DEVELOPING SEVENTH GRADE STUDENTS' SCIENTIFIC EPISTEMOLOGICAL BELIEFS, SCIENCE PROCESS SKILLS AND LAKE ECOSYSTEM UNDERSTANDINGS THROUGH LAKE EYMIR EDUCATION PROGRAM

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ABSTRACT

DEVELOPING SEVENTH GRADE STUDENTS' SCIENTIFIC EPISTEMOLOGICAL BELIEFS, SCIENCE PROCESS SKILLS AND LAKE ECOSYSTEM UNDERSTANDINGS THROUGH LAKE EYMIR EDUCATION PROGRAM

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The main purposes of this study were to investigate the effectiveness of an inquiry-based education program on students' science process skills, scientific epistemological beliefs, understandings of a lake ecosystem and examine their views about the education program. In this study, a single subject experimental research with pretest and posttest design was used. The sample of the study was 52 seventh grade students in a public school located in the Eymir Lake basin, in Golbasi district of Ankara. The education program had 8-week in-classes (16 hours), 4-week fieldworks (16 hours) and 2 seminars (2 hours) designed in order to fulfill the competencies, values, skills and objectives determined by the Ministry of National Education. In line with this target, the treatment was implemented in 2017-2018 Spring Semester. Science teachers were given training before the course and the implementation of lessons were performed by science teachers of each classroom. Qualitative and quantitative data were collected from the students through Demographic Information Questionnaire, Science Process Skills Test, Epistemological Belief Questionnaire, Lake Ecosystem Drawing Test and Students' Review Questionnaire. SPSS 25.0 Statistical program and paired samples t-test were conducted for the analysis of the quantitative data and inductive data analyzing methods were utilized for analyzing qualitative data. The results indicated that Lake Eymir Education Program was effective on students' scientific epistemological beliefs, scientific process skills and understandings of ecosystem conception. Students had also positive views about in-class activities, fieldworks and seminars given by scientists.

Keywords: Inquiry-based Learning, Middle School Students, Ecosystem, Science Process Skills, Epistemological Beliefs

ÖZ

YEDİNCİ SINIF ÖĞRENCİLERİNİN BİLİMSEL EPİSTEMOLOJİK İNANÇLARININ, BİLİMSEL SÜREÇ BECERİLERİNİN VE GÖL EKOSİSTEMİ ANLAMA DÜZEYLERİNİN EYMİR GÖLÜ EĞİTİM PROGRAMI ARACILIĞIYLA GELİŞTİRİLMESİ

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Bu çalışmanın amacı, araştırma sorgulamaya dayalı öğretim yöntemi ile hazırlanmış bir eğitim programının ortaokul öğrencilerinin epistemolojik inançları, bilimsel süreç becerileri ve göl ekosistemi anlayışları üzerindeki etkisini araştırmak ve öğrencilerin bu eğitim programı hakkındaki görüşlerini incelemektir. Araştırmada ön-test son-test ölçümlü tek grup deneysel çalışma modeli kullanılmıştır. Çalışmanın örneklem grubunu Ankara ilinin Gölbaşı ilçesinin Eymir Gölü havzasında bulunan bir devlet okulunda okuyan 52 yedinci sınıf öğrencisi oluşturmaktdır. 8 hafta sınıf içi (16 saat), 4 hafta alan çalışması (16 saat) ve 2 adet seminerden (2 saat) oluşan eğitim programı Milli Eğitim Bakanlığı tarafından belirlenen değerleri, yetkinlikleri, becerileri ve kazanımları destekleyecek şekilde tasarlanmıştır. Bu hedef doğrultusunda uygulama 2017-2018 İlkbahar Dönemi'nde uygulanmıştır. Öğretmenlere ders öncesinde eğitimler verilmiş ve uygulamalar sınıfların fen bilgisi öğretmenleri tarafından gerçekleştirilmiştir. Demografik Bilgi Anketi, Bilimsel Süreç Becerileri Testi, Bilimsel Epistemolojik İnanç Ölçeği, Göl Ekosistemi Çizim Ölçeği ve Öğrenci

Görüşü Anketi aracılığıyla öğrencilerden nitel ve nicel veriler toplanmıştır. Elde edilen nicel verilerin analizinde SPSS 25.0 İstatistik programı ve eşleştirilmiş örneklemler t-testi kullanışmıştır. Nitel verilerin analizi ise tümevarımsal yöntemlerle kod, alt-kategori, kategori ve temalar oluşturularak belirlenmiştir. Çalışma sonuçları Eymir Göl Eğitim Programı, öğrencilerin bilimsel epistemolojik inançları, bilimsel süreç becerileri ve göl ekosistem kavramlarını anlamaları üzerinde istatistiksel olarak etkili bulunmuştur. Öğrenciler ayrıca sınıf içi eğitim etkinlikleri, arazi çalışmaları ve bilim insanları tarafından verilen seminerler hakkında olumlu görüşler belirtmiştir.

Anahtar Kelimeler: Araştırma Sorgulamaya Dayalı Öğrenme, Ortaokul Öğrencileri, Ekosistem, Bilimsel Süreç Becerileri, Epistemolojik İnançlar

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CHAPTER 1

INTRODUCTION

According to Organization for Economic Cooperation and Development's report (OECD, 2016), the results of Program for International Student Assessment (PISA) project applied in the year 2015 on 15-year-old students indicate that Turkish students' science performance score is much lower than the global average score of 72 countries. This alarming finding actually was revealed in the results of all PISA conducted for five times between the years 2000 and 2015. Students' life satisfaction and sense of belonging at school were also under the average level of other participated countries. Particularly, it was found that according to the majority of the Turkish students who sat the in PISA 2015 do not think that they participate in scientific activities in science lessons enough, although they think that science topics are interesting.

Trends in International Mathematics and Science Study (TIMMS) as a widely known scale conducted by International Association for the Evaluation of Educational Achievement (IEA, 2016) on at least 60 active countries evaluates fourth and eighth grade students' achievement in every four years. In TIMMS, even if eighth grade Turkish students' science achievement score has gradually increased in the last four exams between the years 1999 and 2015, it was always under the global average score.

Considering both PISA, which focuses on evaluating students' ability to use academic knowledge to understand the world and solve daily life problems and TIMMS which focuses on evaluating students' academic knowledge with more curriculum based scale, Turkish students having low scores indicates the certain need of developing the quality of Turkish middle school science education program so that students possess global competencies. In order to manage this, following current trend for educational policies in world is essential.

Throughout the past fifty years, there have been many educational reforms around the world about the learners' role in the learning process based on the expected outcomes from learners. The majority of these reforms was on the side of students as active learners in learning process rather than students as passive receivers. Active learning refers educational activities in which students perform an activity and aware of what is being done (Bonwell & Eison, 1991). Teachers allowing students having experience, explore, reach the information and feel need to receive further information is the essential point, instead of teachers transfer information to students directly (Dunlop & Grabinger, 1996). This leads students to be in the center of learning and engage them to learn more; hence, learning becomes more meaningful (Hake, 1998; Laws et al., 1999).

By the trend of student-centered instructions, curriculum policies of many countries as Australia, Canada, England, Finland, Ireland, Israel, New Zealand, Singapore, Spain, Taiwan, Turkey and US (Bukova et al., 2005) were shifted towards constructivism approach. Constructivism is a learning theory claiming that knowledge is constructed by every child through their own experiences. The application of constructivism approach into classrooms make students physically and mentally active and responsible from their own learning by the teacher's facilitating. Instead of acquiring the information without any effort and just doing because the teacher tells students to do -for the sake of doing-, students constructing knowledge by thinking and doing.

In Turkey, inquiry-based learning in the context of constructivism determined as the instructional method by Ministry of National Education (MoNE, 2013; 2018).

Inquiry-based learning allows such opportunities children as wondering more about a concept, finding answers by themselves, justifying their own prior knowledge, and solve daily life problems. Teaching was not limited with only with inquiry-based instructional method in curriculum. Other active learning strategies that students were at the center of learning such as problem-based learning, argumentation, engineering design and collaborative learning were suggested as alternatives. By various instructional methods, students were expected to have success in school, work and life. Students having developed skills and meeting competences influence not only individual learners, but also it influences next generations of nations and world.

Inquiry-based learning enlightens the way of thinking like a scientist which is considered as the secret of success to become successful at PISA by OECD after the latest PISA exam in 2015. By inquiry-based learning, students can explore knowledge by using scientific methods; for example, they make inferences, formulate hypotheses, gather data gather by observations and make explanations based on evidences (NRC, 2000). Students act like a scientist in authentic scientific process by comprising of the stages of questioning, hypothesis generation, exploration, experimentation, data interpretation, conclusion, communication and reflection via inquiry-based learning (Pedaste et al., 2015). Many studies showed the effectiveness of inquiry-based learning on the development of science process skills among students (Adesoji & Idika, 2015; Anagün & Yaşar; 2009; Gök et al., 2014; Kanlı & Yağbasan, 2008; Pabuçcu, 2008; Polyiem, Nuagnchalerm & Wongchantra, 2011; Kılavuz, 2005).

Scientists use their scientific processes skills to understand the world. These skills are used by scientists to predict and explain phenomena and solve the problem (Carin et al., 2005). These skills are grouped into two by Martin's (1997) study as basic process skills, and integrated process skills. Observing, inferring, measuring, communicating, classifying, and predicting are basic process skills. Controlling variables, operationally defining, formulating hypotheses, data interpreting, experimental designing and modelling are integrated process skills (Martin, 1997). Noting that thinking like a scientist and going through the similar scientific processes do not refer always having a career as a scientist in future. Thinking like a scientist is important as one of the 21st century competencies allowing students better decision making in daily life.

In addition to science process skills, students' beliefs about "the nature scientific knowledge and knowing" are important for thinking like a scientist. These beliefs are called epistemological beliefs (Hofer & Pintrich, 1997). They comprise of the beliefs about the source of knowledge, justification for knowing, certainty of knowledge and development of knowledge (Conley, Pintrich, Vekiri & Harrison, 2004).

Date back to Plato, there are beliefs and justification besides truth in knowledge; in other words, not all received knowledge is true. Being able to distinguish what is truth and what is belief is surely an essential point for science. This difference was clarified by Glaserfeld (1998) by the statement that "in science, for instance, there is, beyond the goal of solving specific problems, the goal of constructing as coherent a model of the experiential world as possible" (p.7). Considering these, students' understanding of scientific knowledge and knowing is most likely different than scientists' understanding.

OECD (2016) also underlined students should be able to understand "scientific truth", since the current body of scientific knowledge is not same scientific knowledge with before, and it will never stay same in future as long as scientific discoveries are made and technology develops. However, most of the middle school students have naïve level of epistemological beliefs (Jones & Araje, 2002). There are learning strategies strongly related to students' epistemological beliefs (Alvermann & Qian, 2000) and inquiry-based instruction is one way to help developing students' epistemological beliefs (Chan & Elliott, 2002; Gök, 2014; Kaynar, Tekkaya & Çakıroglu, 2009). Defining science content in which students can practice science process skills and scientific epistemological beliefs depends on the science curriculum of every country. The important science concepts worldwide can be understood by looking at global assessments. PISA and TIMMS assessing half a million of students always cover some specific subjects. One of these topics under biology domain is ecosystems. For example; TIMMS evaluates students' academic knowledge about understanding ecosystems topic for almost 20 years and the number of its learning objectives about ecosystems are similar for years. Considering TIMMS 2011, 2015 and 2019, it is seen that ecosystems topic including ecological processes and interactions has the highest number of objectives in biology domain for eighth grade students.

Ecosystem as a quite complex system includes living and nonliving components which are in constantly direct and indirect interaction within each other and all other ecosystems. The understanding of ecosystem concepts needs ability to see the physical, chemical and biological world in a wide perspective. Although it was claimed that eighth grade Turkish students perceived Living Things and Energy topics as the least difficult unit among all other science units in their grade level (Tuncel & Fidan, 2018), the studies assessing their understandings of ecosystems revealed that middle school students, high school students, pre-service teachers and even science teachers have poor understandings about ecological concepts (Acebal, & Prieto, 2018; Grotzer et al., 2010; Özkan, Tekkaya & Geban, 2004; Jordan, Gray & Demeter 2009; Jin et al., 2019, Yörek, Uğulu, Şahin & Doğan, 2010).

Further, understanding ecosystems is crucial since all life forms including human are dependent to ecosystems to survive. Ecosystems provide a broad assortment of services such as drinking water, food, nutrient cycle, agricultural irrigation, climate regulation, and recreation for human benefits. It makes society responsible to protect natural ecosystems. Nevertheless, the value of ecosystem services is not appreciated by society fully. Millennium Ecosystem Assessment (MA, 2005) reported that global human-induced change on ecosystem over the last 50 years is more rapid and extensive than in any time in human history. Growing human population and higher demands on ecosystems cause more degradation of ecosystems; therefore, it jeopardizes not only human well-being, but also all biosphere.

Within the scope of this study, this study aims to develop students' science process skills, epistemological beliefs, and students' understandings of a lake ecosystem through Lake Eymir Education Program. This program was designed based on the inquiry-based learning approach and it consists of in-class activities, fieldworks and meet-a-scientist seminars.

1.1 Significance of the Study

The major shifts in science education curriculum of developed countries around the world were towards constructivism approach. Instead of acquiring the information, constructing knowledge in schemas provides students become more active and engaged in learning process in science education so that learning becomes more permanent and meaningful. Inquiry-based learning under constructivism approach is a way to students being active in science classrooms. While the constructivism approach had taken a place in Turkish science curriculum in 2005, Ministry of National Education of Turkey determined inquiry-based learning an instructional method in constructivism framework in the recent science curriculums (MoNE, 2013; 2018). The treatment in this study was designed by inquiry-based learning under constructivism root for middle school students. Thus, this study is significant to reveal the results of examining the effectiveness of inquiry-based learning on students.

By inquiry-based learning, students go through the stages of orientation, questioning, hypothesis generation, exploration, experimentation, data interpretation, conclusion, communication and reflection (Pedaste et al., 2015). These stages are very similar to the processes which scientists experience. Scientists; for instance, define and modify, variables, make observation, predict, gather data and experimenting. Teaching these skills called science process skills is one of the main goals of science education. Students working on scientific knowledge needs also sophisticated beliefs about nature of knowledge and knowing. The call for a need for students to develop science process skills and scientific epistemological beliefs is clear, especially taking notice of global assessments PISA and TIMMS results that show the importance of thinking like a scientist. Moreover, these skills and beliefs are beneficial to students in their school, work and life. This study aims to develop students' science process skills and scientific epistemological beliefs; therefore, it is important to take a step toward meeting global competences of students.

Apart from science process skills and scientific epistemological beliefs, building academic knowledge is an important component of science education. Science education attach great importance to ecosystems topic by considering the threat of ever-growing degradation of ecosystems. The significance of understanding of ecosystems topic was underlined by worldwide assessments as well. The current study presents a solution to blend science process skills, epistemological beliefs and ecosystem topic in the same program.

In Turkey, middle school students usually learn ecosystems with in-classroom activities under the root of formal education. Students conceptualizing all dynamism of an ecosystem in mind is neither easy nor fun for them without practicing the topic in real life. Besides this, teachers have difficulties to make students feel engaged to learn a natural ecosystem inside concrete buildings. In the study of David Orr (1992, p.207), it was stated that "education that supports and nourishes a reverence for life would occur more often out-of-doors and in relation to the local community". According to him, the education also should help people to be ecologically literate and understand how nature works (Orr, 1992). Similarly, in his well-known old book, The School and Society: The Child and the Curriculum, John Dewey (1902) as a psychologist mentioned that practice in nature is important as much as subject matter. Additionally, a wide range of studies from psychology to education offer education in nature and supporting greener learning settings since students become calmer, feel comfort and become more open to have social interaction (Haase & Hille, 2010; Kuo, Barnes & Jordan, 2019). Notwithstanding these benefits limiting students with in-class activities is not effective for them to learn ecosystems while excluding them from nature. Students need to practice what they have learned in-class by experiences in nature.

When students and the teacher meet with nature, ecosystem topic can be combined in a scientific way which students can do experiments. This scientific active engagement with the external world was described as fieldwork by The UK Quality Assurance Agency (QAA, 2002). Fieldworks are the outdoor activities which students make scientific experiments; in contrast to field trips which students walk around without interacting anything for scientific purposes. The current study encourages students to be in contact with major natural ecosystem components, mainly animals, plants, soil, and lake water, and to help them to comprehend their surroundings in a scientific way. Taking the call for instructional materials on ecosystem topic (Yücel & Özkan, 2015) into account, this study presents an example of developing students' understanding of ecosystems with in-class activities and fieldworks activities through inquiry-based learning in the line of national science curriculum.

Students' understanding of ecosystems assessed by drawings in the present study, in contrast to common quantitative tests about assessing students' understandings.

Drawing helps to reveal how students understand the components of ecosystem and relationships, instead of asking students to guess and pick one answer from a list of answers. Although drawing tests are used by many studies conducted to examine students' understandings of environment or ecosystem in general, there was no study found that investigate particularly the lake ecosystem understandings of students by drawing. Furthermore, there are very limited experimental studies aiming to develop students' understandings of ecological concepts. The current study contributes empirical evidences to literature by investigating students' understanding of the lake ecosystem through drawings.

In addition to in-class and fieldwork activities, Lake Eymir Education Program presents an example of bringing scientists and students together by meet-a-scientist seminars, which allow students having the opportunity to communicate, observe and work together with real scientists. Since, middle school students' image of scientists influences students' interest and attitudes toward learning science (Özel, 2012), this opportunity may help students to have positive views about science and scientists.

By inquiry-based learning, students seek for answers to questions about understanding the natural world just like scientists do. What scientists do may contain designing activities too. Scientists make designing and take the role of designers in scientific activities sometimes by being unaware of doing it (Braha & Maimon, 1997). Students acting beyond scientists and use their scientific knowledge to build engineering designs to solve real-world problems is also important because solving real-world problems is the aim of science education. In this view, Turkish national curriculum suggests middle school students to do science and engineering applications by transferring their scientific academic knowledge to real life to solve real-world problems (MoNE, 2018). In parallel with science curriculum, there were also two different engineering design activities under the root of inquiry in Lake Eymir Education Program. These activities were performed as partially in-class activities and fieldwork activities in order to allow students experiencing different learning opportunities and real-world problems, while they use scientific knowledge.

As a whole, inquiry-based Lake Eymir Education Program was designed to blend in-class activities, fieldwork activities and meet-a-scientist seminars to allow students developing science process skills, epistemological beliefs and understandings of a lake ecosystem.

1.2 Problem Statement

The purpose of present study is to examine the effectiveness of inquiry-based Lake Eymir Education Program on seventh grade students' science process skills, epistemological beliefs and understandings of a lake ecosystem. Furthermore, the students' views about the education program are investigated.

1.2.1 Research Questions

1. What are the effects of an inquiry-based Lake Eymir Education program on seventh grade students' science process skills, scientific epistemological beliefs and understandings of a lake ecosystem?

   1.1 To what extent does Lake Eymir Education Program influence seventh grade students' science process skills?

   1.2 To what extent does Lake Eymir Education Program influence seventh grade students' epistemological beliefs?

   1.3 In what way does Lake Eymir Education Program influence seventh grade students' understandings of a lake ecosystem?

2. What are seventh grade students' views about Lake Eymir Education program?

1.3 Hypotheses

Null Hypotheses:

> $H_0$1: There is no statistically significant difference in the scores of science process skills of 7th grade students before and after the treatment.
>
> $H_0$2: There is no statistically significant difference in the scores of epistemological beliefs of 7th grade students before and after the treatment.

1.4 Definitions of the Terms

Scientific Inquiry: “The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” (NRC, 1996, p.23)

Inquiry-based Learning: “Something that students do, not something that is done to them” (NRC, 1996, p.2)

Science Process Skills: Skills used by scientists to predict, explain phenomena and solve the problem (Carin et al., 2005)

Epistemological Beliefs: Beliefs of the nature of knowledge and knowing (Hofer & Pintrich, 1997).

Ecosystem: “A dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit” (Millennium Ecosystem Assessment, 2005, p.3)

Lake Ecosystem: The physical, chemical and biological processes in lakes and their interaction

CHAPTER 2

LITERATURE REVIEW

This chapter presents a brief literature review and the studies related to the important concepts of the study. At the beginning of this chapter, the theoretical framework of inquiry-based learning and related studies in science education are given. On this ground, scientific epistemological beliefs and science process skills are explained by covering the empirical studies instructed with inquiry-based learning. In the last part, understandings of ecosystem concepts in the literature and the effectiveness of inquiry-based learning on these understandings are explained.

2.1 Inquiry-based Learning

2.1.1 Constructivism as a Theoretical Framework

Constructivism is well-known learning theory the foundation of which was laid by Socrates and Aristoteles thousands of years ago. The concern of this theory is the way knowledge is constructed in human mind and the way learning occurs. In 20^{th} century, educational theorists particularly Jean Piaget, John Dewey, Jerome Bruner and Lev Vygotsky made important contributions for developing constructivism theory. Under the light of their contributions, the constructivism theory was disunited in two major categories; cognitive and social constructivism (Fosnot, 1996), although the area continued to grow by contributions such as radical constructivism (Glaserfeld, 1984) and cultural constructivism (Hutchinson, 2006).

Cognitive constructivists claim that building knowledge for learning needs a process; it is dynamic, interactive and independent activity (Bybee, 1997; Piaget, 1952; Papert 1980; Tobin & Tippins, 1993). As Glasersfeld (1995) said that “concepts cannot simply be transferred from teachers to students; they have to be conceived" (p.2). In cognitive constructivism, knowledge is built through description and reflections of individuals' experiences the world (Bereiter, 1994; Piaget, 1970; 1976; Tam, 2000). Conversely, in social constructivism, knowledge is built by social interaction with other individuals (Vygotsky, 1978).

