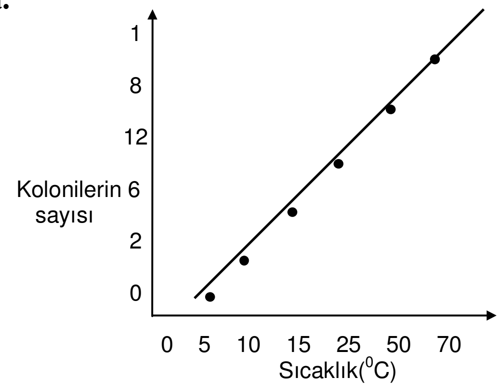
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

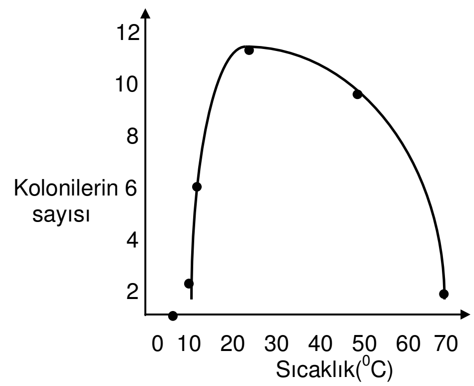
Deney odasının sıcaklığı (^0C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

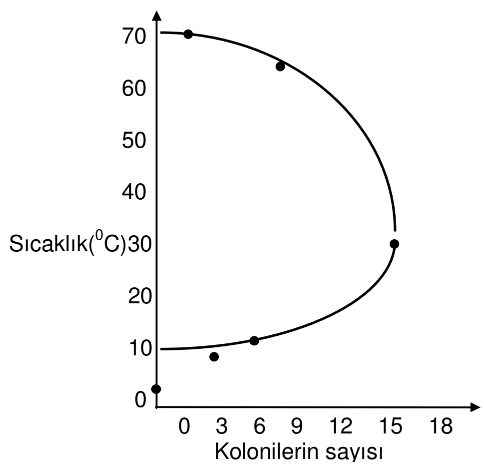
a.



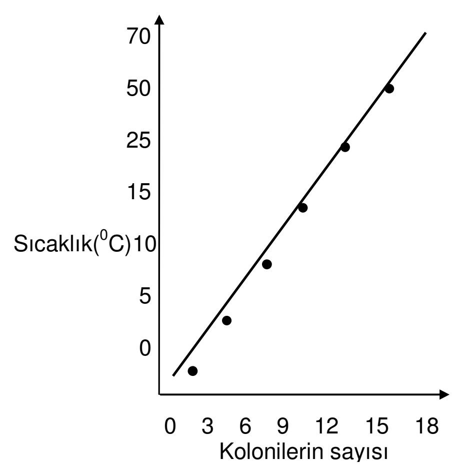
b.



c.



d.



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

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

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

c. 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?

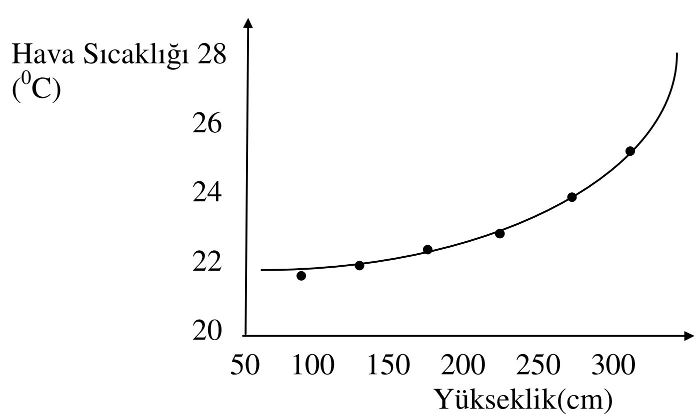
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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 ilişki 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?

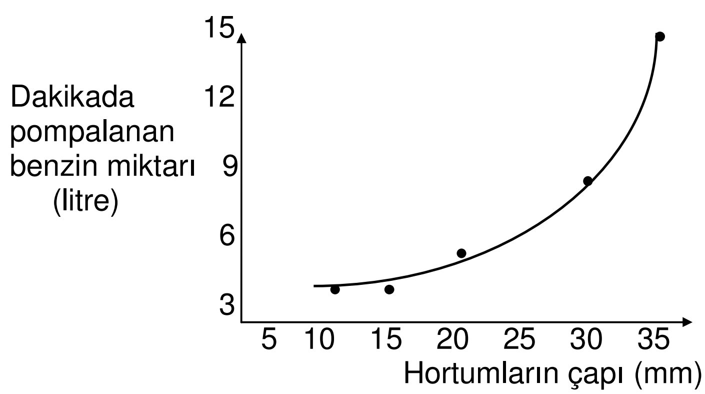
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

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.