In constructivist theories, feeling motivated and be ready for taking new information to construct knowledge is important. The motivation is driven by intrinsically such as by curiosity, enjoyment and purpose in cognitive constructivism; while social constructivism has both extrinsic motivation such as rewards, fear of failure, and intrinsic motivation. After learners become motivated and ready for learning, they need to have experiences the world.

In constructivism, it is stated that the reality of world and knowledge can be different (Driscoll, 2000). The reason is that people having different experiences leads perception of world is defined as objective (Jonassen, 1991; Moussiaux & Norman, 2003). According to Piaget (1962), experiencing the same information individually and practicing the same situation creates patterns, schema, in children mind. As long as new experiences were met, these mental patterns are either being added in old schemas, namely assimilation or completely new schemas are constructed, namely accommodation. From point of his well-known theory, cognitive development theory, the equilibration of unbalance state between assimilation and accommodation results in cognitive growth.

In the book *Developing Inquiry*, Suchman (1960) who is a leader in developing inquiry-based learning, came up with the idea of discrepant events to create unbalance state in students' minds. These events are described unexpected outcomes which led the learner questions his/her own prior knowledge. For example, stabbing a balloon by a skewer passed through balloon without the balloon pops. Discrepant events increase students' curiosity and increase their motivation.

On the contrary to assimilation and accommodation terms, Vygotstky (1986) asserted that learning occurs through social interaction in addition to personal experiences. He emphasized on learning occurring in an environment where the cultural and social effect are (Lemke 2001; Palincsar 1998; Richardson, 1999; Wertsch, 1991) more than individual effect. In social context, adult guidance and peer work were highlighted as important for social constructivism learning theory (Dewey, 1938; Vygotsky; 1962, 1978). Vygotsky divided learning activity into two different parts; learning among other people, namely inter-psychological, and learning inside the individual, namely intra-psychological. By this separation, he pointed that children's development has social factors and, communicating with someone else is essential for development in learning.

Biological maturation is also important in constructivism. Inhelder and Piaget (1958) proposed four stages of cognitive development. Formal operational stage was the final stage of four and it was referring adolescence around twelve years old to adulthood. This stage is described as the time individuals start to think abstract concepts and relationships without the need of interacting with physical objects. Their thinking turns to be systematic in which they are able to think about cause and effect relationships and assess probabilities and what if conditions.

The nature of constructivist theories as being active in learning, the need of new individual experiences as well as the need of scaffolding in a social context, and cognitive development stages changed the views about formal education. The pedagogical studies shifted towards progressive education; which refers the opposite of traditional teaching methods.

In this "Progressive Education Movement", John Dewey (1897), the architect of the base of inquiry-based learning, described the definition of education, school, subject matter, method and social progress. To him, students were passive and not curious about the knowledge; so there has been problems emerged. He realized the need of giving students something they can work in classrooms, instead of listening (Dewey, 1899) and he made suggestions for teachers engaging students to learning through keeping curiosity alive by his own words in the book, *How We Think*:

> With respect then to curiosity, the teacher has usually more to learn than to teach. Rarely can they aspire to the office of kindling or even increasing it. Their task is rather to keep alive the sacred spark of wonder and to fan the flame that already glows. Their problem is to protect the spirit of inquiry, to keep it from becoming blasé from overexcitement, wooden from routine, fossilized through dogmatic instruction, or dissipated by random exercise upon trivial things (Dewey, 1910, p. 10).

Via the claim of learning by doing that refers students carrying out activities actively by themselves asserted (Dewey, 1933), constructivists debated extensively about the teacher's and students' positions in constructivism classrooms alongside the lesson design. Researchers define teachers as facilitators in constructivist classrooms (Atwater 1996; Barak & Dori 2009; Fosnot, 2005; Tam, 2000). Teachers' duty in these constructivist classrooms were claimed to draw a path based on curriculum objectives and content for students to walk on and let students explore (Kember & Leung 1998; Hmelo-Silver, Duncan & Chinn, 2007). Moreover, in order to eliminate misusing or misunderstanding constructivism in education literature and make the fact that constructivism is learning theory, not a teaching method, four essential criteria for constructivist learning environments were advocated by Baviskar, Hartle and Whitney (2009):

1. Eliciting prior knowledge: The learner reveals the prior knowledge of the learner to relate it with new knowledge.

2. Creating cognitive dissonance: The learner is aware that his/her prior knowledge is insufficient and feels a need to acquire new knowledge.
3. Application of the knowledge with feedback: The learner interprets his/her prior knowledge, change it with new knowledge, and relate the new knowledge in a wide range of contexts.

4. Reflection on learning: The learner reflects the new knowledge that s/he has learned.

By taking into consideration constructivist learning framework, inquiry-based teaching offers a method for constructivism.

2.1.2 Inquiry-based Science Teaching

According to National Science Education Standards (NSES), inquiry is a learning process where students actively engaged in learning by "doing science" (National Research Council [NRC], 2000, p. 13). To promote an inquiry-based learning environment for students to do science, inquiry-based science teaching is important.

Teaching science through inquiry and *teaching science as inquiry* have different meanings although both terms have been used as *inquiry-based science teaching* in the literature. *Teaching science through inquiry* refers "having students take part in inquiry investigations to help them acquire more meaningful conceptual science knowledge"; while *teaching science as inquiry* refers "helping students understand how scientific knowledge is developed" (Lunetta, Hofstein & Clough, 2007, p. 396). To teach effective inquiry-based teaching, five fundamental criteria in science classroom with inquiry instruction established in the book, Inquiry and the National Science Education Standards (Table 2.1).

Table 2.1 Essential Features of Classroom Inquiry and Their Variations (NRC, 2000, p.29)

Essential Feature	**Variations**			
1. Learners are engaged by scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Leaner sharpens or clarifies question provided by teacher, materials or other source	Learner engages in questions provided by teacher or other source
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions. 3.	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
4. Learners formulate explanations from evidence to address scientifically oriented questions.	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence and how to use evidence to formulate explanation
5. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
6. Learners communicate and justify their proposed explanations.	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use sharpen communication	Learner given steps and procedures for communication
	More ------------------	Amount of learner self-direction	------------------	Less
	Less ------------------	Amount of direction from teacher or material	------------------	More

According to Table 2.1, it was stated that inquiry-based science teaching regarding the teacher's guidance are ranged more to less in several variations; for instance, the teacher can give directives to students more by proving a data set and analyzing method in an inquiry. All classroom activities including five fundamental features as *full inquiry* in the United States national science education standard document, *e*ven though inquires not following the sequence were called as *partial* inquiry in the related literature (*N*RC, 2000). These variations of inquiry instruction have been also much debated issue in the literature.

Researchers examined inquiry instruction into three, four, five or six levels (Colburn, 2000; Herron, 1971; Schwab, 1962; Shulman & Tamir, 1973; Sutman, Schmuckler & Joyce, 2008; Furtak, 2000; McComas, 2014; Banchi & Bell, 2008). For example, Furtak (2006) mentioned guided inquiry instruction between two edges of continuum of science instruction that were direct science instruction and open-ended science instruction. In addition to the levels in this continuum, Banchi and Bell (2008) introduced one more level of teaching inquiry. According to their four levels of inquiry instruction, c*onfirmation inquiry* is where traditional scientific activities in classrooms or laboratories where students follow predetermined directions of teachers of textbooks. The results of all students match with each other. In these "cookbook" experiences, the participation of teacher into activity is the highest among inquiry levels. In *structured inquiry* level of instruction, the results of students' experiments differentiate from each other, while the question and procedure were provided by the teacher. In *guided inquiry* level, students become more involved in the procedure. The ways which students examining the problem are varied. During *open inquiry*, students become responsible for questions, procedure and solution and the guidance from teacher becomes the lowest among all inquiry levels.

Similar to Bachi and Bell (2008), Sutman et al. (2008) mentioned the roles of the teacher and students in inquiry classrooms. In their matrix, the level in which students are passive and the teacher is always active was called zero level inquiry instruction

In the matrix of their inquiry instruction in Table 2.2, there are three phases and two sub-phases for each experience. These phases include pre-laboratory, during laboratory and post-laboratory experiences. The activity of students gets increased in each level of instruction and from pre-laboratory to post-laboratory. The instructions in even zero level of inquiry instruction are different from traditional classrooms' instructions in terms of several points. Firstly, the lesson starts with questions taking attention of students and making them curious about the topic in every level of inquiry instruction; contrary to the teacher directly introducing the topic to students in traditional instruction. Also, the students take physical or mental responsibility in activities or experiments and the results, even if the teacher is active in all five phases of inquiry instruction. They think about what is being learned, instead of just watching the teacher. Another difference is that the students taught by inquiry instruction reach an open-ended summary leading other inquires in the field; while the students taught by traditional instructions consider limited and close-ended summary (Sutman et al., 2008).

Table 2.2 Levels and Phases of Inquiry Instruction (Adapted from Sutman et al., 2008)

	Phase				
	Pre-Laboratory		Laboratory	Post-Laboratory	
Level	*Inquiry* (Proposing problem or issue)	*Method* (Plan a procedure to be explore)	*Investigation* (Carries out an activity or experiment, observe or collect data and analyze data or results)	*Conclusion* (Summarize answers or explanations)	*Extension* (Considers how the discoveries can be applied or can lead to other inquiries)
0	Teacher	Teacher	Teacher	Teacher	Teacher
1	Teacher	Teacher	Teacher	Teacher	Students
2	Teacher	Teacher	Teacher	Students	Students
3	Teacher	Teacher	Students	Students	Students
4	Teacher	Students	Students	Students	Students
5	Students	Students	Students	Students	Students

Besides, Sutman et al.'s framework with five phases, there has been already a growing interest into eventuating inquiry phases with different explanations in lines or cycles. For example, Llewellyn's (2002) 5E inquiry cycle includes the stages of engage, explore, explain, elaborate and evaluate. Gutwill and Allen (2012) defined four stages for inquiry; asking questions, making predictions, designing experiments and analyzing data.

Pedaste et al.'s (2015) reviewed the education literature systemically about the cores of inquiry cycles used in inquiry-based instruction. Their study included 32 journal articles between the years 1972-2012 in EBSO host Library database. At the end of the review, the framework constructed had five phases, nine sub-phases and their frameworks show the relations between phases (Figure 2.1). This framework made the inquiry-based learning clearer by summarizing the literature.

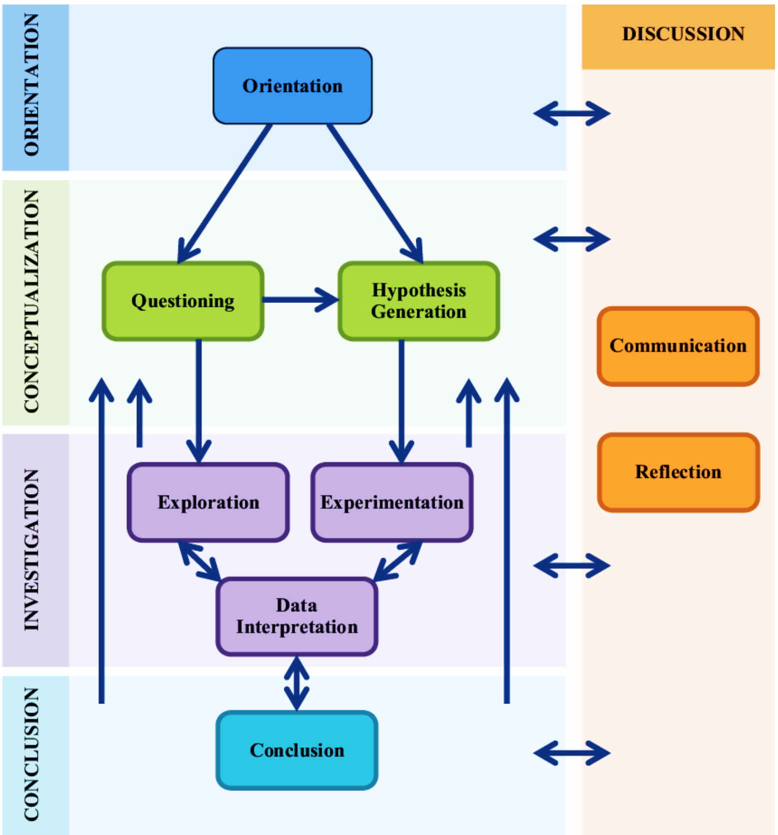


Figure 2.1 Inquiry-based learning framework (Pedaste et al., 2015)

Comparing the traditional learning methods such as direct instruction, inquiry-based learning has been reported more effective according to the synthesis, reviews and meta-analysis that conducted from even 50 years ago till today (Bittinger, 1968; Hermann, 1969; Alfieri et al., 2011 as cited Lazonder & Harmsen, 2016). Since the science curriculum was changed in the favor of inquiry-based learning, the researchers' concerns shifted from comparing the effectiveness of traditional and inquiry classrooms on students into comparing the effectiveness of different amount of teacher's guidance in inquiry-based activities.

Minner, Levy and Century (2010) made a wide-scale research about the effects of inquiry-based science instruction on K-12 students' learning. Their research included outcomes of 138 studies conducted in 18 following years between 1984 and 2002. Almost all of studies were carried out in the United States. The majority of providers of instruction were regular classroom teachers. The result of their *Inquiry Synthesis Project* indicated that more than half of studies had positive effect of inquiry-based science instruction on the student content learning and retention. Higher inquiry saturation, where students become more active and using more hands-on activities, were significantly increased students' likelihood of understanding science contents rather than lower inquiry saturation. Additionally, there was no significant effect of inquiry saturation and all learning outcomes; but increased students' conceptual learning. Finally, it was reported that students' active thinking and participation in inquiry phases affected their conceptual learning positively.

In a recent meta-analysis of Furtak, Seidel, Iverson and Briggs (2012), 22 studies which had examined the effects of inquiry-based instruction and published between the years 1996-2016 were reviewed. Their purpose was exploring the effect of different guidance level in inquiry-based instruction on students' learning. These studies were in domain of science and the levels of students were ranging from middle school to high school. The results showed that teacher-guided inquiry classrooms had higher effect size than student-guided inquiry.

Lazonder and Harmsen (2016) investigated 65 educational studies in science domain and 5 studies in mathematics which were instructed by inquiry-based learning. Their aim was to examine the effect of guidance level on inquiry-based learning outcomes. The varieties of guidance in these studies were ranged as “scaffolds, explanations, prompts, heuristics, status overview, and process constraints”. The results showed that guidance in inquiry-based learning has a significant positive effect on inquiry learning activities, performance success and learning outcomes. The highest positive effect was on performance success.

Aktamış, Hiğde and Özden (2016) reviewed 19 studies about the effects of traditional instruction and inquiry-based instruction on students’ science achievement, science process skills and attitudes toward science. Their meta-analysis was covering experimental studies conducted in Turkey in a decade after year 2005-2015. The result of their research revealed that there were positive effect sizes of students’ science academic achievements, science process skills and attitudes toward science in the favor of inquiry-based learning. The highest effect size in these three variables was of science achievement scores of students.

In practical of inquiry-based instruction, researchers claimed that teachers and pre-service teachers faced with many difficulties such as lack of knowledge about the inquiry-based instruction, dispute in learning styles, classroom management, the assessment techniques, lack of materials for usage in the classroom or laboratory, prearranged content and time limitation (Anderson, 2002; Bayram, 2015; Gejda & LaRocco, 2006; Lotter, Harwood & Bonner, 2006; Goossen, 2002, Krauss, 2008; Marx et al., 2004; Tairab & Al-Naqbi, 2017). These challenges of promoting inquiry-based activities result in unsatisfying outcomes on students’ science learning.

Taking into account of the constructivism framework, the nature of inquiry-based learning and the studies conducted in this area, the focus point of current study is developing students' scientific epistemological beliefs, science process skills and understandings of a lake ecosystem through inquiry-based science instruction.

2.2 Scientific Epistemological Beliefs

2.2.1 Characteristics of Scientific Epistemological Beliefs

Epistemology, as a major branch of philosophy, deals with understanding what knowledge is, how knowing occurs and how knowledge is justified by individuals. The subjective beliefs regarding the nature of knowledge and knowing are defined as epistemological beliefs (Hofer, 2002). The levels of epistemological beliefs vary in different fields such as science, mathematics, psychology and medicine (Buehl, Alexander & Murphy, 2002; Hofer, 2006). The scientific epistemological beliefs were differentiated from epistemological beliefs by focusing only on individuals' beliefs about the nature of scientific knowledge and scientific knowing (Schommer & Walker, 1995; Buehl et al., 2002).

For five decades, the researchers in the field of psychology and education have interested in understanding individuals' epistemological development and epistemological beliefs. Starting with longitudinal works of the psychologist William G. Perry (1968; 1970) on college students, there have been various schemes of epistemological beliefs' growth were constructed (Baxter-Magolda & Porterfield, 1985; Belenky, Clinchy, Goldberger & Tarule, 1986; Kuhn, 1991; Knefelkamp, 1974; Knefel & Slepitza, 1978; King, Kitchener, Davison, Parker, & Wood, 1983).

In his sequential model, Perry defined nine positions under four stages of intellectual and ethical development; *dualism, multiplicity, relativism* and *commitment in relativism* based on the data by interviews and questionnaires (Table 2.1). According to him, position of students in learning concept was changing from dualism stage, when students view right and wrong knowledge was determined by only a certain authority in an absolute level, towards the stage commitment in Relativism, when students experienced the world by being the part of the authority and developing commitment to values and beliefs of accepted truth and other people (Perry, 1970).

Perry's work inspired Belenky and her colleagues (1986) to study with women by claiming that Perry worked with mostly male students. They generated Women's Ways of Knowing Model with five different perspectives, instead of a model with epistemological developmental stages. In first perspective of their model, *silence*, women stayed in silent by thinking that the knowledge is absolute and determined by an authority. In second perspective, they *received knowledge* by thinking that every question has only one true answer; except this, all other answers are wrong. Women started to see themselves as a source of knowledge in their own experiences in *subjective knowledge* perspective. They interpret their own experiences critically in *procedural knowledge* within orientations of *separated knowing* and *connected knowing.* They finally thought that knowledge was constructed wrong or right by every individual in *constructed knowledge* perspective (Table 2.1).

Baxter Magolda (1992) used Perry's four positions and Belenky et al.'s five perspectives to analyze the data that she gathered from a mixed gender sample of college students. Her work showed four pointed ways of knowing through Epistemological Reflection Model. Students thought that knowledge is certain and determined by an authority in *absolute knowing.* Uncertainty of knowledge appeared in *transitional knowing,* and students thought that not all truth is known by the authority. Students thought that true knowledge comes from not only authority but also other individuals in *independent knowing* and knowledge reconstructed by justifying new situations.

Different than the models of Perry, Belenky et al., and Baxter Magolda, the sample of King and Kitchener's (1994) study was containing high school students as well as adults to understand epistemological beliefs of participants about the nature of knowledge. King and Kitchener's Reflective Judgment Model, there were seven stage introduced within three levels (Table 2.1). It was thought that knowledge was certain and individual experiences are not valid for true knowledge in *pre-reflective* level of the model. The thoughts that knowledge is not certain and every individual has own knowledge appeared in the second level *quasi-reflective*. In *reflective* level, knowledge was thought as an outcome of justification of knowledge by each individual. This level was similar to Baxter Magolda's justification of knowledge according to new situations.

Similarly to King and Kitchener's (1994) study, Argumentative Reasoning Model was developed by using adolescence as a sample in Deanna Kuhn's (1991) study. The findings of the study were collected in three epistemological views. In this model, adolescence's thought was found very similar to adults in other studies and they were called as *absolutists* due to their views that knowledge is certain and known by experts. *Multiplists* had views that experts varied in commenting the knowledge and knowledge is certain. *Evaluatists* viewed that knowledge is uncertain and justifications of different knowledge determines the truth.

In contrast to the studies conceptualizing epistemological beliefs as a whole including the work of Perry (1970), Schommer (1990) claimed that epistemological beliefs are not composed of one dimension (Table 2.3). She described epistemological beliefs under at least five dimensions which are 'independently' developed. In other words, an individual's epistemological beliefs can be sophisticated in one dimension and can be naïve in one dimension (Schommer, 1990; 1993). The flexibility of thinking was defined as *fixed ability* and it is ranged from fixed epistemological beliefs at birth to be open to change of epistemological beliefs. *Quick learning* refers the variance of individuals' speeds of learning and ranged from changing the epistemological beliefs fast to slow. *Simple knowledge* indicates the structure of knowledge ranging from unrelated and simple to related and complex. *Certainty knowledge* is the certainty of knowledge ranging from absolute right or absolute wrong to tentative knowledge (Buehl, 2003; Schommer, 1990; Schommer-Aikins, 2002).

Hofer and Pintrich (1997) criticized Schommer's fixed ability and quick learning dimension in terms of being not related with what knowledge is or how knowledge is justified. According to them, the certainty of knowledge and simplicity of knowledge are the sub-dimensions of *nature of knowledge*, while the source of knowledge and justification for knowing are the sub-dimensions of *nature of knowing*. Also, they differentiated the individuals' epistemological beliefs as *received* view and *reasoned* view indicating that justification is critical in epistemological beliefs to evaluate knowledge (Saunders, 1998).

Conley, Pintrich, Vekiri and Hannison (2004) designed a model of epistemological beliefs by using four dimensions of Hofer and Pintrich's (1997) study. The *source* and *certainty* dimensions represented the epistemological beliefs of individuals on nature of knowing; while *development* and *justification* concerned with nature of knowing. They also designed a questionnaire which researchers in science education used.