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.

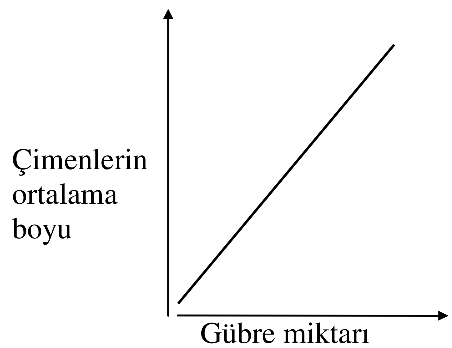
d. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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.

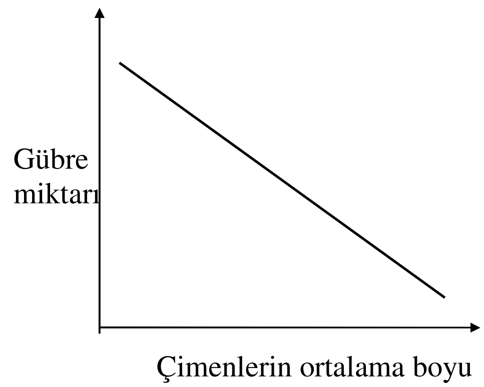
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

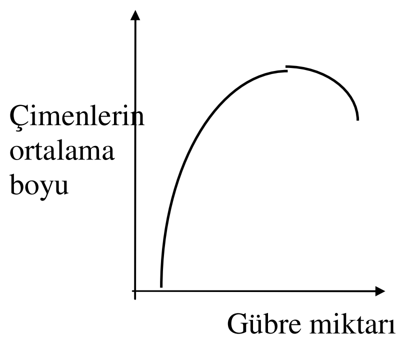
a.



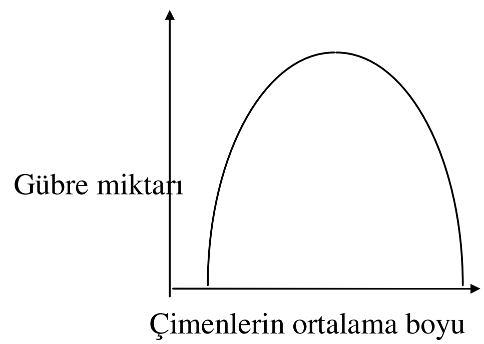
b.



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?

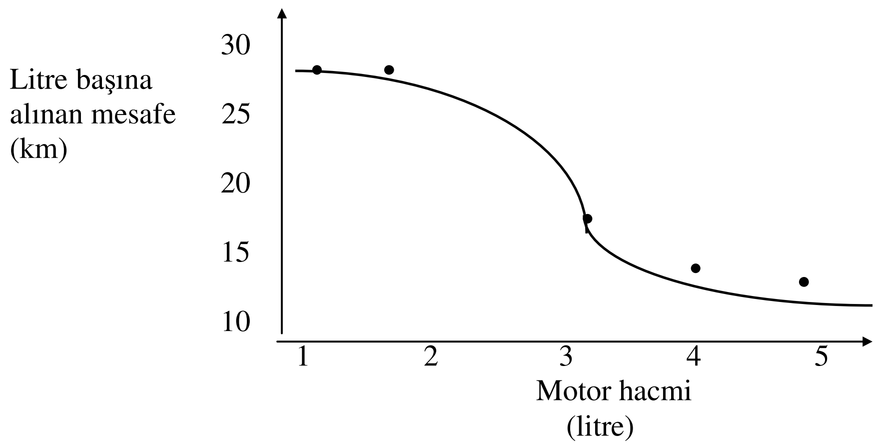
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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 arabalaıın 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.

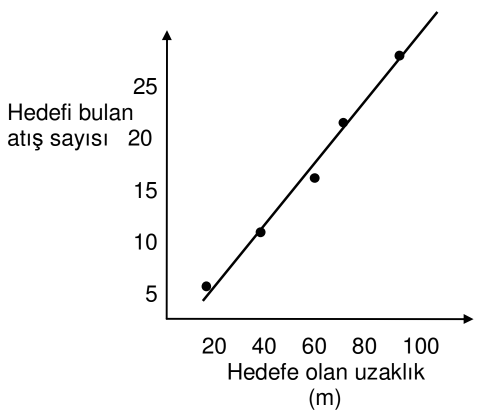
d. Çekilen demir tozlarının ağırlığı ile.