Table 2.3 Models of Epistemological Beliefs Development (Adapted from Hofer & Pintrich, 1997)

Model	**Researcher(s)**	**Epistemological Beliefs' Positions**	**Core Dimension**	**Dimension**
Intellectual and Ethical Development	Perry (1968, 1970)	• Dualism • Multiplicity • Relativism • Commitment within relativism	Certainty of knowledge Source of knowledge	Single-dimensional
Women's Ways of Knowing	Belenky et al. (1986)	• Silence • Received Knowledge • Subjective knowledge • Procedural knowledge (a) Connected knowing (b) Separate knowing • Constructed knowledge	Source of knowledge	Single-dimensional
Epistemological Reflection	Baxter Magolda (1988, 1992)	• Absolute knowing • Transitional knowing • Independent knowing • Contextual knowing	Certainty of knowledge Source of knowledge Justification for knowing	Single-dimensional
Reflective Judgment	King and Kitchener (1994)	• Pre-reflective thinking • Quasi-reflective thinking • Reflective thinking	Certainty of knowledge Simplicity of knowledge Source of knowledge Justification for knowing	Single-dimensional

Note: The Positions were ordered from naïve to sophisticated epistemological beliefs.

Table 2.3 (Continued)

Model	**Researcher(s)**	**Epistemological Beliefs' Positions**	**Core Dimension**	**Dimension**
Argumentative Reasoning	Kuhn (1991)	• Absolutists • Multiplists • Evaluatists	Certainty of knowledge Source of knowledge Justification for knowing	Single-dimensional
Independent Epistemological Beliefs	Schommer (1990)	• Fixed ability • Quick learning • Simple knowledge • Certain knowledge	Certainty of knowledge Development of knowledge Source of knowledge Justification for knowing	Multi-dimensional
Epistemological Belief Model of Hofer & Pintrich	Hofer & Pintrich (1997)	• Nature of knowledge (a) Certainty of knowledge (b) Simplicity of knowledge • Nature of knowing (a) Source of knowledge (b) Justification for knowing	Certainty of knowledge Development of knowledge Source of knowledge Justification for knowing	Multi-dimensional
Epistemological Belief Model of Conley et al.	Conley et al. (2004)	• Source • Certainty • Development • Justification	Certainty of knowledge Development of knowledge Source of knowledge Justification for knowing	Multi-dimensional

Note: The Positions were ordered from naïve to sophisticated epistemological beliefs.

2.2.2 Empirical Research on Developing Scientific Epistemological Beliefs

Developing epistemological beliefs of students has been the concern of educational studies. One group of researchers in literature investigated the effect of students' epistemological beliefs on such variables as academic achievements (Conley et al., 2004; Dorman, 2001; Evcim, 2010, Hofer & Pintrich, 1997; Hofer, 2000; Pamuk, 2014; Schommer, 1990; Schommer 1993, Schreiber & Shinn, 2003; Stathopoulou & Vosniadou, 2007; Tolhurts, 2007, Topçu & Yılmaz-Tüzün, 2009, Uğraş, 2018), learning approaches and quality of learning (Brownlee, Purdie & Boılton-Lewis, 2001; Buehl & Alexander, 2001; Deryakulu, 2004). Apart from these researchers explaining why epistemological beliefs of students need to be developed, another group of researchers examined how these epistemological beliefs can be improved. Within this scope, they examined the influences of different variables such as experiences (Belenky et al., 1986; Schommer, 1994), social interaction (Bendixen, 2002), learning approach (Aypay, 2011; Chan, 2003) and teachers' epistemological beliefs (Brownlee, Boulton-Lewis, & Purdie, 2002; Chan, 2008) on students' epistemological beliefs.

Empirical research in development of students' epistemological beliefs started with the Perry's (1970) study that had obtained the data by interviews and checklist from liberal art students in two different universities. His study leaded many debates due to focus one dimensional change. Schommers' (1990) four-dimensional model's instrument, Epistemological Questionnaire (SEQ) with 63-items was an alternative to debates. It was revised by Schraw, Bendixen, and Dunkle (1995; 2002) and its final version had five dimensions with 28-items in total. In that revision, the new dimension *omniscient authority* was added and the name of *fixed ability* was changed into *innate ability*. The last three dimensions of Schommer's model; *quick learning, simple knowledge and certain knowledge* did not change. This Epistemological Beliefs Inventory developed by Schraw et al. (2002) translated and adapted into different languages such as Chinese (Chan, Ho & Kun, 2011; Wang, Zhang, Zhang, Hou, 2013), German (Paechter et al., 2013), Korean (Jeong, 2003) and Turkish (Cam, Topçu, Sülün, Güven & Arabacıoğlu, 2012; Deryakulu & Büyüköztürk, 2002; Dinç, İnel & Üztemur, 2016, Yılmaz-Tüzün & Topçu, 2008). These instruments have been popular to assess undergraduate especially pre-service teachers and high school students. On the other hand, the Epistemological Beliefs Questionnaire, with 26-items, 5-point Likert scale along four dimensions, adapted by Conley et al. (2004) from Elder's (2002) work has been used generally on middle school students.

In their experimental study, Conley et al. (2004) collected data in two different times from 187 fifth grade students in five different middle schools during nine weeks. In this period of time, students were provided with inquiry-based instruction and hands-on activities in the unit of chemical properties of matter. It was found that students' epistemological beliefs about source and certainty of knowing were improved after implementation; while there was no significant change in their epistemological beliefs about development of knowledge and justification for knowing.

Smith, Maclin, Houghton, and Hennessey (2000) studied on the same 35 students in different schools from first grade through sixth grade for more than five years. One of the classrooms was determined as constructivist classroom, while another one was comparison classroom where traditional teaching methods utilized. At the end of qualitative data collection by interviews after implementations, it was concluded that students' epistemological beliefs of science in constructivist classrooms were developed. Students significantly had a better understanding that the body of scientific knowledge is growing and there are differences on individuals' initial thoughts.

Zaleta (2014) studied on the effectiveness of different types of inquiry instruction; open or structured. The sample of the study consisted of 303 sixth students in 17 intact classes in northeastern middle school. Nine of these classrooms were randomly assigned as experimental group and 8 classrooms as comparison group. The experimental groups were provided open-inquiry approach by two teachers as treatment; while comparison group had guided-inquiry approach by other two teachers. Epistemological Beliefs Questionnaire of Conley et al. (2004) and semi-structured interviews were applied on students twice in two months. The questionnaire was aiming measuring students' level of epistemological beliefs; while the interviews were aiming students' evaluations of their thoughts about learning environment. The results revealed that the inquiry-based learning was effective but the type of inquiry instruction has no significant difference on developing students' epistemological beliefs.

Considering Turkish experimental studies on scientific epistemological beliefs, Kaynar (2007) investigated the effectiveness of 5E learning cycle approach on 160 sixth grade students. Two of four intact classes were randomly assigned as control group and took direct teaching over three weeks. The same science teacher implemented the treatment about the cell, organelles and transportation of matter within cell concepts in experimental classes. The quantitative data were collected before and after treatment via using Epistemological Beliefs Questionnaire of Conley et al. (2004). The results of his study showed that sixth grade students who learned cell context through 5E learning cycle approach became significantly more sophisticated in epistemological beliefs than students who learned the same context from same teacher through direct instruction.

In a similar study, Gök (2014) examined the impact of 7E learning cycle approach on 185 sixth grade students in six intact classes. Half of these classes were randomly assigned as experimental group and another half as comparison group. The topic was three body systems; skeletal system, circulatory system and respiratory systems. Conley et al.'s (2004) epistemological beliefs questionnaire was used again in this study for gathering data. The results of students' scores in pre-test and post-test showed that the epistemological beliefs of students instructed with 7E learning approach were significantly developed in terms of source dimension. Students' scores of epistemological beliefs got raised in certainty, development and justification dimensions; however, these changes were insignificant.

Apart from investigating the effects of learning cycles, Tucel (2016) carried out a study with 60 eighth grade students in two different classes to examine the effects of Science Writing Heuristic approach on students' epistemological beliefs. The class assigned as experimental group and instructed with science writing heuristic approach for 13 weeks. Within this approach, students used scientific methods in laboratory activities through inquiry. The context of implementation consisted of four consecutive science units; sound, living things and energy, states of matter and heat and electricity. Conley et al.'s (2004) Epistemological Beliefs Questionnaire was used in data collection before and after treatment. The results indicated that students' epistemological beliefs instructed with science heuristic approach had significantly more developed. There was no significant change in source and certainty dimensions in both groups.

2.3 Science Process Skills

2.3.1 Characteristics of Scientific Science Process Skills

In the learning process, understanding scientific concepts is not always enough to be knowledgeable. Students need to apply scientific knowledge into real situations to comprehend the world in a better way and be equipped with this knowledge to solve the daily life problems (Germann, 1994). For achieving these, experiencing the way scientists reach information is commonly suggested in science learning.

The skills used by scientists in scientific processes are basically named as science process skills, although various definitions were proposed in different studies. Gagne, Yekovich and Yekovich (1993) named science process skills as the skills for solving problems in a systematical way. Ayaş, Çepni, Johnson and Turgut (1997) described science process skills as the skills facilitating science learning, developing students' sense of responsibility in learning process, developing methods of investigation and increasing permanence of learning.

Science process skills were popularized around 1970s by highlighting the mastery of science process skills more than science concept in Science-A Process Approach (SAPA/SAPA II). This approach by American Association for the Advancement of Science with 105 modules focused on skills in scientific processes of kindergarten to sixth grade students. These skills are divided into generally two major categories; one as basic science process skills and the other one as integrated science process skills. Basic science process skills are simple, while integrated science process are complex. The basic science process skills are observation, inference, measurement, communication, classification, prediction (Martin, 1997). Basic science process skills are used by scientists in everyday life during designing and conducted experiments. Padilla (1990) had usage of time-space relationships which points another time and place in categorization of basic science process skills, different than Martin's (1997) study. Being able to use basic science process skills are related to cognitive development stages of students (Padilla, 1990). Integrated science process skills consist of controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models (Padilla, 1990; Padilla & Okey & Garrard, 1984). Integrated science process skills required to be able to use basic science process skills as prerequisites (Germaann & Aram, 1996). Integrated science process skills in Martin's (1997) study were named as determining controlling variable, formulating hypothesis, interpreting data, making operational definitions, experimenting and modeling (Aslan, 2015).

Science process skills were also divided into three groups in literature: basic science process skills, causal science process skills and experimental process skills (Çepni et al., 1997). To their classification, basic science process skills are comprised of observation, measurement, classification, data recording, and number-space relationship. Causal science process skills consist of predicting, operationally defining, interpreting data, and resulting. Experimental science process skills are formulating hypothesis, handling data and modelling, decision making, controlling and changing variables, and designing an experiment.

Science process skills are not the skills to be used in science classrooms or laboratories. These skills are life-long learning skills. Each individual in the world needs to have science process skills and use it in daily life considering the simultaneous interaction of science and society with each other (Hupper, Lomask & Lazarowitz, 2002). Gaining these skills from childhood is important to understand the world better. Practicing life-long skills in classrooms is substantial in education. To out a better point on it, observation is one of the science process skills allow the learner distinguishing the similarities and differences of an object or a situation (Harlen, 1989) and classification regard organizing complex concepts in a simpler and systematic way in groups (Çepni et al., 1996). In Piaget's point of view to learning (1966), knowledge is developed by each experience of the world. If children have an ability of observation and classification in earlier ages, they will construct better schemes in their mind and arrange them in more.

By claiming that science process skills are the essential abilities serving individuals to have deeper knowledge about the world, Ostlund (1992) designed a variety of hands-on activities in which students can use science process skills. Besides hands-on activities, researchers suggest children being in physical activities through developing science process skills (Rezba, Sprague, McDonnough & Matkins, 2007).

2.3.2 Empirical Research on Developing Science Process Skills

Since developing students' science process skills is accepted as one of the main goals in national science education in many developing countries, the research in the field has focused on investigating the relationship between science process skills and other variables, and ways of developing science process skills, instead of debating the necessity of science process skills.

In the research examining the linkage between variables, a positive correlation between science process skills and science achievement (Bang & Baker, 2013; Bybee, 2000; Feyzioğlu, 2009) and attitudes toward science (Zeidan & Jayosi, 2015) was reported. Regarding development of science process skills, hands-on activities (Başdaş, 2007), learning cycles (Anagün & Yaşar, 2009; Kanlı & Yağbasan, 2008), self-regulated learning (Gülay, 2012), outdoor activities (Ayvacı, 2010) were claimed as effective learning strategies (Yıldırım, Çalık & Özmen, 2016).

Science process skills are commonly practiced through inquiry-based instruction in science classrooms. There are many studies suggest inquiry-based learning to develop science process skills (Çelik, 2013; Duran, 2014; Kocagül, 2013; Şimşek & Kabapınar, 2010; Yalçın, 2014).

The assessment of science process skills covers qualitative methods such as laboratory reports and observations. Considering the limitations crowded classrooms and time limitation, quantitative methods were preferred more in literature. By using scales, there have been many experimental studies conducted.

In a recent study presented in Philippines, Dela Cruz (2015) investigated the effectiveness of guided-inquiry-based learning modules on seventh and eighth grade students on students' science process skills. The module's aim was developing students' science understanding and provide independent opportunities for them to investigate through research as well as experimentation. The treatment was applied on 41 students in two experimental science classes by the teacher and it lasted seven weeks. Data were collected by survey before and after treatment. The findings of this study indicated that students' levels were raised from proficient level to advanced proficiency which refers that students integrated science process skills were significantly developed.

Tatar (2006) examined the effect of inquiry-based learning on science process skills, attitudes toward science and science achievement of 104 seventh students in four schools. Two of schools were randomly assigned as experimental group and instructed by inquiry-based learning activities; while the comparison group had traditional instruction. The unit of the treatment was Our Planet. The results showed that students' science process skills, attitudes toward science and science achievement had significant effects in inquiry-based learning.

By single group pre-test and post-test experimental design, Şimşek and Kabapınar (2010) investigated the effects of inquiry-based learning on 20 fifth grade students' science process skills, conceptual understandings of matter, and science attitudes. The implementation lasted for eight weeks within laboratory applications. This study indicated inquiry-based learning is significantly effective on students' science process skills and conceptual understanding of matter, but not on attitudes toward science.

Similar to the aim of the study mentioned previously, Çelik and Çavaş (2012) conducted a study with 44 students, half of which was assigned as experimental group. The study designed as quasi-experimental. The unit of implementation was reproduction, growth and living organisms and the 5E learning cycle was used in experimental group. Their findings indicate that inquiry-based learning is significantly effective on developing students' science process skills, science achievement and attitudes toward science course.

Similarly, Koksal and Berberoğlu (2014) conducted a study with 304 sixth grade students in Turkey. 162 of students were assigned as experimental group and they instructed with guided-inquiry, while the rest was assigned as control group and instructed by inquiry-based methods determined by national science education in Turkey. Data were collected with survey methods as pre-test and posttest. Before treatment, the science classroom teachers were trained about the instruction. The treatment was 22 class hours and the unit was Reproduction, Development, and Growth in Living Things. Statistical results showed that guided-inquiry has a significant positive effect on science process skills of students. Nonetheless, the findings of Yıldırım's (2012) quasi-experimental study with 55 eighth grade students in three different classrooms did not support this. Yıldırım (2012) investigated the effect of guided-inquiry and traditional instruction in laboratory conditions on students' science process skills and the content knowledge of floating, sinking, buoyancy and pressure. Two of three classrooms in the study were experimental groups, while the other one was the control group.

Kaya and Yılmaz (2016) examined the effect of open inquiry-based learning on 65 seventh grade students within the unit Force and Movement through four weeks, sixteen hours in total. The classroom of 33 students was randomly assigned as experimental group. The implementation was made by the same science teacher and data were collected through quantitatively before and after treatment. The results showed that there is a significant effect on students' science process skills in the favor of open inquiry-based learning.

2.4 Empirical Research on Middle School Students' Understanding of Ecosystem Concepts

Anthropogenic degradation of ecosystems is directly related to education field. Local and global policy makers, universities, schools, natural resources agencies have had development plans for ecological improvements by environmental education since at the end of 18^{th} century. The environmental education has started to develop by talking global human impact in United Nations Conference with the participation of 113 countries (UNESCO, 1972). In next two congregate had education topic in focus;

Belgrade Charter (UNESCO, 1975) was developed in Belgrade Conference and Tbilisi Declaration (UNESCO-UNEP, 1977) was developed in Intergovernmental Conference. The recent outcome, 2030 Agenda for Sustainable Development adopted by General Assembly of United Nations (2015) determined aims for a better world. Usage of the ecosystems sustainably; in other words, with little or no damage on environment by thinking next generations, was emphasized in the goals. Sustainability have three interrelated components; social, economic and ecological. Each of these major components has its own minor components and the branches have complex and dynamic relationships in itself as well.

In science education, ecosystems are difficult concepts to understand due to having many components and complex direct and indirect connection with its components from biotics, to abiotic; from micro scale to macro scale, and from visible to invisible. In addition, natural ecosystem are open systems which refers continuous various inputs such as water, wind, oxygen and organic material coming from other ecosystems and continuous outputs going to other ecosystems. In the literature, numerous international and national research show that middle schools and high schools students have very limited knowledge about ecosystems, their components and their interaction with another (Adeniyi, 1985; Bozkurt, 2001; Carlsson, 2002; Çokadar, 2010; Erol & Gezer, 2006; Hellden 2004; Lin & Hu, 2003; Shepardson, 2006; Toman, 2018; Yu, 2003; Yücel & Özkan, 2015). The most common cognitive problems about ecosystems are matter and energy transformation (Wilson, et al., 2006; Hartley et al., 2011). Recent studies in Turkey support these results by students' problems to conceptualize problems of water cycle (Çardak, 2009; Derman & Yaran, 2017; Işık, Uzunçakır, Öztekin & Şahin, 2016), matter cycle (Cimer, 2012; Özkan, 2005), carbon cycle (Çelikler & Topal, 2011). Besides the studies focus on bringing students misconceptions out (Jordan et al., 2009; Littledyke, 2004; Eromesele & Ekholuenetale, 2016; Phenice & Griffore, 2003; Shepardson, 2006), there are very limited experimental studies aiming to develop students' understandings of ecological concepts.

In their experimental study, Özkan, Tekkaya and Geban (2004) investigated the effectiveness of conceptual-change-text oriented instruction on 58 seventh grade students to eliminate their misconceptions about the ecology concepts. 28 of these students were assigned as the experimental group and took the conceptual-change-text instruction, while 30 of students were assigned as control group and received by traditional instruction. The treatment was last five weeks and the data were collected by test and interviews before and after treatment. The findings of the study revealed that conceptual-change-text oriented instruction, as a constructivism instruction, was significantly effective on students' conceptual understandings of ecological concepts and eliminating misconceptions about food chain, energy flow and population.

Manoli et al. (2014) examined the impact of Eartkeepers program on 491 fourth to seventh grade students in nine different schools. The study started with 196 students in first year and continued with 295 students in second year. This earth education program had in-class and outdoor activities in a natural place. The data were gathered by questionnaire and interviews for exploring students' understandings of ecological concepts. The first year outcomes of the study indicated that students' understandings of energy flow, matter cycle and change on ecosystems over time were significantly developed in both years.

CHAPTER 3

METHODOLOGY

In this chapter, the methods used throughout the study were explicated under ten sections as research design, context of the study, sample, variables, data collection, treatment, treatment fidelity and verification, data analysis, trustworthiness of the study and assumptions, limitations and ethical issues.

3.1 Study Field

This study conducted in Golbasi, located 20 km south of Ankara (Figure 3.1). The in-class activities were performed in a middle school between Lake Eymir and Lake Mogan, and fieldworks were performed in Lake Eymir and Middle East Technical University (METU) Limnology Laboratory.

Lake Eymir (39°57' N, 32°53' E) was formed as a result of filling up with alluvium in the collapse caused by tectonic activities in the valley Mogan-Eymir-İncesu stream (Beklioglu, 2000). It is is a relatively shallow lake with mean depth 3.2 m and surface area with 100-130 ha (Coppens et al., 2016). Lake Eymir's major inflow, (E Inflow I) comes from Lake Mogan and the other inflow comes from Kışlakçı Brook (E Inflow II) which usually dries in summer (Beklioğlu, İnce & Tüzün, 2003).

The major inflow carrying domestic wastewater of TEAŞ to Lake Eymir and Kışlakçı Brook inflow are the causes of deterioration of water quality (Beklioğlu, 2000). Even if the untreated domestic wastewater flow to lake was blocked by a Golbasi sewage system in 1995, and biomanipulation was successfully employed for the first time in Turkey at Lake Eymir by decreasing two different fish types between 1998-1999 so that the water quality is increased, the water level and the water quality have been affected very negatively from dry season began at 2003. (Beklioğlu et al., 2003). The second manipulation which was successfully implemented between 2006 and 2007, and the wet season starting at 2009 helped to increase the water quality of Lake Eymir again (Özen et al., 2010; Beklioğlu, 2013). METU Limnology Laboratory has been conducted ecological, limnological and paleolimnological studies in Lake Eymir and Lake Mogan, obtain physical, chemical and biological data from both lakes every 15 days since 1997 except when ice covered the lakes' surfaces.

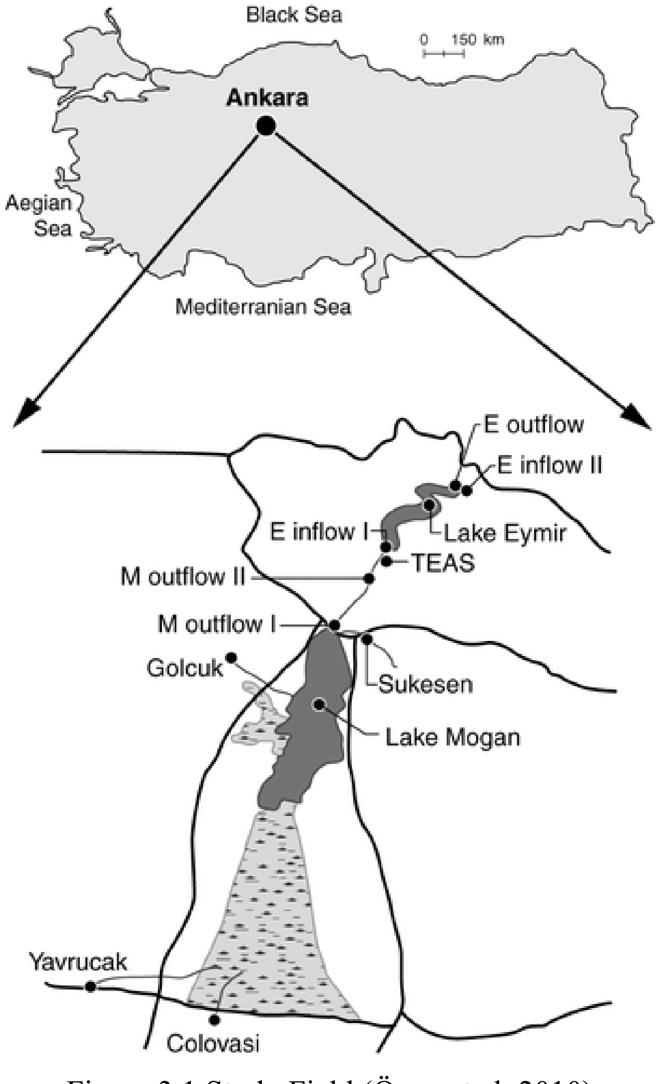


Figure 3.1 Study Field (Özen et al. 2010)

3.2 Research Design

In order to check the presence of the cause and effect relationship, experimental research designs are used in social sciences. The researcher can observe both experimental and control groups to assess a treatment in experimental studies. Despite of the fact that having control groups and experimental groups under observation of the researcher would increase the strength of pattern of the experimental study, it is not available to administer a control group for every study. Single subject research design is one of the most popular experimental design used in educational field. It is a type of quasi-experimental research design which allows the researcher to observe only one selected group which is not randomly assigned (Silverman, 2015). According to single subject research design, the researcher can apply the experimental treatment and measure its effect before and after exposing the treatment on the same subject, if there are no other available subjects (Fraenkel, Wallen & Hyun, 2015).

Alike to many experimental studies in educational field (Creswell, 2014), the current study conducted with non-randomly assigned classrooms. The lake ecosystem topic was determined as independent variable. Since every school administration and science teachers choose different topics and activities based on general objectives for Science Application Course every year, it was difficult to find a control or comparison group to test. In these circumstances, the implementation was practiced on one experimental group in this study. Two classes instructed by different science teachers at different times in a same day were assigned as the experimental group for the treatment.

There are two types of single subject experiments; one group posttest only design and one group pretest and posttest design (Silverman, 2015). Although evaluating the effect of treatment only with posttests is suitable in single subject research design, pretests results as well as posttest results of students were collected in this study, since using one group pretest and posttest design is accepted as a way of minimizing the problem of having not control or comparison group (Creswell, 2019). The duration of treatment was eight continuous weeks. Single group pretest-posttest research design was implemented to evaluate the effectiveness of a lake training program, Lake Eymir Education Program on 7th grade students' science process skills, scientific epistemological beliefs, understandings of a lake ecosystem and views about the treatment as displayed in Table 3.1.

Table 3.1 Research Design of the Study

Group	Pre-test	Treatment	Post-test
EG	SPST, EBQ, LEDT, DIS	LEEP	SPST, EBQ, LEDT, SRQ

Note: EG: Experimental Group, LEEP: Lake Eymir Education Program, SPST: Science Process Skills Test, EBQ: Epistemological Beliefs Questionnaire, LEDT: Lake Ecosystem Drawing Test, and DIS: Demographic Information Survey

There are three types of designs in educational studies; quantitative, qualitative and mixed methods (Creswell, 2014). In quantitative research methods, data are collected statistically and analyzed in numerical form to be able to detect the causal relationship between variables (Borg & Gall, 1989). Questionnaire and survey are the most common tools for quantitative data collection in experimental studies. On the other hand, qualitative research methods benefit from descriptive data instead of statistical data to have information about the variables in the study (Bogdan & Biklen, 1982). In other words, researchers gather qualitative data through "examining documents, observing behavior, or interviewing participants" (Creswell, 2014, p. 186). Besides these, pictures and words are accepted as qualitative data (Johnson & Christensen, 2008). Mixed-methods research design allows researchers to collect multiple forms of data; both quantitatively and qualitatively (Creswell, 2014).

In this study, quantitative methods were employed to collect data about science process skills, epistemological beliefs and demographic information of students. Even though quantitative data tools are sometimes beneficial to supply the data to the researcher and suitable to collect data from many participants, they limit the expressions and thoughts of participants in the study (Raman & Abdullah, 2000). In order to evaluate understandings, the data about students' understanding of a lake ecosystem were collected by qualitative data collection methods and opinions about training program were gathered by mixed data collection methods as illustrated in Figure 3.1.

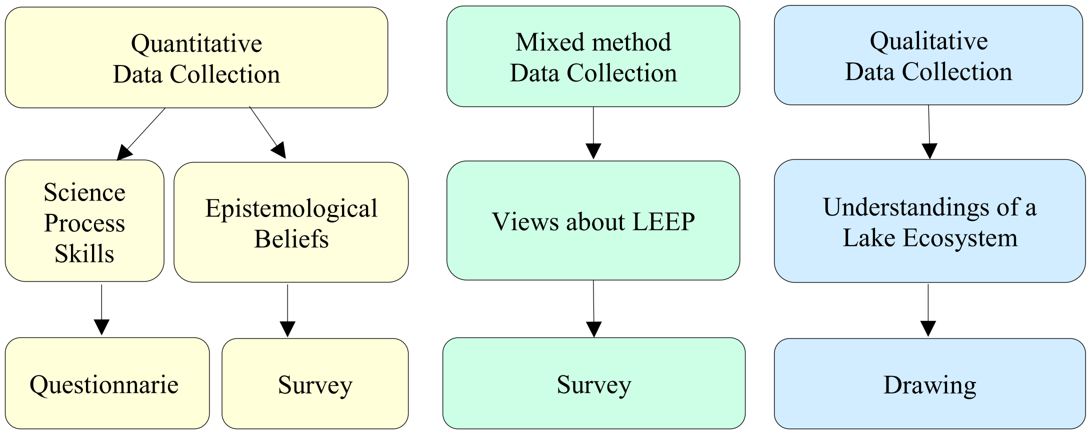


Figure 3.2 Data collection methods used in this study

3.3 Sample of the Study

The target population was all 7th grade students in public middle schools in Ankara. Due to easy transportation to Lake Eymir, 7th grade students in closer schools to Lake Eymir, Golbasi district were chosen as accessible population.

A convenience sampling method was utilized to determine the sample of the study. A public middle school in the basin of Lake Eymir was chosen since it was easy to reach. Among six 7th grade classes, four classrooms were enrolled the Science Application course. None of these classrooms have the same instructor intentionally. Two of these classrooms were selected randomly.

After two classrooms of students were determined as in the sample of the study, the science teachers of two classrooms were informed about the study within the meetings. The teachers were informed about the aim and context of the study at first.

Also, they were trained about a lake ecosystem for two hours session. At the second meeting, the instruction, the lesson materials and variables were introduced. After all, LEEP materials and timetables were given to teachers. During all classes inside and outside activities which teachers led, the researcher was there to monitor, help if it is necessary, regulate the procedure and edit next lesson plans based on the feedbacks of teachers after each class session.

The demographical data of the sample of this study was given in Table 3.2. It assumed that all students in the sample have seen a lake before because they were living next to a lake. Furthermore, just after the week when the ecosystem topic was taught to 7th grade students in their Science course at Spring Semester in 2016-2017, the study conducted. Hence, students could have a basic level of knowledge about the lake ecosystem.

The total number of students in the sample of the current study was 52 seventh grade students. Half of the students was from Classroom A; while another half was from Classroom B. The number of female students (*N*=22, 42.3%) and male students (*N*=30, 57.7%) were similar. A great majority of students (*N*=45, 86.5%) were 13 years old, although other students were one year younger (*N*=3, 5.8%) or one year elder (*N*=4, 7.7%). While most of the fathers of students were employed (*N*=45, 86.5%), around one quarter of mothers of students were employed (*N*=14, 26.9%). Considerably bigger part of mothers of students were graduated from only primary school (*N*=18, 34.6%); on the other hand, most of fathers' education level was secondary school (*N*=20, 28.5%). Similarly, the number of fathers who graduated from university (*N*=8, 15.4%) was more than the mothers who graduated from university (*N*=2, 3.8%). There was no retired mother of students and no illiterate father of students as seen.

Table 3.2 Characteristics of the Students

		Frequency (*f*)	Percentage (%)
Gender			
	Girls	22	42.3
	Boys	30	57.7
	Total	52	100
Classroom*			
	Classroom A	26	50
	Classroom B	26	50
	Total	52	100
Age			
	12	3	5.8
	13	45	86.5
	14	4	7.7
	Total	52	100
Employment Status of Mother			
	Employed	14	26.9
	Unemployed	37	71.2
	Missing	1	1.9
	Total	52	100
Employment Status of Father			
	Employed	45	86.5
	Unemployed	2	3.8
	Retired	2	3.8
	Missing	3	5.8
	Total	52	100
Educational Level of Mother			
	Illiterate	3	5.8
	Primary school	18	34.6
	Secondary school	13	25
	High school	15	28.8
	University	2	3.8
	Missing	1	1.9
	Total	52	100
Educational Level of Father			
	Primary school	11	21.2
	Secondary school	20	38.5
	High school	12	23.1
	University	8	15.4
	Missing	1	1.9
	Total	52	100

**Classrooms were labelled as A and B regardless their real names.*

3.4 Variables

There are two types of variables in this research, independent and dependent variables. The independent variable was assumed the variable that affects the dependent variable.

3.4.1 Independent Variables

The independent variable of the study was the inquiry-based lake training program. The effect of this program was aimed to be investigated in this study.

3.4.2 Dependent Variables

Affected variables in this study were namely science process skills, epistemological beliefs, understandings of a lake ecosystem and views about the Lake Eymir Education Program. The first one was measured by Science Process Skills Test (SPST), the second one measured by Epistemological Beliefs Questionnaire (EBQ), the next one was measured by Lake Ecosystem Drawing Test (LEDT) and the last one was measured by Students' Review Questionnaire (SRQ).

3.5 Data Collection

Data collection instruments and data collection procedure were explained in this part of the study.

3.5.1 Data Collection Instruments

The data gathered both quantitatively, qualitatively and mixed methods. There were five instruments to collect data; Demographic Information Survey (DIS), Science Process Skills Test (SPST), Epistemological Beliefs Questionnaire (EBQ), Lake

Ecosystem Drawing Test (LEDT), and Students' Review Questionnaire (SRQ). Data collections instruments, aim of measurement, data collection method and the time of instruments were represented in Table 3.3

Table 3.3 Instruments, Method and Time of Data Collection in the Study

Instrument	Aim of measurement	Data collection method	Pre test	Post test
SPST	Investigating students' science process skills	Quantitative	X	X
EBQ	Investigating students' epistemological beliefs	Quantitative	X	X
LEDT	Investigating students' understandings of a lake ecosystem	Qualitative	X	X
SRQ	Investigating students' views about the education program	Mixed		X

3.5.1.1 Demographic Information Survey (DIS)

The data about demographic information of students were obtained by Demographic Information Survey. There were seven questions asked students to mark. These questions were gender, classroom, age, employment status of mother, employment status of father, educational level of mother and educational level of father.

3.5.1.2 Science Process Skills Test (SPST)

The instrument used to investigate science process skills of students was originally developed by Okey, Wise and Burns (1982). There are five dimensions and 36 items with four alternatives. The scale was translated and adapted into Turkish by Geban, Aşkar and Özkan (1992). The reliability coefficient of this multiple-choice test was found .81 in the Turkish version, while it was .82 in the original version. In present study the Cronbach's alpha reliability coefficient was found .85 which indicates a high level of internal consistency for the scale within the sample of the study. This instrument used before and after the treatment. Dimensions and items of Science Process Skills Test was given in Table 3.4 and the instrument was given in Appendix A.

Table 3.4 Dimensions and Items of Science Process Skills Test

Dimension of SPST	**Number of Items**	**Item Numbers**
Identifying Variables	12	1, 3, 13, 14, 15, 18, 19, 20, 30, 31, 32, 36
Operationally Defining	6	2, 7, 22, 23, 26, 33
Identifying Testable Hypotheses	9	4, 6, 8, 12, 16, 17, 27, 29, 35
Data and Graph Interpretation	6	5, 9, 11, 25, 28, 34
Experimental Design	3	10, 21, 24

3.5.1.3 Epistemological Beliefs Questionnaire (EBQ)

The Epistemological Beliefs Questionnaire (EBQ) was used to examine scientific epistemological beliefs of 7th grade students in this study. This questionnaire was developed originally by Conley, Pintrich, Vekiri and Harrison (2004) by using Hofer and Pintrich's (1997) framework (Appendix B). There are four dimensions of the scale; *Source, Certainty, Justification* and *Development*. As claimed by Hofer and Pintrich (1997), there are two major areas about epistemological beliefs which are beliefs about the nature of knowing and beliefs about the nature of knowledge. The Source and Justification dimensions of EBQ reflect beliefs about the nature of knowing, while the Certainty and Development dimensions of EBQ reflect beliefs about the nature of knowledge to Conley, Pintrich, Vekiri and Harrison (2004) This questionnaire has 26 items rated on a 5-point Likert type scale (1= strongly disagree;

5= strongly agree). It was translated into Turkish by Özkan (2008) by removing Item 2 and Item 7 from the original version of the questionnaire in data analysis because of negative correlation. The items of Source and Certainty dimensions merged into one single dimension as Source/Certainty in Turkish version of the questionnaire. Hence, Turkish version of the questionnaire consists of three dimensions; *Justification, Development* and *Source/Certainty* (Table 3.5).

Table 3.5 Dimensions and Descriptions of EBQ (Conley et al., 2004; Özkan, 2008).

Dimension	**Concern**	**Received View**	**Reasoned View**	**Example**
Justification	About the role of experiments and how individuals justify knowledge	Knowledge requiring no justification, receiving the knowledge that others provide	Knowledge constructed through use of evidence and assessment of expert opinion	Good answers are based on evidence from many experiments
Development	About science is an evolving and changing subject	Absolute, fixed nature of Knowledge	Evolving and changing nature of knowledge	Sometimes scientists change their minds about what is true in science
Source/Certainty	About knowledge residing in external authorities and about single right answer	Knowledge originating outside the self, residing in external authority and there is single right knowledge	Knowledge constructed by the knower and there is more than a single right knowledge	All questions in science have one right answer.

The reliability coefficient Cronbach's alpha estimating of internal consistency of EBQ was calculated for each dimension is respectively 0.77, 0.59 and 0.70 in Özkan's study, while these values were found respectively α= 0.83, 0.81 and 0.86 in the current study (Table 3.6). The total reliability coefficient Cronbach's alpha was calculated as 0.88. This questionnaire was given to students before and after the treatment.

Table 3.6 Dimensions and items of Epistemological Beliefs Questionnaire

Dimension of EBQ	**Number of Items**	**Item Number**	**Özkan's (2008) Study Reliability**	**Current Study's Reliability**
Justification	9	3, 5, 9, 11, 14, 18, 22, 24, 26	0.77	0.83
Development	6	4, 8, 13, 17, 21, 25	0.59	0.81
Source/Certainty	9	1, 6, 10, 12, 15, 16, 19, 20, 23	0.70	0.86

3.5.1.4 Lake Ecosystem Drawing Test (LEDT)

Drawings are very effective tools for evaluation purposes (Barraza, 1999). Drawing tests offer researchers to reveal more subtle opinions of participants (Glynn & Duit, 1995; Weber & Mitchell, 1995) and they increase both the response rates and eagerness to respond (Meyer, 1991, Nossiter & Biberman, 1990). For data collection draw-and-explain method was used. This method allows participants express themselves both verbally and visually (White & Gunstone, 1992). There have been draw an environment tests were used in science education literature for more than six decades for both teachers and students. The draw an ecosystem test or drawing about ecological concepts of students were also used in recent science education literature (Ahi, 2016; Eliam, 2002; Jordan et al., 2009; Lin & Hu, 2003; Sanford et al., 2017;

Shepardson, 2010; Shepardson et al., 2018; Snowden, 2017). Although drawings are used mostly for forest ecosystem and grassland, desert ecosystem drawings, marine ecosystems or watershed drawings, there was not a specifically draw-and-explain lake ecosystem. Based on draw-and-explain method, Lake Ecosystem Drawing Test (LEDT) was administered to the students before and after the treatment to assess their understandings about a lake ecosystem. LEDT instrument consists of two sections. In the Draw section students were asked to draw what a lake ecosystem looks like with the all details that they have known hitherto. In the Explain section students were asked to explain what they wanted to express by their drawings (Appendix C).

3.5.1.5 Students' Review Questionnaire (SRQ)

This test was designed by the researcher for examining the views of 7th grade students about Lake Eymir Education Program. Quantitative part of this scale was made of 13 items rated on a 5-point Likert scale (1= strongly disagree; 5= strongly agree). On the other hand, the number of open-ended items in this scale was determined as 3 since it was intended to take detailed information from students without giving boredom to them more by high number of questions which would have needed long and detailed answers. The instrument was used only as posttest. The Cronbach's Alpha reliability coefficient of quantitaive items of SRQ was calculated as α= .76 which indicates a high level of internal consistency. Qualitative part of the SRQ instrument was given below in Table 3.7 and SRQ scale is given in Appendix D.

Table 3.7 Open-ended items of Review of Students Test

Open-ended items of SRQ
What was your favorite part in LEEP?
What would you want to change in LEEP?
Provide other opinions and suggestion please, if you have any.

3.5.2 Data Collection Procedure

There are six steps in data collection procedure (Figure 3.3). First of all, the researcher reviewed related literature in detail to determine research questions and instruments of the study. The articles and dissertations reviewed by the databases; METU Library, EBSCOHOST, ERIC, ULAKBIM National Databases, Science Direct and Wiley Online Library by using keywords “nature education”, “environmental education”, “lake ecosystem”, “inquiry-based learning”, “middle school students”, “science process skills”, “scientific epistemological beliefs, “ecosystem education”, and “drawing test”. Based on this review, research questions were determined and instruments were determined. Secondly, the permissions were gathered from owners of instruments by e-mail and a training program was developed with regard to the aim of the project and the aim of the study. The project school was conducted to check their conditions to be assured about suitability of the schools according to aim of the project. Other permission about using instruments and applying the project were taken in applied to Research Center for Applied Ethics (Appendix E) at Middle East Technical University and the Ministry of Education (Appendix F). During the third stage, the school was visited about one month ago before applying pre-test by the researcher and project team to explain the project and the purpose of the study. Altogether with the researcher, project team, school administration and science teachers were determined the dates and the hours of outside classroom activities and meet-a-scientist seminars. By various meetings with science teachers and project team before applying pre-tests, post-tests and treatment, the objectives and trainings were revised. Fourthly, students were informed about the purpose of the study by verbally, and the permission papers (Appendix D) were distributed to each student to give their parents to read and decide to assign or not. The students brought permission papers to the next lesson as they are signed with name, surname and phone number on by parents of the students. To be sure that all parents of students have seen allowance papers, the parents called one by one to say thanks for allowance, invite them to seminars or to introduce the project and the purpose of the study verbally to parents. Pretest results were collected just before the project has started. The school was visited in 30th March, 2017 to conduct pretests and 8th June, 2017 to conduct posttest.

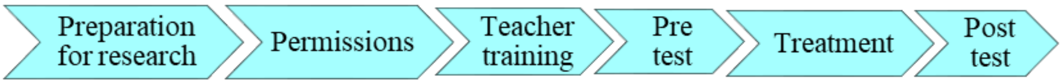


Figure 3.3 Stages of Data Collection Procedure

For collecting data, students firstly were informed about their contribution to this study and the importance of answering every item sincerely. It was told them that they have a right not to join the treatment and the results will not affect their school grades. First 15 minutes were given for the EBQ data collection and then chocolates were distributed students to make them feel happy before SPST data collection. 35 minutes were given students to fill SPST.

For drawing data collection by LEDT instrument, students were asked to explain what they wanted to describe by their drawings in Explain section. A set of colorful crayons and colored pencils and an A3 size paper which has instructions on were given to each student prior to pre-test. Students were encouraged to use all colors for drawing anything they have known about a lake ecosystem. Besides the aim of the study, it was told students that there will not be any judgement about their artistic painting or drawing skills to make them feel much freer to express themselves while drawing. 20 minutes were given to students to complete both sections of LEDT. They were not allowed to look at each other during filling out the instruments. The researcher and the science teacher of each classroom were waited in each classroom during all data collection. Researcher was there with classroom teachers during the whole procedure of obtaining pre-tests for distributing papers to students, observe the students to be sure that every student response pretest by their own, and replies if there is a part that is not understandable by students. Students who completed their task left their papers on teacher's table and wanted to wait silently in the classroom.
After pretest results were collected, the lesson plans were started to being implemented by science teachers of each classroom under the researcher's

observation. Before and after each class session, the researcher and the teachers were discussed verbally about the feedbacks of students toward the lesson in terms of content, time and procedure. Finally, after 8 weeks treatment ended, students were informed about posttests. The same instructions and gifts for pretests were given again to students for posttest as well. While the data by EBQ, SPST and LEDT instruments were collected as pretest and posttest, reviews of students about the LEEP was collected by SRQ instrument as posttest. The name of students or any other demographical information were not asked in Student Review Test to obtain objective evaluation of students.

3.6 Treatment

The design of the treatment and its components; in-class activities, outdoor activities and meet-a-scientist seminars were given elaborately in this section.

3.6.1 Design of the Treatment

In order to design LEEP lesson plans in this study, one main question and five sub questions were discussed in Figure 3.4.

Based on the main question, the objectives and contents in national science curriculum were investigated. Compulsory formal education and training in Turkey is twelve years; primary school, lower secondary school and high school. Each school level takes 4 years. The qualifications in formal science education and training of these schools are basically determined by Vocational Qualification Institution by revisions of Ministry of National Education (MoNE) and other educational components (Turkish Vocational Qualification Institution).