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

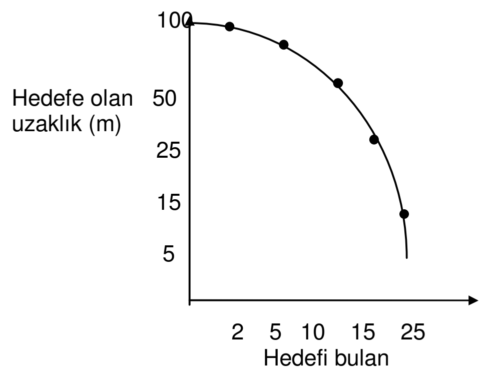
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

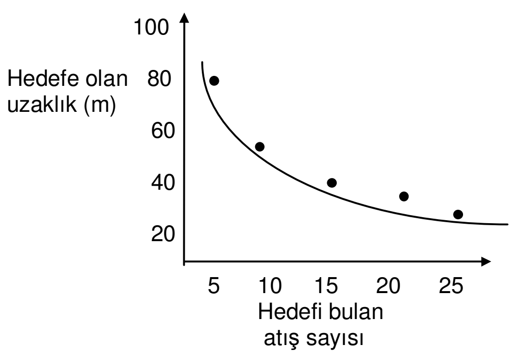
a.



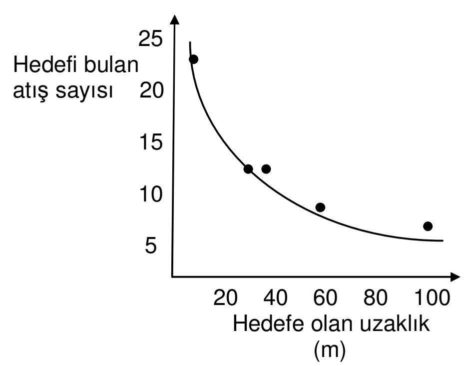
b.



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 LESSON BASED ON BYBEE'S 5E LEARNING CYCLE TEACHING STRATEGY

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

1.ENGAGEMENT:

At the beginning of the treatment, the teacher created groups of four or five student in order to maximize the interaction in class. The teacher made a demonstration. She dipped red litmus paper into vinegar and then water with soap solution. The students observed the color changes of the red litmus paper.
According to students' observations the teacher asked a question to the class: "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?" Then she gave students opportunity to think 5–7 minutes about questions individually and then share it with their group. Instead of interfering students discusions about questions, teacher helped students by raising questions to find their answers. Teacher didn't give answers of the questions in this phase.Then, the teacher 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. So, students had an idea about the focus of the lesson and what they would be doing by the end of this phase. The students were introduced to the topic.

2. EXPLORATION:

The teacher gave some solutions used in daily life 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 role of the teacher is to let the student manipulate materials to actively explore concepts, processes or skills. Here, 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 she explained the concept using students' previous experiences. The teacher used examples from daily life in order to make concepts more concrete. For the answer of the question asked in "engagement" phase, she 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). (Some examples of bases were brought to the class by the teacher and after she had shown them she 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.

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?

APPENDIX F

Table F.1 Percantages 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	70	87.2	62.2	83.2
2	61.3	78.0	35.3	69.4
3	26.0	70.2	48.0	34.4
4	71.2	88.5	78.4	92.6
5	65.0	77.0	5.5	62.9
6	91.9	100	60.3	93.8
7	17.5	96.9	80.2	92.2
8	79.6	90.1	74.9	90.1
9	33.9	100	49.2	92.8
10	5.3	78.7	43.4	60.6
11	10.2	71.4	20.2	38.6
12	64.8	100	80.1	89.7
13	57.2	79.7	60.3	52.0
14	60.6	79.7	50.7	58.8
15	36.8	83.2	63.2	44.8
16	59.8	78.6	52.0	46.4
17	52.6	68.8	35.2	70.1
18	38.3	54.9	28.6	42.4
19	20.0	29.6	20.9	26
20	38.2	65.2	25.3	32.0
21	37.4	57.1	49.2	42.9
22	26.9	52.8	15.6	32.1
23	43.6	58.8	57.1	46.9
24	22.8	62.8	38.0	37.6
25	52.6	72.4	23.7	72.3