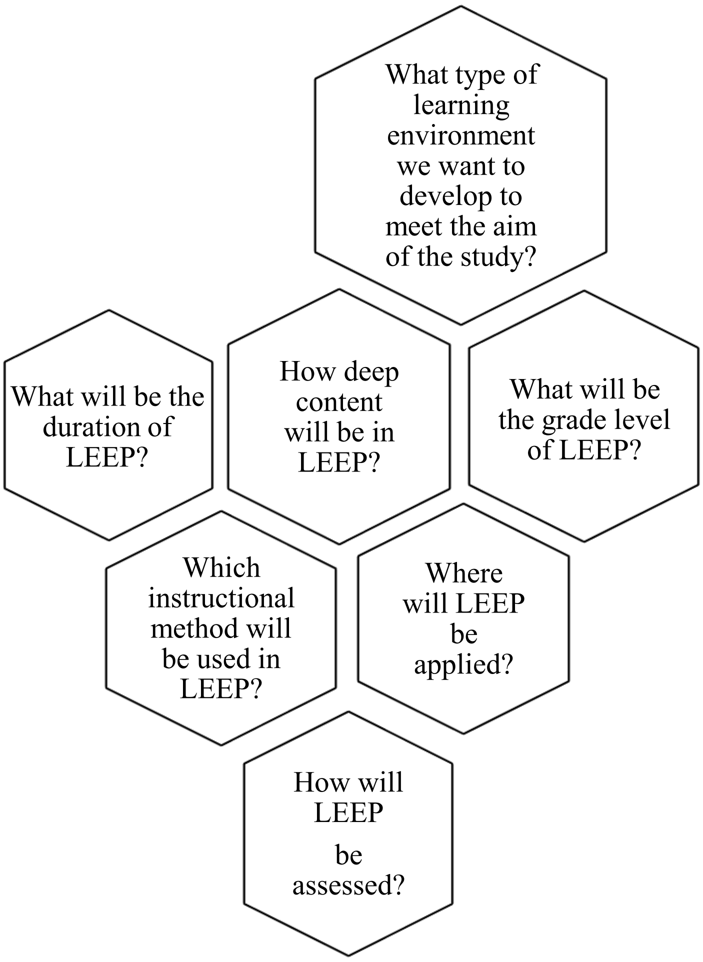


Figure 3.4 Questions for Planning Lesson Plan-s in LEEP

Within harmony with European Qualifications Framework (EQF), Turkish Qualifications Framework (TQF) identifies eight key qualifications for Science Application Course (SAC) for lower secondary school students which are 5, 6, 7 and 8th grade students. With regard to qualifications, there are 21 objectives at total in 33 weeks in SAC for 7^{th} grade students (MoNE, 2013). The treatment in this study contained 6 objectives in 8 weeks. Ministry of Education does not only focus on improving cognitive skills of students by these objectives. It also focuses on improving students' three important skills which were determined in Science Application course (SAC). Competences, objectives, skills and themes inspected for designing the treatment in the study were given in Table 3.8.

Table 3.8. Competences, Objectives, Skills and Themes Inspected for Designing the Treatment in the Study

Key competences in TQF (Turkish Vocational Qualification Institution, 2015, pp.23-24)
1. Communication in the mother tongue
2. Communication in foreign languages
3. Mathematical competence and key competences in science/technology
4. Digital competence
5. Learning to learn
6. Social and civic competences
7. Sense of initiative and entrepreneurship
8. Cultural awareness and expression
Objectives of SAC for 7th Grade Level (MoNE, 2013)
Objective 7.4, Week 6 – Make direct and indirect measurements
Objective 7.14, Week 26 – Design an ecosystem model
Objective 7.15, Week 27 – Discuss the negative impacts on ecosystems and their possible consequences.
Objective 7.16, Week 28 – Provide suggestions for conservation of ecosystems
Objective 7.20, Week 32 – Investigate scientists and their important contributions to science
Objective 7.21, Week 33 – Explain various types of daily life events with science

Table 3.8. *Continued*

Specific Objectives of SAC (MoNE, 2018, pp.7-8)
1. Helping to understand the development or change processes of scientific knowledge 2. Helping to understand the characteristics of scientific knowledge 3. In the process of understanding the human-society-environment relationship, adopt scientific process skills and scientific research approach and produce solutions for the problems encountered 4. Developing reasoning, scientific thinking habits and decision-making skills by using sociological subjects 5. Taking responsibility for daily life problems and using scientific process skills, life skills and engineering design skills in solving these problems 6. Raising awareness of current, scientific and technological innovations 7. Developing career awareness and entrepreneurship skills 8. Being ensure about the adoption of universal ethics, national cultural values and scientific ethical principles 9. Developing curiosity, attitudes and interest in the learning environment 10. Realizing the importance of safety in scientific studies and to contribute to the application
Essential Skills of SAC (MoNE, 2018, p.8)
Nature of Science and Science Process Skills Life-long skills Engineering and Designing Skills

By considering the qualifications, objectives and skills which were mentioned in Table 3.9, an inquiry-based learning environment intended to be formed. The ecosystem topic was searched in the curriculum. The curriculum of 8^{th} grade students was not investigated because of busy schedule of 8^{th} grade, caused by national entrance exam for entering high school. Ecosystem topic was covered in Science course and Science Application course of 7^{th} grade level (MoNE, 2013). Science Applications course was preferred to be implemented LEEP because there was longer time to carry out Lake Eymir Education Program' activities. The topic was expanded by integrating the lake ecosystem topic by using inquiry-based instruction.

The related literature review was examined to find the gaps and difficulties about teaching ecosystems. Inquiry-based learning, problem-based learning, project-based learning and design-based learning approaches were being used in Science Application course (MoNE, 2018). Also, scientific process skills and the nature of science were the focus of LEEP, just as it was emphasized by Ministry of Education for Science Application course (MoNE, 2018). Activities are recommended to be observable, interdisciplinary, contain cooperative and group works, are supported by discoveries and short videos and the materials of activities are recommended to be easily reachable, low cost and eco-friendly material. By looking at all qualification, objectives and criteria, it was claimed that LEEP contains almost all points emphasized in Science Application course by Ministry of National Education (MoNE, 2013, 2018).

Nature Course textbook and objectives published by Ministry of Education (MoNE, 2017) for middle school students was also benefitted to make additional changes while designing the context of the LEEP. Regarding to aims and themes mentioned in designing of the treatment, drafts of twelve lesson plans were developed. The manager of the limnology laboratory and the professor at Biology Department evaluated the training program in terms of ecological point of view. The supervisor of this thesis from the department of Mathematics and Science Education were evaluated the educational part of the treatment and the research. The opinions of an expert from Educational Sciences were taken for the study.

At the end of all feedbacks and revisions, a lake ecosystem training program with twelve lesson plans for eight weeks was developed by the researcher. Three constituents of the treatment were formed; in-class activities, outdoor activities and meet-a-scientist seminars. In-class activities were employed in the classrooms and laboratories in the sample school. Outdoor activities were performed in Lake Eymir and limnology laboratory of Middle East Technical University. Meet-a-scientist seminars were carried out in the middle school of the study via scientists visiting. The topics in lessons and seminar topics of treatment, LEEP, were given in the Table 3.9.

In LEEP's lessons inquiry-based instruction was used. Inquiry-based instruction is student centered and teachers guide students to learn a new concept by addressing process and thinking skills. Not only guiding, but also engaging, challenging and encouraging the students to the learning is necessary to provide an effective inquiry-based instruction.

Table 3.9 Topics in Lessons of Lake Eymir Education Program

	In-Class Activities & Seminars	Lake Eymir & Limnology Laboratory Fieldworks
WEEK 1	• Water cycle • The evolution of aquatic ecosystems	
WEEK 2	• Freshwater sources in earth • Differences between freshwater and salt water • Formation of lakes • Lake ecosystem services	
WEEK 3	• Salinity • Relationship between salinity, temperature and living organisms • Dissolved oxygen • Relationship between dissolved oxygen, temperature and living organisms • Lake stratification and turn over	
WEEK 4	• Nutrients and lakes • Carbon, phosphorous and nitrogen cycles • Light	• History of Lake Eymir • Introduction of buoy system and water quality probes in Lake Eymir • Light • The relationship between nutrients and growing

Table 3.9 Contimued

WEEK 5	• The relationship between light, turbidity, suspended solid matter and living organisms • Temperature	• Temperature • Decomposition
WEEK 6	• The relationship between depth of lake and temperature • The evolution of oxygen • Living organisms in lake ecosystems Ecosystem, habitat, species and population	• The relationship between nutrients and phytoplankton • The relationship between phytoplankton and zooplankton • The relationship between zooplankton and fish
WEEK 7	• Energy flow (food chain, food net, energy pyramid) • Biotic relationships (symbiosis, competition and predation) • Seminar of Biodiversity and Classification in Living Organisms	• Aquatic invertebrates • Aquatic birds • Lake sediment and paleoecology
WEEK 8	• Eutrophication • Lake sediment and paleoecology • Global warming and climate change • Seminar of Lake Ambassadors Training: I Know, Love and Save My Lake	

For designing the lesson plans in LEEP, backward design was used. Based on desired output, the evidences were determined and instruction was planned. This backward design is recommended as an effective technique for designing curriculum (Wiggin & McTighe, 2005). Hammerman's frame (2006) for assessing high quality inquiry-based instructional materials was used as a base (Table 3.10).

Table 3.10 Eight Essentials Considered for Assessing High Quality Inquiry-Based Materials

Alignment of High-Quality Inquiry-Based Science Materials With 8 Essentials (Hammerman, 2006, p.xxviii).
1. Develops an understanding of basic concepts
2. Develops process and thinking skills
3. Actively engages students in learning
4. Builds understanding of ways that science is linked to technology and society
5. Provides experience necessary to support and develop or modify interpretations of the world
6. Enhances reading and writing
7. Allows for a diversity of strategies for learning
8. Allows for a variety of ways for students to show what they know and are able to do

In her book, Eight Essentials of Inquiry-Based Science, the assessment criteria for inquiry-based instructional materials were determined as in Table 3.10. Hammerman suggested these eight essentials for implementing inquiry-based approach, assessing curriculum and informing instruction.

After meeting the eight requirements for high quality instructional inquiry-based materials, a lake ecosystem concept was investigated for teaching. Although a lake ecosystem concept was not new to students, there were new specific concepts aimed for students to learn.

Students should not be limited with direct instructions about new concepts. They need to understand concepts deeply, the way of reaching information and have environment to be creative. On this account, the learning cycle in the inquiry process were run for this study. Fundamentally, inquiry-based instruction in LEEP aimed to cause disequilibrium in students' mind and students became curious, started to wonder and began to be engaged to activities. Later, they were exposed to scientific experiences and opportunities for showing their understanding were given. Hence, the learning cycle's three main phases; explore, explain and elaborate were used. This learning cycle was developed by Karplus and Atkins (1977) based on the Piaget's mental functioning (1964). Students made investigations and collected data in explore phase. They explained what they have learned based on the data they gathered in explain phase. They adapt what they have learned into new concepts, made assimilation and deepen their understanding in elaborate phase.

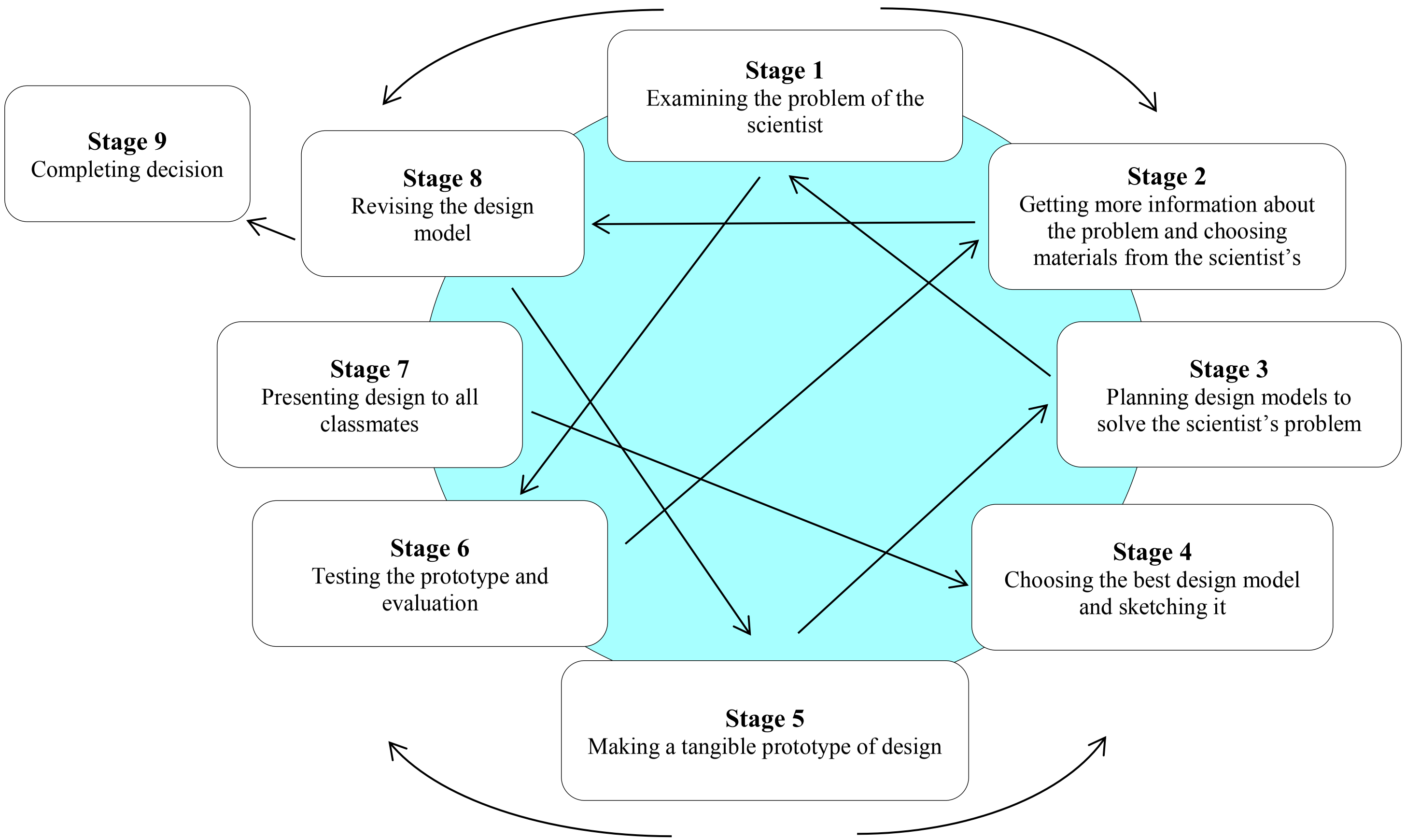
To set an example to LEEP activities, the frame of two lessons were mentioned. By these two lessons, familiar concepts were remembered to students to engage them into lesson, before introducing new concepts such as the origin of water and formation of lakes. Therefore, it was expected students to develop understanding of a lake ecosystem which was measured by LEDT. The first lesson provided students improve their science process skills in terms of identifying variables, operationally defining and identifying testable hypothesis; while the second lesson provided improving science process skills in terms of experimental design in addition to SPST dimensions in the first lesson. All three dimensions of EBQ were addressed in both lessons (Table 3.11).

Table 3.11 Examples of Lesson Frames Regarding the Purpose of the Study

	Type of Activity	Lake Ecosystem Concepts	SPST Dimensions	EBQ Dimensions
1st Lesson Plan	In-door	The importance of water for human and other living organisms Water cycle The origin of water	Identifying Variables Operationally Defining Identifying Testable Hypotheses	Justification Development Source/Certainty
2nd Lesson Plan	In-door	Salt water vs. Fresh water Water sources in Earth Turning salty water into fresh water Lakes and lake formation	Identifying Variables Operationally Defining Identifying Testable Hypotheses Experimental Design	Justification Development Source/Certainty

There are two engineering design-based activities in LEEP which were developed by the researcher. An educational environment was served to students to produce a solution, make a design to solve a problem and test it to improve their engineering design. In these engineering design-based activities, students used their prior knowledge, identified the needs of the design, managed possible risks and limitations designed a solution among many other possible solutions, tested it at lake, learned from failure, and developed alternative solutions. Through this, students proved their success by multidisciplinary works rather than only at science achievement tests both inside and outside classroom and developed their 21st skills especially creativity, critical thinking, collaboration, communication. For these two activities, an engineering design process pattern was followed by adapting it into related topic, instruction and students' level of the study (Hynes et al., 2011). The adapted engineering design process illustrated in Figure 3.5.

There is a cycle and nine stages of designing in Figure 3.5. Arrows imply that getting through some stages and going back to some previous stages, where arrows points, are possible. In this study, there were engineering design-based activities. The first activity was about light transmittance at fourth week and the second activity was about water sampling at fifth week of the treatment. These two engineering design activities were carried out both inside and classroom.



Adapted from the design processes of Hynes et al. (2011).
Figure 3.5 Engineering Design Process in LEEP

For the in-class activity, students were divided into groups of four or five. Groups of students began involving in designing process by a scenario that a scientist meets with a daily life problem. Teacher did not tell the main problem and students examined the main problem of the scientist by guidance of teacher. At the second stage, students exchanged their opinions by discussion with their group members to get more information about the problem. After discussion, they chose materials from a crowded list of materials; related or unrelated. The important point here was that there was not only one possible design from the list of materials given or not only one correct product. The aim was finding the best product that is applicable, durable, practical and economical. At the third stage, they plan different design models for solving the problem. They discussed about the best model among their groups and sketch it by labelling materials. They also wrote their aims, which materials they chose for their design and present the teacher before the in-class activity ends. Each group gave a copy of their best design model's sketch to teacher. First four stage were carried out inside class compulsory and the fifth stage was given as homework. The teachers told students to work their group members to make a tangible prototype of their design models till the next lake field activity. In this way students were allowed to get more scientific information by talking with other people, reading science books or internet search engines. It was a good opportunity for students communicate, read or watch about science, technology, engineering and mathematics with other people different than classmates. Student groups brought their prototypes to test in the lake field for sixth stage (Figure 3.18). After all groups tested their designs in the lake and wrote notes about their prototypes with its positive and negative sides, each group presented their prototype. In stage eight, each group revised their prototypes for making their prototypes better. They wrote and presented their views about which parts of their designs they could fix or change for a better product, if they had a chance and completed their decision in the final stage. The stages were adapted from designing process of Hynes et al. (2011).

Besides designing part, students wrote their research question, determined variables, write a hypothesis. They tested their prototypes, made measurements, calculations, draw tables and graphs about variables and interpret their results by using their scientific and mathematical skills. They sent their results to researcher phone. The scientific tools similar to their designs used in scientific researches were introduced to students. The student groups who wanted to do measurements with them allowed to use them. After coming back to classrooms, at the fifth and sixth weeks, students summarized what they have done at lake to their classmates who could not join to the lake field activities and they played a scientific simulation game about the topic through tablet computers.

The evaluation of two engineering design activities in LEEP was made by teachers according to success criteria determined by the researcher based on groups' success in each stage and the final product. The members of the group who had the highest score were rewarded after each of both activities.

3.6.2 Components of the Treatment

The treatment administered in this study consisted of three main parts; in-class activities, outdoor activities and meet-a-scientist seminars.

3.6.2.1 In-class Activities

In-class activities of Lake Eymir Education Program applied within the context of the Science Application course. Science Application course is two hours a week and an elective course added into curriculum of 5th to 8th grade students in the year 2012-2013 by Ministry of National Education. The main objectives of Science Application course were basically helping students to explain nature by scientific information, understanding the features of scientific information with experiments, running scientific studies just as scientists do by improving students' curiosity, questioning, critical thinking, problem solving and decision-making skills (MoNE, 2018). By this lesson, students have more time to experience science processes skills which they have learned in science course. Teachers need more course resources which they meet the objective of Science Application course (Bozdoğan, Bozdoğan & Şengül, 2014; Coşkun, 2016; Çavus & Kaplan, 2013; Çavus, 2016). LEEP meet all the objectives of current Science Application course. The activities can be helpful materials for Science Application course teachers (MoNE, 2018). Major in-class activities in LEEP and their purposes about the content, the lake ecosystem, were given in Table 3.12 and the photos during classroom activities were represented in figures from Figure 3.6 to Figure 3.10.

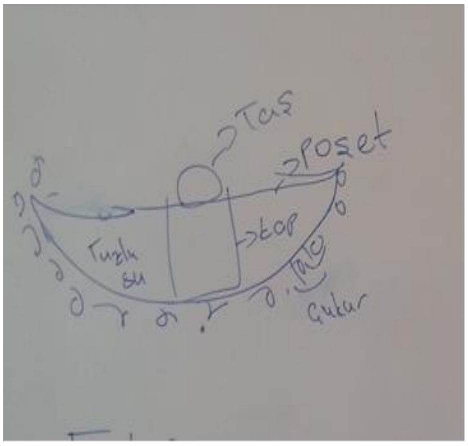


Figure 3.6 In-Class Activities Example 1

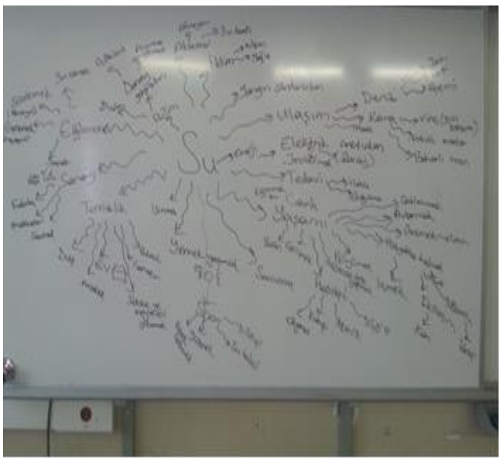


Figure 3.7 In-Class Activities Example 2

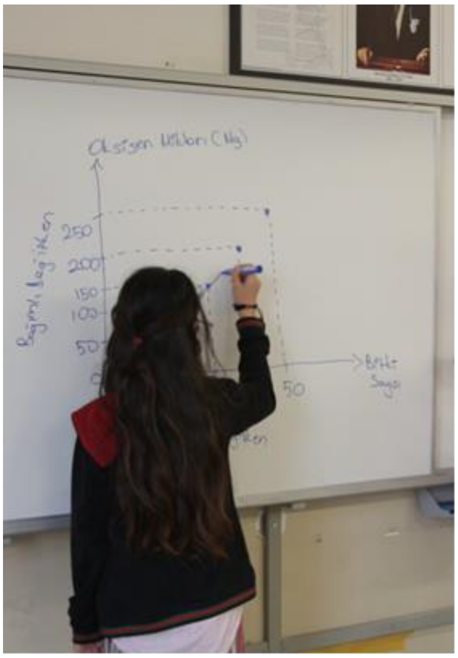


Figure 3.8 In-Class Activities Example 3

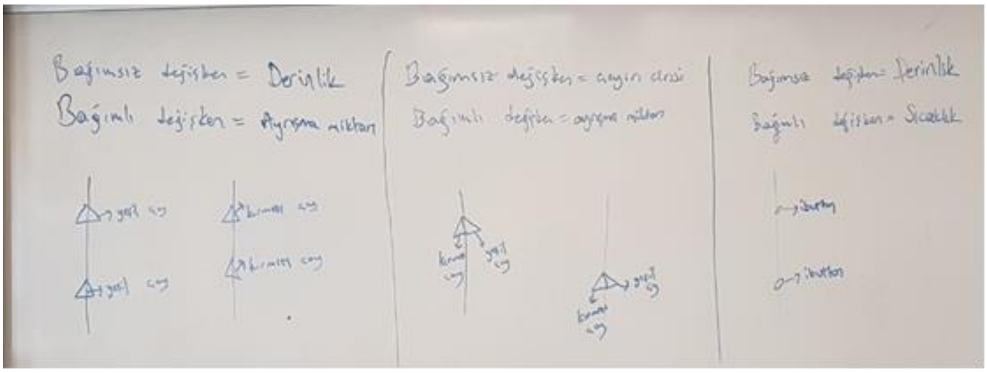


Figure 3.9 In-Class Activities Example 4

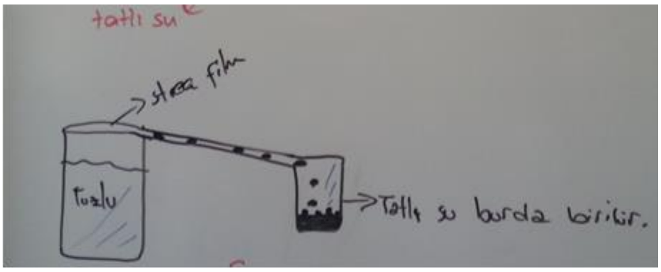


Figure 3.10 In-Class Activities Example 5

Table 3.12 Weekly In-class Activities and their Purposes in Lake Eymir Education Program

	Activity	**Purpose Related to Lake Ecosystem**
WEEK 2	Water cycle modelling and experiment	This activity was conducted in order to enable students to express the relationship between water cycle, temperature and salinity through different models and to recall the vital importance of water for living organisms, and to discuss the effect of salt on living diversity. One of the models was selected and tested to visualize by the students in the classroom.
WEEK 3	Fizzy drink observation and modelling	This activity was designed to enable students for comparing gases in fizzy drinks and gases in lake water, for discussing the effect of dissolved oxygen content on viability and diversity, and for designing different models to increase the amount of dissolved oxygen in lakes.
WEEK 3	Lake stratification experiment	This experiment was carried out in order to enable students to differentiate the changes caused by temperature changes in lakes and to discuss the effects of living things in the lake ecosystem on their lives.

Table 3.12 (Continued)

WEEK 4	Light transmittance design	This design allowed students to identify the relationship between light transmittance, plants and photosynthesis, to express this relationship through models, to design models by testing the products in the lake, to introduce their models to classmates, to compare the data obtained with limnology tools and their own instruments.
WEEK 5	Light transmittance simulation	This interactive simulation was carried out to enable the students to try the instrument which measures the light transmittance used in limnology researches and based on this, to interpret the differences of living organisms in a lake ecosystem. In addition, this simulation provided an opportunity for students to use a scientific measuring instrument that measures light transmittance by using technology in classroom environment.
WEEK 5	Water sampling design and measurement	Making this design allowed students to examine whether there is a relationship between water temperature and depth, to express this relationship through designing models, to introduce models to their classmates, to test the products by their models in the lake, to compare the data gathered via limnology tools and their own instruments.
WEEK 7	Eutrophication modelling	This activity was carried out to enable students to define the relationship between nutrient content and phytoplankton number, to design related models, to infer that the amount of phosphorus in the detergents they use may reach a lake from its basin and cause the increase of algae in the lake and discuss the importance of being a responsible citizen for protecting lake ecosystems.

3.6.2.2 Fieldwork Activities

Fieldwork activities consisted of practical trainings LEEPat Lake Eymir and Limnology Laboratory in Middle East Techincal University. Within the scope of LEEP, fieldworks have been organized in order to increase the permanence of the theoretical knowledge that the students have learned or will learn, to make scientific studies in nature, to learn by doing and experiences, and to recognize Lake Eymir ecosystem by hands-on acitivites. In these activities, voluntary undergraduate members of the BiyoGen (Biology and Genetic student community) guided to each four or five students. The guiders beforehand each outdoor activity had been informed about the pedagogical field about the ecosystem of the lake by the researcher.

The primary task of the leaders was to take the necessary safety measures (such as wearing a life jacket) when the activities were going to take place on the pier and to ensure that the students take these precautions. The transportation from students' school to Lake Eymir or university laboratories was provided by a bus. Various scientific experiments, measurements and testing of student designs were carried out on our project's Scientific Pier and in the Kemal Kurdaş Ecological Research and Education Station in Eymir which allocated to biology department of the university. Therefore, the students had the opportunity to make laboratory observations, measurements and experiments in a lake water easily and to use the laboratory materials at the ecological station where there were tables, chairs, library and almost all scientific laboratory equipments.

In addition to these, in order to enable the students to see how a laboratory in the university looks like and how scientific studies about lake ecosystems are being performed away from the lake, students were brought to METU Biology Department. After other laboratories in biology building and study areas were introduced, the limnology laboratory was visited. The graduate students working in laboratory informed students about their studies and scientific activities conducted by students with the help of laboratory assitants. Consequently, all the educational activities in Lake Eymir and limnology laboratory aimed to get to know a lake ecosystem in a scientific perspective by improving the students' science process skills, epistemological beliefs and understandings of a lake ecosystem. The main objectives of practical training in LEEP were given in Table 3.13 and the photos fom fieldworks were given in figures from Figure 3.11 to Figure 3.17.

Figure 3.11 Fieldwork Activities Example 1

Figure 3.12 Fieldwork Activities Example 2

Figure 3.13 Fieldwork Activities Example 3

Figure 3.14 Fieldwork Activities Example 4

Figure 3.15 Fieldwork Activities Example 5

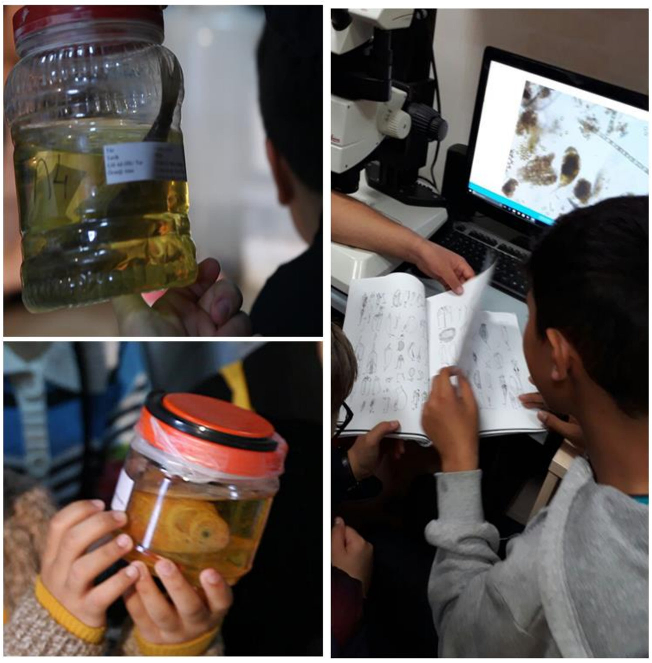


Figure 3.16 Fieldwork Activities Example 6

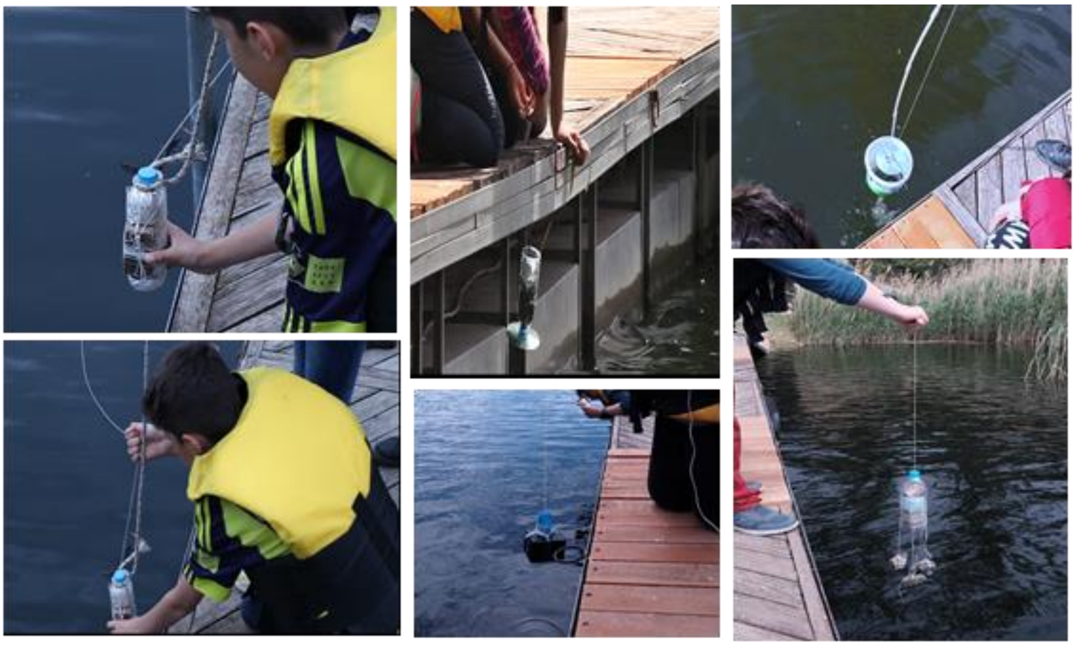


Figure 3.17 Fieldwork Activities Example 7

Table 3.13. Weekly Fieldwork Activities in Lake Eymir Education Program

	ACTIVITY	*PURPOSE RELATED TO LAKE ECOSYSTEM*
WEEK 4	Leaf analysis	This protocol was developed originally by NETLAKE. The students were able to find and classify the Phragmites Australis plant, establish the relationship with the amount of nutrients in the lake and make measurements about lake ecosystem to share their data within the scope of citizen science through a mobile application called LakeObserver.
WEEK 4	Water color quality	This protocol was developed originally by NETLAKE. It was aimed students to associate water color with the amount of nutrients, light and chlorophyll in the lake and share their data within the scope of citizen science through EyeOnWater mobile application.
WEEK 4	Measurement of lake depth	The aim of measuring lake depth was enabling students to define and recognize a scientific measuring tool used in limnology research, its purpose and working principle as well as scientific data collection by using it. In addition, students were encouraged to produce design ideas by asking how they could design alternative models by reverse engineering.

Table 3.13 (Continued)

WEEK *4*	Light transmittance design and measurement	This measurement was used for students to define and recognize a scientific measuring tool used in limnology research and practice using it. Students modelled the alternatives of a scientific measurement instrument, tested their models in lake, revised them and compared their results with the results of their classmates and the data they gather by using the actual scientific instrument.
WEEK *5*	Water sampling design and measurement	This measurement is used for students to recognize, understand the purpose of a measuring instrument used in limnological research and learn how to use it. The alternatives of this measurement instrument, which are still used today, were modeled, tested, revised and results were compared by the students.
WEEK *5*	iButton protocol	This protocol was originally developed by NETLAKE. The students were able to collect continuous data for a week with using portable batteries that record the temperature measurements placed at different depths of lake water, graph the results and correlate them with the temperature stratification in the lake and interpret the effect of temperature on dissolved oxygen and living places.

Table 3.13 (Continued)

WEEK 5	Teabag protocol	This protocol was originally developed by NETLAKE. It was conducted for students to calculate how much weight of different herb species in dissolution-resistant plastic tea bags have been changed for one week after placing them at different depths of lake water, and to interpret the results by associating with decomposition and alimentary relationships.
WEEK 6	Phytoplankton observation	This observation was made by students to classify phytoplankton species according to their similarities and differences, to use an advanced microscope and to understand the size of phytoplanktons.
WEEK 6	Zooplankton observation	This observation was made by students to classify zooplankton species according to their similarities and differences, to use an advanced microscope and to understand the size of phytoplanktons.
WEEK 6	Aldehyde-fixed fish observation	This observation was made in order to enable students to learn why and how fish records are being kept in scientific laboratories and to establish the relationship between prey and predator by looking at the size and structure of different fish.

Table 3.13 (Continued)

WEEK 6	Chlorophyll-a precipitation	This activity was conducted to enable students to involve in scientific processes (estimation, hypothesis, measurement, data collection, interpretation, inference, etc.) leaded by researchers in laboratory, differentiate the relationship between chlorophyll, photosynthesis and phytoplankton and to assess the effect of technological instruments used.
WEEK 7	Multi probe measurement	This activity was performed by the students to recognize, understand and learn to use a scientific instrument used in limnology research and discuss the relationship among the variables; temperature, dissolved oxygen and salinity.
WEEK 7	Invertebrate sampling and observation	This activity was conducted to enable students to identify the habitat of aquatic invertebrates live, to see how and with which instruments are being used for sampling and observation, to classify invertebrates according to similarities and differences, and to relate the size of invertebrates according to their trophic levels.

Table 3.13 (Continued)

WEEK 7	Birdwatching	This activity was conducted to enable students to identify the habitat of aquatic birds, to see how and with which instruments are being used to observe, and to classify birds according to similarities and differences, and to relate the size of birds according to their trophic levels.
WEEK 7	Paleoecological sampling	By this sampling activity, students discussed how the researchers get knowledge about the history of the lake and make scientific inferences about biodiversity of the lake ecosystem about the history of lake. Students were enabled to observe paleoecological sampling methods and make predictions about the future of the lake ecosystem.

3.6.2.3 Meet-a-scientist Seminars

The aim of the seminars held by experts in the field was to share scientific knowledge with students as well as to provide an opportunity for students to meet a real scientist and ask questions. Within this context, there were two seminars were organized in the seventh and eight weeks of the treatment. In order to realize a meaningful transfer of information, the informative presentations were made clear and simple. Through these seminars, students were expected to expand their insights about how science progresses and how scientific studies are made, and were given the opportunity to develop a positive attitude towards nature and science by being curious about the subject. Each seminar session was held at the school in a way almost one hour based on the agreement of the school administration, teachers, speakers and researchers. Topic and the speaker information were represented in Table 3.14 and photos from seminars were given in the Figure 3.18 and Figure 3.19.

Table 3.14 Meet-a-scientist Seminears in LEEP

Topic	**Speaker**
Biodiversity and Classification in Living Organisms	Dr. Mert Kukrer, Biology Department, METU
Lake Ambassadors Training: I Know, Love and Save My Lake	Prof. Dr. Meryem Beklioglu, Biology Department, METU

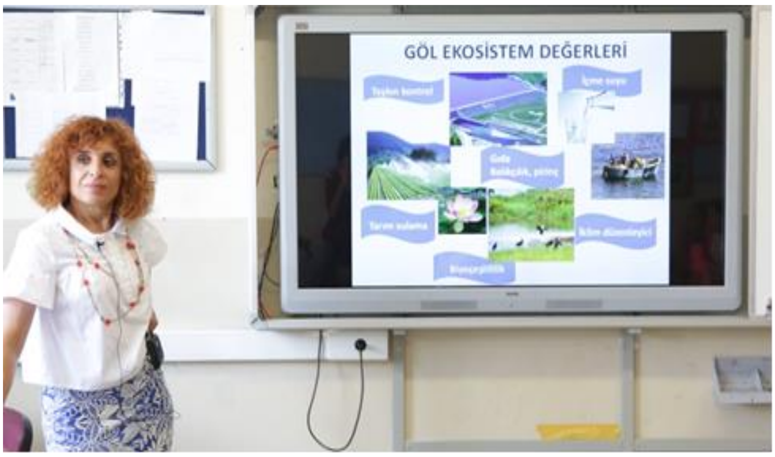


Figure 3.18 Meet-a-scientist Seminars Example 1

Figure 3.19 Meet-a-scientist Seminars Example 2

3.7 Treatment Fidelity and Verification

Treatment fidelity refers the consistency and accuracy of intervention and implementation. In this study, there was an experimental group consists of two classrooms and two different science teachers. The instructional materials were reviewed by the experts. Treatment fidelity was checked by the researcher's providing both teachers the same objectives, lesson plans, materials and instructions before the treatment. The teachers and researcher talked before and after each week's implementation. The researcher joined in lessons as observer. The treatment verification in both classrooms were evaluated by classroom observation checklist during the implementation of the treatment for eight weeks (Table 3.15).

Table 3.15 Inquiry-Based Classroom Behaviors (Hammerman, 2006, p.XXX)

Inquiry Classroom Teacher Behaviors	**1**	**2**	**3**	**4**	**5**
Uses a variety of methods and strategies to investigate and analyze questions and address standards; communicates with students using vocabulary					
Allows students to ask questions and design activities; mediates and monitors learning					
Facilitates student thinking; allows students to explain concepts; uses wait time in questioning; encourages critical and creative thinking					
Learns with students; revises content and approaches based on student achievement data					
Uses a variety of sources; provide a meaningful context for engaged learning					
Instruction guides to concept and skill development and varied applications to selves, their community, and the world					
Student as Active Learner					
Records data, processes information and builds understanding					
Uses terms and facts to describe, interpret, and communicate					
Designs activities, research, and investigations to answer questions					
Shares responsibility for learning; assesses self					
Student Work-Varied					
Emphasis on investigations, student-generated data, research and meaning					
Tasks vary; investigations are real-world with emphasis on data and research					
Teacher and students direct tasks					
Shows evidence of thinking, reasoning, problem solving, explanations, and research					
Uses visuals to show and describe understandings and relationships					

The inventory in the Table 3.16 was designed to define the inquiry-based classroom climate (Hammerman, 2006). There are three categories; teacher's behaviors, student's role and the nature of student work. Based on the items of this inventory, the implementation of teachers and the classroom environment were assessed by the researcher during each lesson. Besides, the researcher took specific notes about the treatment during the classes. After each lesson ended, the researcher and teachers discussed about the lesson about protocol implementation. By this means, same implementation of treatment was provided for both groups in the study.

3.8 Data Analysis

The purpose of the study was to examine the effects of LEEP Lake Ecosystem Education Program on science process skills, scientific epistemological beliefs, perceptions of a lake ecosystem and views about the treatment of 7^{th} grade students. Data analysis can be explained in two parts; descriptive statistics and inferential statistic.

3.8.1 Descriptive Statistics

The minimum and maximum values, means and standard deviations, skewness and kurtosis values were calculated for each continuous variable instrument of the study.

3.8.2 Inferential Statistics

The data gathered by quantitative, qualitative and mixed data collection methods. Data analysis was performed quantitatively for all instruments of the study. The statistical analyses of data were performed by SPSS 24.0 (Statistical Package for Social Sciences) for Windows. For coding qualitative data, Microsoft Office Excel program was used.

Missing data may affect the results of the statistical tests and hence comprehending the results. For dealing missing data, there are several ways; for instance, the related subjects may be deleted or list and pair wise deletion may be applied. In this study the respondents who picked all answers or joined in either pretest or posttest were accepted as missing data of full questionnaire; therefore, these subjects were completely excluded from the analysis. Missing items were handled by replacing them with the mean scores of each item.

Assumptions of paired sample t-test were checked to run a statistical test with SPSS. After data was prepared for analysis and assumptions were checked for inferential statistics, paired sample t-test was conducted for SPST and, EBQ to compare two means of the same subject before and after treatment. The quantitative part of SRQ where data collected only as posttest and DIS where data collected only as pretest analyzed descriptively.

The qualitative data collected from students by self-report methods. Visual graphic techniques were used for LEDT; and open-ended questions were used in SRQ instrument. For conducting qualitative analysis, categories, codes and success criteria for LEDT, and SRQ were determined by the researcher from middle science education and an expert of the freshwater ecosystems from biology department. The coding was conducted separately before sharing the findings between. Later, the differences of findings were agreed upon by arguments for establishing the reliability and validity of the data. The scope of students' understanding a lake ecosystem concept, a rubric was developed based on the patterns by the researcher.

3.9 Trustworthiness of the Study

The findings and interpretations are accepted as valid based on the trustworthiness of the study. In this research, trustworthiness of the study was explained under internal validity, external validity and reliability sections.

3.9.1 Internal Validity

The unintended difference on dependent variable affects independent variable (Fraenkel & Wallen, 2006). Despite of the fact that researchers take some precautions for eliminating internal validity threats, there are unavoidable threats affecting the results of social studies (Allen, 2017). The potential internal validity threats in this study and the elimination of these threats were explained in this section.

Unlimited differences of subject characteristics such as students' gender, age, ethnicity, maturity, intelligence, socioeconomic background and so on can affect the results of the research. In this study, subject characteristics were quite similar (Table 3.2).

Since there were two different teachers in classrooms doing implementation of the treatment, implementation threat is possible for this study. The researcher attended to all treatment sessions of both classrooms and evaluated implementations by observation checklist to ensure treatment validity and control implementation threat. Location can affect performances of students and their answers. The pretests and posttests were collected in their own classrooms since they are familiar to be in it. A silent classroom environment with good lighting and ventilation in both classrooms were provided in order to eliminate location threat.

Data collector bias and data collector characteristics threat was prevented by the researcher collected the data from all subjects next to classroom teachers. The researcher informed students about the aim of the instruments and waited students in the classroom until they leave all instruments.

Testing is an internal validity threat because students can memorize the items of pretests and mark them as they remembered in posttests or they can make corrections of their prior mistakes in posttests. To eliminate this, students were not told that they

have taken the same instruments as posttests. Moreover, the posttests were conducted after eight weeks of treatment. Therefore, the possibility of students giving the same or corrected answers at pretests and posttests were minimized.
The maturity of students did not significantly change after treatment because the treatment was held eight weeks long. The amount of time of the research was not very long to cause mental or physical changes on students.
Mortality threat was avoided by the researcher taking the student lists of classrooms and marking which students missed filling the pretests or the posttest. If a student had lack of a score in any variables of pretests, his or her related pretest results were directly excluded from the data analysis.

The researcher joined at all classroom sessions of the treatment, pretests and posttest as well as being in communication with both teachers continuously. There were no unforeseen circumstances which trigger students' performances in a positive or negative way happened during the study, so the responses of the students were not affected by history threat.

Regression threat is caused by the initial differences affecting the results of posttests. This threat is eliminated by conducting pretests of science process skills, epistemological beliefs and the lake ecosystem drawings.

3.9.2 External Validity

The possible external validity threats were minimized by choosing the sample of the study from a public school in the basin of Lake Eymir. The generalizability of the study was limited because of convenience sampling methods. However, based on the number of the students in classrooms at Golbasi district which was calculated as 37 students per primary or middle class by MoNE (2019); ages of 7th grade students, mostly ranged from 12 to 14 years old, and socioeconomic background of students living in public schools in Golbasi district low or medium, the results of the study was generalized into accessible population.

3.9.3. Reliability

The reliability of implementation was employed by observation checklist explained in the treatment fidelity and verification section of the study. The observer of treatment implementation was the researcher. The observation was evaluated by using an inventory for inquiry-based classroom climate (Hammersman, 2006) and researcher's notes taken during each class session for both classrooms.
A subject who did not attend pretest or posttest of the same instrument was removed from the analysis; in other words, there was no replacing or pairing of different subjects for the same instrument.

The reliability of all quantitative instruments was determined by calculating Cronbach's alpha. Besides, mean and standard deviations of each instruments were calculated.

For assessing reliability of qualitative data, intercoder agreement reliability technique was obtained (Creswell, 2014). The categories, codes and success criteria were determined by the researcher from middle school science education and a Ph. D. degree expert of the freshwater ecosystems from biology department. The coding was conducted separately before sharing the findings between. Later, the differences of findings were agreed upon by arguments for establishing the reliability and validity of the qualitative data.

3.10 Assumptions, Limitations and Ethical Issues

3.10.1 Assumptions

1. The treatment was applied under standard conditions.
2. The instruments SPST, EBQ, LEDT and SRQ were administered under standard conditions.
3. The students gave sincere answers to the items of instruments.

3.10.2 Limitations

1. The research concept was limited with the lake ecosystem topic.
2. The sample of the study was limited with fifty-two 7th grade students which indicates a small part of accessible population; therefore, the generalizations are limited.
3. The duration of the study was ten weeks in total including eight week-long treatment.
4. The observer of the implementation in both classrooms was only the researcher.
5. There was no control or comparison group.

3.10.3 Ethical Issues

After the owners of each instrument were asked for using the instruments.to start conducting the current study, METU Human Subjects Ethics Committee Center was applied and they examined the proposal of the study and approved that there was no potential harm to students so the study to proceed. Later, the allowance from Strategy Development Center of Ministry of National Education, school administration, teachers, parents of the students and students was also taken by letters and meetings for conducting this study. The aims and a short description of the study was given to students verbally and the permission papers sent to all parents. Students and their parents were also informed that the students' names on pretests and posttests were only seen by the researcher and recoded into numbers to protect data under confidentiality. The phone number and e-mail address of the researcher were written in allowance paper in case a parent wanted to make a direct contact with the researcher.

CHAPTER 4

RESULTS AND CONCLUSIONS

This chapter reports the results and conclusion of the research under three parts; explaining descriptive statistics analyses, inferential statistics analyses to test null hypotheses, and the findings as conclusion of the study.

4.1 Descriptive Statistics Analyses

The data of Demographical Information Survey was composed of nominal and ordinal values. The data frequencies and percentages of DIS were presented in the table of characteristics of students in previous chapter (Table 3.2).

Before analyzing the quantitative data, the names of all students were labelled as subject numbers to keep students anonymous. The variables were formed for SPST and EBQ instruments, the negative items (item 1, 6, 10, 12, 15, 16, 19, 20, 23) in EBQ were reversed (1=5, 2=4, 3=3, 4=2, 5=1) and dimensions of SPST and EBQ were computed as new variables. For checking the percentage of missing data at the data set, overall summary was checked for EBQ (Figure 4.1) and SPST (Figure 4.2).

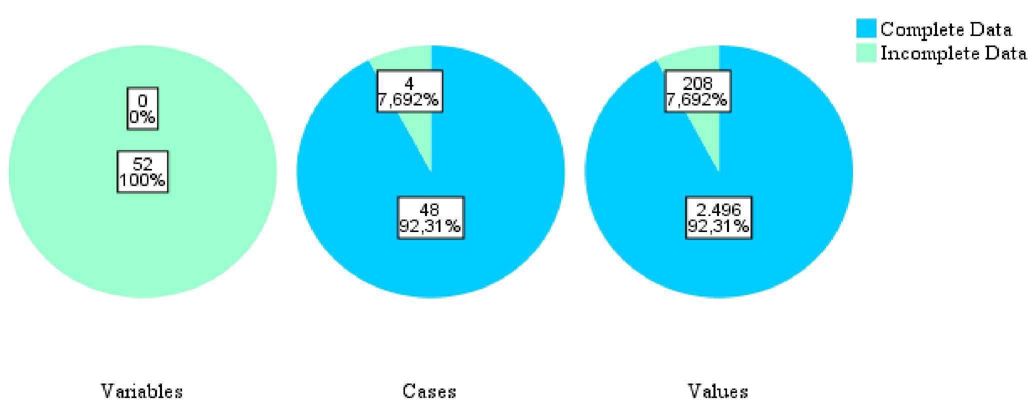


Figure 4.1 Overall Summary of Missing Values in EBQ before Data Preparation

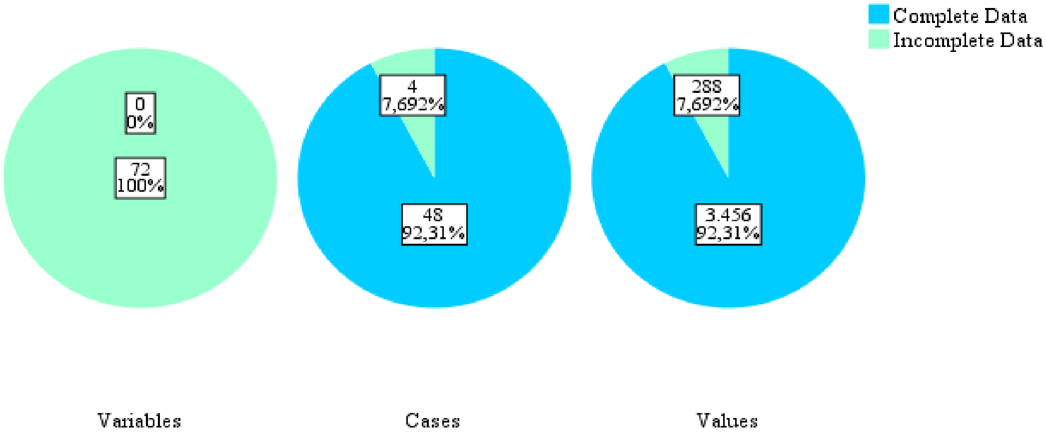


Figure 4.2 Overall Summary of Missing Values in SPST before Data Preparation

In the raw data, the percentages of missing subjects were more than 5% which indicated that normality of data set may be affected because of missing data (Tabachnick & Fidell, 2007). Therefore, these subjects who had missing data of full questionnaire (*N*=4, 7.69%) were removed from the data set. After removing 4 subjects from the data set, there was no missing data left for EBQ. Among 48 subjects, students who have missing partial data about a single or several items was handled by understanding missing data mechanism. Little's MCAR test conducted for SPST (Chi-Square = 231.109, DF = 489, Sig. = .772). Since p>.05, the null hypothesis that is the missing data is missing completely at random was accepted and the missing data fixups was done by series mean imputation.

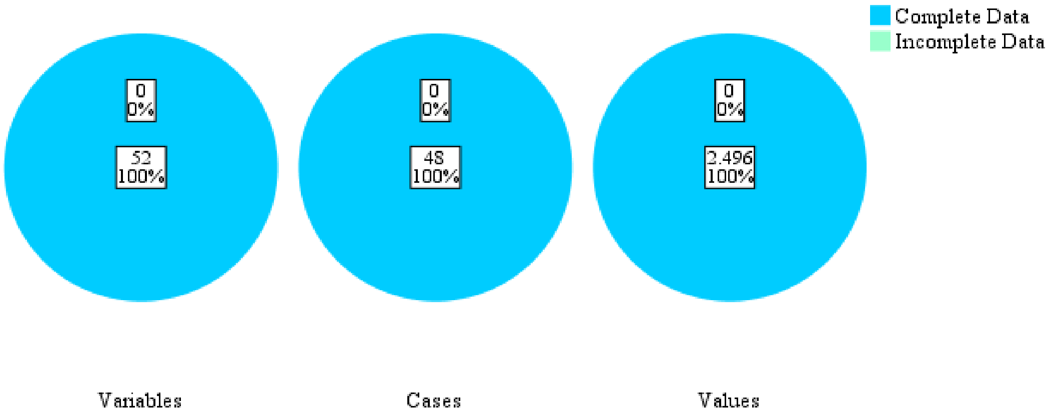


Figure 4.3 Overall Summary of Missing Values in EBQ after Data Preparation

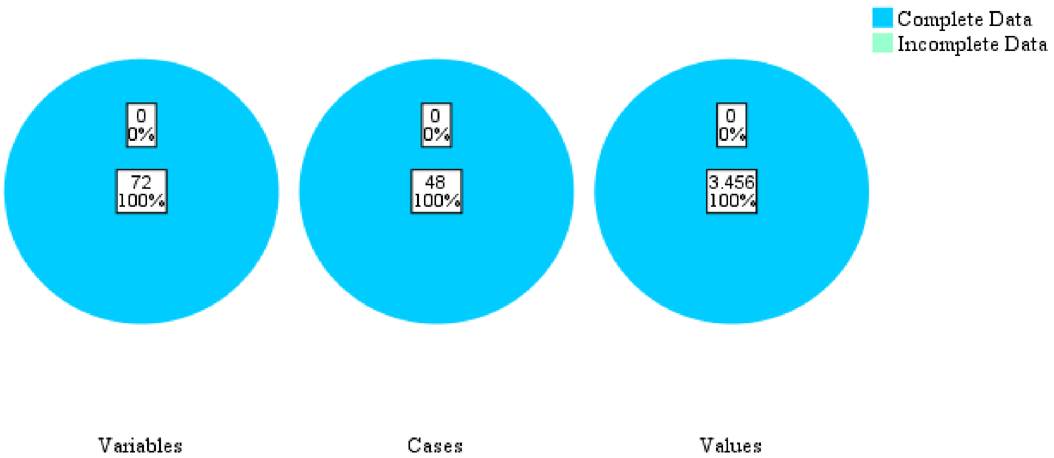


Figure 4.4 Overall Summary of Missing Values in SPST after Data Preparation

4.1.1 Descriptive Statistics Analysis of SPST

The descriptive statistics of SPST and EBQ were reported based on the clean data set (Table 4.1 through Table 4.4). While the lowest score that a student took from SPST before treatment was 5.00, it increased to 8.00 after treatment as seen at Table 4.1. In a similar way, the maximum score was raised from 31.00 to 35.00 over 36 total score. The mean values of SPST after treatment are higher than the mean values of SPST before treatment. The posttest scores of students more homogenous than the pretest scores and the pretest and posttest scores of SPST distributed normally.

Table 4.1 Descriptive Statistics of Science Process Skills Test

SPST	N	Min	Max	Mean	SD	Skewness	Kurtosis
Pretest	48	5.00	31.00	15.20	6.64	0.62	-0.45
Posttest	48	8.00	35.00	20.36	8.07	0.34	-0.96

Note: The SPST has 36 items and scores range from 0 to 36.

In order to provide further details, the descriptive statistics of each dimension in pretest and posttest of SPST were calculated (Table 4.2). Although the minimum score of pretest and posttest of SPST, 0 minimum values was found in each dimension. Maximum score of three dimensions; operationally defining, data and graph interpretation, and experimental design did not change, while identifying variables and identifying testable hypothesis scores were increased after treatment. There was an increase in the means of each dimension of SPST. From the highest level of increase to lowest level of increase in the means were identifying variables, identifying testable hypothesis, data and graph information, operationally defining and experimental design; respectively as seen clearly in Figure 4.5.

Table 4.2 Descriptive Statistics of Dimensions of Science Process Skills Test

SPST	N	Min	Max	Mean	SD	Skewness	Kurtosis
Identifying Variables							
Pretest	48	0.00	10.00	4.67	2.63	-0.48	-0.53
Posttest	48	0.00	12.00	6.23	3.24	0.45	-.048
Operationally Defining							
Pretest	48	0.00	6.00	2.58	1.58	0.54	-0.60
Posttest	48	0.00	6.00	3.17	1.48	0.03	-0.38
Identifying Testable Hypotheses							
Pretest	48	0.00	8.00	3.53	2.06	0.50	-0.61
Posttest	48	0.00	9.00	4.91	2.35	-0.02	-0.98
Data and Graph Interpretation							
Pretest	48	0.00	6.00	2.85	1.34	-0.07	0.11
Posttest	48	0.00	6.00	4.18	1.46	-0.59	-0.13
Experimental Design							
Pretest	48	0.00	3.00	1.58	1.09	-0.22	-1.22
Posttest	48	0.00	3.00	1.88	1.12	-0.50	-1.15

Note: The number of items is 12, 6, 9, 6 and 3 at Identifying Variables, Operationally Defining, Identifying Testable Hypotheses, Data and Graph Interpretation and Experimental Design dimensions, respectively.

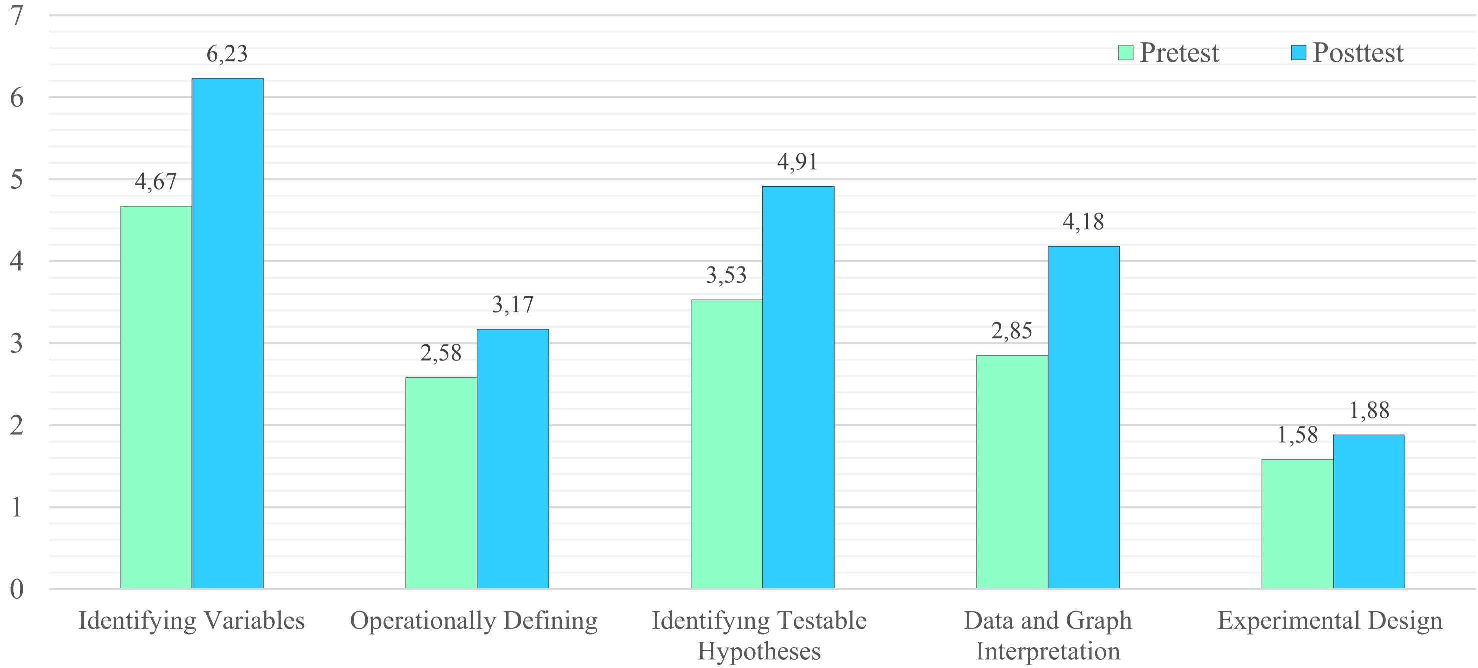


Figure 4.5 Pretest and posttest means of each dimension in SPST

4.1.2 Descriptive Statistics Analysis of EBQ

Table 4.3 displays descriptive statistics of EBQ. There were 24 items which each item was scored ranging from 1 to 5; that 5 refers strongly agreement. The minimum and maximum values of EBQ before treatment was raised after treatment. Correlatively, there was a mean difference. The mean value of pretest was 82.75 and posttest was 101.58. Skewness and kurtosis values indicate normal distribution with exception one kurtosis value. The normality of data distribution will be evaluated by different methods in the advance of conducting any statistical test in inferential statistics section.

Table 4.3 Descriptive Statistics of Epistemological Beliefs Questionnaire

EBQ	**N**	**Min**	**Max**	**Mean**	**SD**	**Skewness**	**Kurtosis**
Pretest	48	39.00	113.00	82.75	15.65	-0.53	0.52
Posttest	48	52.00	120.00	101.58	15.91	-1.65	2.34

Note: The EBQ has 24 items and the scores range from 0 to 120.

The descriptive statistics of EBQ were enlarged upon dimensions of EBQ (Table 4.4). The highest mean of dimension in pretest and posttest was Justification; while the lowest mean was pertaining to Development dimension. There was one student who had 45 points over 45 points from Justification dimension at pretest. After treatment, the number of students who gave all answers true in Justification dimension was raised into five. On the contrary, the minimum score at Source/Certainty dimension decreased, in spite of the fact that there was rising in the mean at Source/Certainty dimension. More detailed comparison of pretest and posttest scores of each dimension can be seen in the figure below (Figure 4.7).

Table 4.4 Descriptive Statistics of Dimensions of Epistemological Beliefs Questionnaire

EBQ	N	Min	Max	Mean	SD	Skewness	Kurtosis
Justification							
Pretest	48	16.00	45.00	35.44	6.36	-1.31	1.80
Posttest	48	24.00	45.00	40.25	4.34	-1.60	3.38
Development							
Pretest	48	7.00	29.00	19.98	5.10	-0.74	0.24
Posttest	48	8.00	30.00	25.81	5.09	-2.17	4.15
Source/Certainty							
Pretest	48	11.00	43.00	27.33	7.74	-0.31	0.35
Posttest	48	9.00	45.00	35.52	8.06	-1.69	2.76

Note: The number of items is 9, 6 and 9 at Justification, development and Source/Certainty dimensions, respectively.

It is important to emphasize here that the means of dimensions of EBQ and SPST differentiates in term of being different types of instruments. The maximum score of a student could take was 5 points from any dimension of EBQ; nevertheless, the maximum score of a student could take was 45, 30, 45 points from Justification, Development and Source/Certainty dimension SPST, respectively.

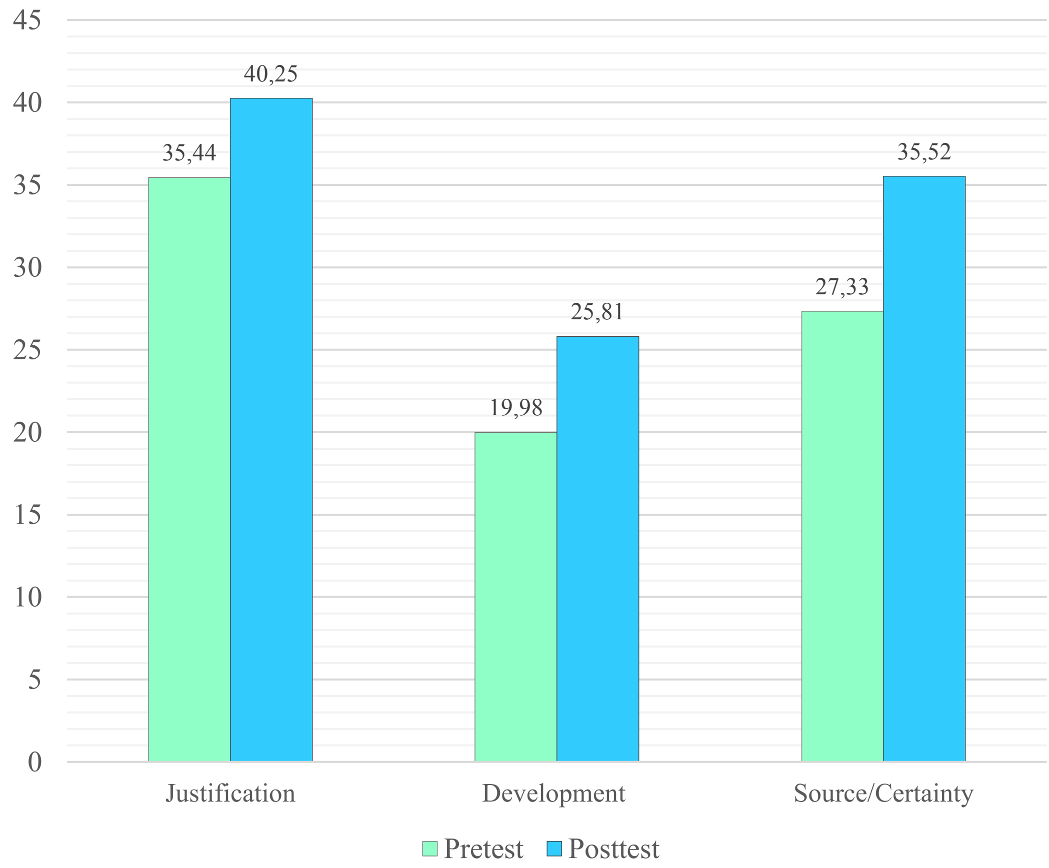


Figure 4.6 Pretest and posttest means of each dimension in EBQ

4.1.3 Descriptive Statistics Analysis of SRQ

The data of SRQ have gathered from subject of the study anonymously. The aim of SRQ was investigating the views of sample about the treatment. Four subjects had missing partial or full of missing data. They were removed from the data set and the data analysis. Descriptive statistics of quantitative items of SRQ, summary item statistics and the descriptive statistics of each item were represented through tables accordingly (Table 4.5, Table 4.6 and Table 4.7).

The mean score of all items were 66.98 over 75.00 as seen at Table 4.5, while the mean of items was calculated 4.47 over 5.00. Results show that the majority of students gave positive reviews about the training program. The scores of groups were homogen and the data distribution of SRQ look normal despite of a presence of few exceptions (Table 4.7). Each item of SRQ was marked as maximum by at least one student. There were six students having 75 points over 75; in other words, they gave completely positive reviews about the treatment. The least agreement on items were on the item 10, 11 and 12. Similarly, the lowest mean was on item 11 and the next was item 12. These items were related to duration and number of components of LEEP.

Table 4.5 Descriptive Statistics of SRQ

SRQ	N	Min	Max	Mean	SD	Skewness	Kurtosis
Posttest	48	53.00	75.00	66.98	5.65	-0.45	-0.25

Note: The SRQ has 15 quantitative items and the scores range from 0 to 75.

Table 4.6 Summary Item Statistics of SRQ

SRQ	Mean	Minimum	Maximum	Range	Variance
Item Means	4.47	3.27	4.90	1.63	0.22

Table 4.7 Descriptive statistics of Each Item in Students' Review Questionnaire

Item	Item Statement	Min	Max	Mean	SD	Skewness	Kurtosis
1	I have learned something new about the lake ecosystem with this training program.	4.00	5.00	4.90	0.31	-2.68	5.38
2	I think that this training program is helpful for me in my current and future life.	3.00	5.00	4.60	0.57	-1.13	0.37
3	The training program was suitable to my grade level.	3.00	5.00	4.62	0.57	-1.2	0.64
4	Training materials (presentations, documents, experiments, discoveries, etc.) were interesting.	3.00	5.00	4.75	0.56	-2.22	3.96
5	The in-class activities were beneficial.	4.00	5.00	4.83	0.38	-1.85	1.47
6	The fieldwork activities helped me to have more permanent information that I learned in classroom.	3.00	5.00	4.65	0.60	-1.52	1.33
7	In the fieldworks, it was beneficial to get information about the topic by meetings with the scientists working at the topic.	4.00	5.00	4.73	0.45	-1.07	-0.90
8	The duration of in-class activities (8 weeks) was enough.	1.00	5.00	3.77	1.37	-0.75	-0.78
9	The duration of fieldwork activities (4 weeks) was enough.	1.00	5.00	3.27	1.38	-0.31	-1.14
10	The number of meet-a-scientist seminars was enough.	1.00	5.00	4.02	1.01	-0.84	-0.22
11	Meet-a-scientist seminars were beneficial.	3.00	5.00	4.65	0.56	-1.35	0.95
12	The duration of meet-a-scientist seminars (2 weeks) was enough.	2.00	5.00	4.04	0.99	-0.50	-1.05
13	I recommend all the trainings in this program be given to others.	1.00	5.00	4.02	1.01	-0.84	-0.22

In order to obtain detailed data of the reviews of students about the treatment, three open-ended questions were asked at SRQ instrument (Table 3.7). The answers of students were coded and categorized according to theme of each question by the researcher. There were eight categories of the first open-ended item of SRQ. The frequencies and percentages categories and codes of answers and were represented below from Table 4.8 to 4.10.

Table 4.8 Frequencies and Percentages of the First Open-ended Item (Q14) at SRQ

	Code		
Categories	***f***	**%**	**Students' Example Statement**
Scientific activities	36	36.73	Making investigation and exploration
Lake Eymir field trips	21	21.43	Watching daphnia in the lake water
Lake ecosystem topic	14	14.29	Learning biodiversity in the lake
Limnology laboratory	9	9.18	Examining zooplanktons and phytoplanktons under microscope
In-class activities	7	7.14	Videos and discoveries
Designing activities	5	5.10	Working with my own design
Meet-a-scientists	3	3.06	Doing experiments with real scientists together
Others	3	3.06	Drawing maps

Note: The number of respondents for qualitative items of SRQ was *N*= 49.

There were scientific works conducted in all in-class, in Limnology Laboratory and at Lake Eymir activities. Based on the students' answers to Item 14; "What was your favorite part in LEEP", the most favorite part of them (*N*= 36, 36.73) in this training was about scientific works (Table 4.8). Lake Eymir fieldwork was the second favorite part of students. More than a quarter of codes were about Lake Eymir fieldwork. The lake ecosystem topic follows these categories with a percentage of 14.29.

Item 15 of SRQ was "What would you want to change in LEEP". Nearly the half of the answers were about no request of change at LEEP, even if they had chance to make a change (Table 4.9). The focus of the suggested change was on the time of activities. Students generally complained about the short duration of the treatment in their responses. The number, type and topic depth of activities were the other willed areas for students to make a possible change.

Table 4.9 Frequencies and Percentages of the Second Open-ended Item (Q15) at SRQ

	Code		
Categories	***f***	**%**	**Students' Example Statement**
No addition	25	49.02	I would not change anything
Duration	14	27.45	I would increase the time of activities
Number of activities	5	9.80	I would want more experiments and seminars
Type of activities	4	7.84	I could not make my design like I thought in my mind. I would want to change my design
Topic depth	3	5.88	I would want getting more information about the living things

Item 16 of SRQ was "Provide other opinions and suggestion please, if you have any". Only six suggestions (N= 6, 12.24%) were provided by students under the third open-ended question of SRQ (Table 4.10). These six statements of students were displayed under the title of example statement at table. Five of all suggestion statements were about scientific activities.

Table 4.10 Frequencies and Percentages of the Third Open-ended Item (Q16) at SRQ

	Code		
Categories	***f***	**%**	**Students' Example Statement**
No suggestion	43	87.76	Everything was very great and it made contribution to my education life.
Suggestions	6	12.24	• There could be more experiments and seminars. • The living things on the lake sediment could be investigated thoroughly. • I would want measuring the depth and temperature of the lake by going aboard to the center of the lake by boat. • I would want making experiments at different lakes. • Going aboard by boat could be fun.

4.1.4 Descriptive Analysis for LEDT

For data analysis of LEDT, inductive data analysis methods were utilized. Instead of searching predetermined codes or patterns; the categories, subcategories and codes emerged from the drawings and explanations of students (Krippendorff, 2013; Patton, 2002). The categories and codes were determined by the researcher and a Ph.D. degree expert of the freshwater ecosystems after first reading. Before sharing the findings, the coding was conducted separately to ensure consistency. If a student had same code for both drawings and explanations, it was accepted as only one code. Codes were revised separately and categories were grouped after second reading. Hereby, every code connected to a category and no empty category left in the data analysis process (Lincoln & Guba, 1985; Krippendorff, 2018). The examples of coding students' drawings and explanations were mentioned below (Chapter 4.1.3.1.; 4.1.3.2; 4.1.3.3 and 4.1.3.4). The data of LEEP were collected from 49 students before treatment and 48 students after treatment. The LEDT results of students before treatment were presented in Table 4.11 and the LEDT results of student after treatment were represented in Table 4.12.

Table 4.11 Categories, subcategories and codes of students' responses to pre-LEDT

Themes	Categories	Subcategories	Codes	*f*
Biotic Components	Consumers	Fish	Carp	8
			Trout	2
			Goldfish	1
			Anchovy	1
			No specific named fish	33
			Total	45
		Aquatic bird	Duck	10
			Cormorant	4
			Swan	1
			Goose	1
			Stork	4
			No specific named bird	13
			Total	33
		Aquatic Invertebrate	Fly	1
			Mosquito	1
			Butterfly	1
			Dragonfly	1
			Centipede	1
			Total	5
		Amphibian	Frog	11
		Reptile	Turtle	5
			Snake	7
			Crocodile	1
			Total	13
		Microorganism	Plankton	2
		Human	Human	4

Table 4.11 (Continued)

Themes	**Categories**	**Subcategories**	**Codes**	***f***
Biotic Components	Producers	Aquatic plants	Reeds	12
			Reed mace	2
			Pondweed	16
			Water lily	12
			Total	42
Abiotic Components	Air	Sun	Sun	19
		Clouds	Cloud	14
		Gases	Bubbles	3
			Total	36
	Soil	Rocks	Rock	6
		Stones	Stone	2
		Sediment	Mud	2
			Total	10
	Neighbor ecosystem	Terrestrial	Forest	24
		Aquatic	Another lake	1
			Total	25

Table 4.11 (Continued)

Themes	**Categories**	**Subcategories**	**Codes**	***f***
Interactions	Biotic-Biotic	Feeding relationship	Plankton eaten by small fish	2
			Small fish eaten by big fish	2
			Fish eaten by bird	2
			Fish eaten by human	1
			Reptile eaten by reptile	1
			Total	8
		Threat	Dead animal because of human trash	1
			Total	1
	Abiotic-Abiotic	Energy	Wave on lake by rain	1
			Total	1
	Biotic-Abiotic	Human activity	Throwing stone to lake water	1
			Water cycling	1
			Boating	1
			Watching	1
			Total	4
		Human made	Port	1
			Boat	3
			Ship	2
			Fence	3
			Bench	2
			Periscope	1
			Hook	1
			Trash	4
			Total	17

Table 4.11 showed that the most common drawing of students about a lake ecosystem was fish. Almost all students (*f*=45) drew fish in lake water. Among these 45 drawings, 11 of them were labelled with a name of fish species which live in a lake (carp *f*=8; trout *f*=2; goldfish *f*=1; anchovy *f*=1). After fish, birds were drawn the most as an animal living in lake ecosystem (*f*=33). Similar to fish drawings, some students who drew birds did not label the species of birds (*f*=13). The most labelled bird was duck (*f*=10). Almost quarter of drawings had reptiles (*f*=13) and amphibians (*f*=11). Four students drew human, while interacting with lake by throwing stone to lake water, water cycling, boating and only watching. There was no microscopic organism except plankton drawings of two students. Both students just illustrated that small fish eats plankton by their drawings and explanations; however, there was no classification of planktons as phytoplankton or zooplankton. It was uncertain that students had known phytoplanktons are producers. Since there was no sign of photosynthesis or sun interaction with plankton, the discussion about plankton drawings between coders were concluded by grouping plankton drawings as living organisms which are consumers. In the same way, no students drew or mentioned decomposers in lake, though one student drew dead fish because of trash thrown by human to the lake. However, there was no explanations of what happened, after fish was dead. Aquatic plants were very common at students' drawings; including pondweed (*f*=16), reeds (*f*=12), water lily (*f*=12) and reed mace (*f*=2). The frequency of aquatic plants was the highest (*f*=42), after the frequency of fish (*f*=45), in the drawings of students. About half of the drawings included a terrestrial ecosystem next to a lake ecosystem, although students were asked to draw a lake ecosystem. One student drew two lakes next to each other. Three drawings had air bubbles next to fish in water. However; no students showed an interaction of sun with lake, although sun was drawn at sky by many students (*f*=19). Likewise, clouds were drawn by fourteen students but only one drawing showed there is a rain pouring from clouds and forming waves on the surface of the lake. 80% of drawings illustrated the lake without rock, stone or mud; but water. Feeding relationships (*f*=8) did not contain producers and decomposers, but only consumers eating another consumer.

Table 4.12 Categories, subcategories and codes of students' responses to post-LEDT

Themes	Categories	Subcategories	Codes	*f*
	Consumer	Fish	Carp	7
			Trout	1
			Tench	1
			Perch	3
			Pearl mullet	1
			No specific named fish	28
			Prey fish	17
			Predator fish	17
			Total	75
		Aquatic bird	Duck	17
			Cormorant	7
			Swan	1
			Goose	1
			Stork	3
			Reed bird	1
			No specific named bird	16
			Total	46
		Aquatic Invertebrate	Fly	2
			Mosquito	1
			Butterfly	3
			Dragonfly	1
			Water spider	1
			Worm	4
			Bug	6
			No specific named invertebrate	4
			Total	22
		Amphibian	Frog	11
		Reptile	Turtle	9
			Snake	15
			Total	26

Table 4.12 (Continued)

Themes	**Categories**	**Subcategories**	**Codes**	***f***
Biotic Component	Consumer	Microorganism	Zooplankton	26
			Water flea	9
			Plankton	1
			No specific named microscopic organism	2
			Total	38
		Human	Human	15
	Producer	Aquatic plant	Reeds	29
			Reed mace	3
			Rice	1
			Pondweed	26
			Water lily	18
			No specific named aquatic plant	1
			Total	78
		Algae	Phytoplankton	24
			Algae	4
			Total	28
	Decomposer	Decomposer	Fungi	4
			Bacteria	2
			No specific named decomposer	8
			Total	14
Abiotic Component	Air	Sun	Sun	28
		Clouds	Cloud	15
		Gases	Oxygen	5
			Carbon dioxide	3
		Weather	Rain	3
			Wind	4
			Total	7
	Soil	Rocks	Rock	5
		Stones	Stone	7
		Sediment	Mud	6
		Fossil	Bones/shell	3
			Total	21

Table 4.12 (Continued)

Themes	Categories	Subcategories	Codes	*f*
Abiotic Component	Water	Gases	Oxygen	6
			Carbon dioxide	4
			Total	10
		Nutrient	Carbon	1
			Phosphorous	4
			Nitrogen	6
			No specific named nutrient	11
			Total	26
		Salinity	Freshwater	2
			Salty lake	1
			Total	3
	Land cover/use	Terrestrial	Forest	19
			Urban	2
			Cropland	2
			Grazing	2
		Aquatic	Another lake	2
			Total	27
Interaction	Biotic-Biotic	Feeding relationship	Phytoplankton eaten by zooplankton	10
			Phytoplankton eaten by fish	1
			Zooplankton eaten by zooplankton	1
			Zooplankton eaten by invertebrates	2
			Zooplankton eaten by fish	9
			Invertebrates eaten by invertebrates	1
			Amphibian eaten by bird	1
			Prey fish eaten by predator fish	7
			Fish eaten by bird	5
			Fish eaten by snake	1
			Fish eaten by human	1
			Total	39

Table 4.12 (Continued)

Themes	**Categories**	**Subcategories**	**Codes**	***f***
Interaction	Biotic-Biotic	Threat	Dead animal because of human trash	2
			Urban runoff	2
			Agricultural runoff	2
			Industrial runoff	2
			Domestic waste	1
			Eutrophication	2
			Total	11
	Abiotic-Abiotic	Energy	Light coming from sun	16
			Heat causing stratification	5
			Wave on lake by wind	5
			Wave on lake by rain	1
			Total	27
		Cycle	Oxygen cycle	4
			Water cycle	1
			Nitrogen cycle	2
			Total	7
	Biotic-Abiotic	Natural activity	Nutrients taken by producers	14
			Sunlight taken by producers	6
			Carbon dioxide consumed by producers	2
			Dead organisms eaten by decomposers	5
			Eutrophication caused by phytoplankton increase	2
			Oxygen produced by producers	5
			Oxygen taken by consumers	4
			Oxygen taken by decomposers	1
			Total	39
		Human activity	Making experiments	6
			Cycling	3
			Standing	3
			Walking	3
			Total	15

Table 4.12 (Continued)

Themes	Categories	Subcategories	Codes	*f*
		Human made	House	2
			Factory	2
			Restaurant	2
			Port	6
			Fence	1
			Boat	1
			Trash	2
			Signboard about no fishing	1
			Binoculars	1
			Water depth meter	1
			Water sampler	2
			iButton	1
			Temperature and salinity probe	1
			Secchi disc	2
			Teabag	1
			Total	26

Table 4.12 shows LEDT results of students after treatment. The most common drawing at posttests was aquatic plants (*f*=78) and then fish (*f*=75); similar to pretest results (fish *f*=45; aquatic plants *f*=42). The most drawn fish was carp before and after treatment (pretest *f*=8; posttest *f*=7). Students used labels for fishes in terms of the common name of new fish species lake (carp *f*=7; trout *f*=1; tench *f*=1; perch *f*=1, pearl mullet *f* =1) and they differentiated fishes into their eating habits as prey or predator at drawings (*f* =17). The number of no specific named fish decreased after treatment (pretest *f*=33; posttest *f*=28).

Just as in pretest results, the most common consumer after fish in lake ecosystem was aquatic birds according to posttest results (pretest *f*= 33; posttest *f*=46). Thirty aquatic birds were labelled and duck was the most common bird labelled (pretest *f*=10; posttest *f*=17). The number of invertebrates increased in a large amount (pretest *f*=5; posttest *f*=22). In addition, the number of reptiles increased after treatment (pretest *f*=13; posttest *f*=26). The most commonly drawn reptile was snake in posttests (*f*=15).

The number of consumer microorganism drawings were higher than the number of amphibian drawings. Instead of zooplankton, some students drew water flea/daphnia as a zooplankton species (*f*=9). The number of microorganism drawing raised in a greatest amount after treatment (pretest *f*=2; posttest *f*=38). Over one third of the students drew human at a lake ecosystem (*f*=15), while doing scientific experiments (*f*=6) and sports like cycling (*f*=3), standing (*f*=3), and walking (*f*=3).

The number of aquatic plant drawings increased after treatment; pondweed (pretest, *f*=16; posttest *f*=26), reeds (pretest *f*=12; posttest *f*=30), water lily (pretest *f*=12; posttest *f*=18), reed mace (pretest *f*=2; posttest *f*=4) and rice (pretest *f*=0; posttest *f*=1).

There were 28 drawings of algae after treatment, while there were no drawings about algae before treatment. At 28 drawings of algae, phytoplankton label was used in 24 drawings. Alike to this result, the decomposers were mentioned at 14 drawings with decomposer name (*f*=8) and more specifically as fungi (*f*=4) and bacteria (*f*=2) after treatment, although there were no decomposers in pretest. Even two students noted that decomposers use oxygen by respiration.

Most of the students who drew sun at their drawings (pretest *f*=19; posttest *f*=28) showed sun effect on lake (pretest *f*=0; posttest *f*=22) in terms of light and heat energy taken by producers or used in water cycle. In the same manner of figuring the effect of an abiotic factor in a lake ecosystem, three students poured rain from clouds among fifteen clouds drawing in posttest.

Oxygen and carbon dioxide were the gases labelled or mentioned in air and water (*f*=8); and rocks, stones, mud, bones and shells were drawn in soil (pretest *f*=10; posttest *f*=21). Similar to pretest drawings, about half of students drew terrestrial land next to a lake ecosystem. Two students drew urban, cropland and grazing land in the lake basin and connected it with lake by showing nutrient runoff to the lake ecosystem.

With regard to trophic level or biotic factors in lake, the feeding relationships among biotics were mentioned in more categories after treatment (pretest *f*=4; posttest *f*=12). The most common code about feeding relationships between living organisms in a lake ecosystem was phytoplankton eaten by zooplankton (*f*=10). The codes of zooplankton eaten by fish (*f*=9) and prey fish eaten by predator fish (*f*=7) and fish eaten by bird (*f*=5) were drawn or mentioned more in drawings more than other feeding relationships.

Eutrophic lake; agricultural, urban and industrial runoff; and domestic waste affecting lake ecosystems negatively were rarely drawn or mentioned while drawing a lake ecosystem at posttest; while they have never mentioned in pretest. Five students represented thermal lake stratification in their drawings (pretest *f*=0; posttest *f*=5). Light energy was the most common energy drawn or mentioned among abiotic factors (pretest *f*=0; posttest *f*=16). The code of heat energy coming from sun to lake caused stratification was equal to wave energy caused by rain and wave energy caused by wind (*f*=5). Only three cycles; oxygen cycle (*f*=4), nitrogen cycle (*f*=2) and water cycle (*f*=1) were partially demonstrated by students' drawings; whereas only water cycle was (*f*=1) drawn in pretest.

Students depicted that producers take nutrients (*f*=14), and sunlight (*f*=6) at more in biotic and abiotic interactions. Decomposers decomposing dead organisms were mentioned by five students. The number of humans made tools in drawings were increased after treatment (pretest *f*=17; posttest *f*=26). Again, the port was the most common human made tool as drawn in pretest. Larger part of these tools were scientific tools after treatment (pretest *f*=1; posttest *f*=7).

To examplifty the data of four stıdents' LEDT results before and after were represented between Figure 4.7 to Figure 4.14.

4.1.4.1 LEDT Results of Student 1

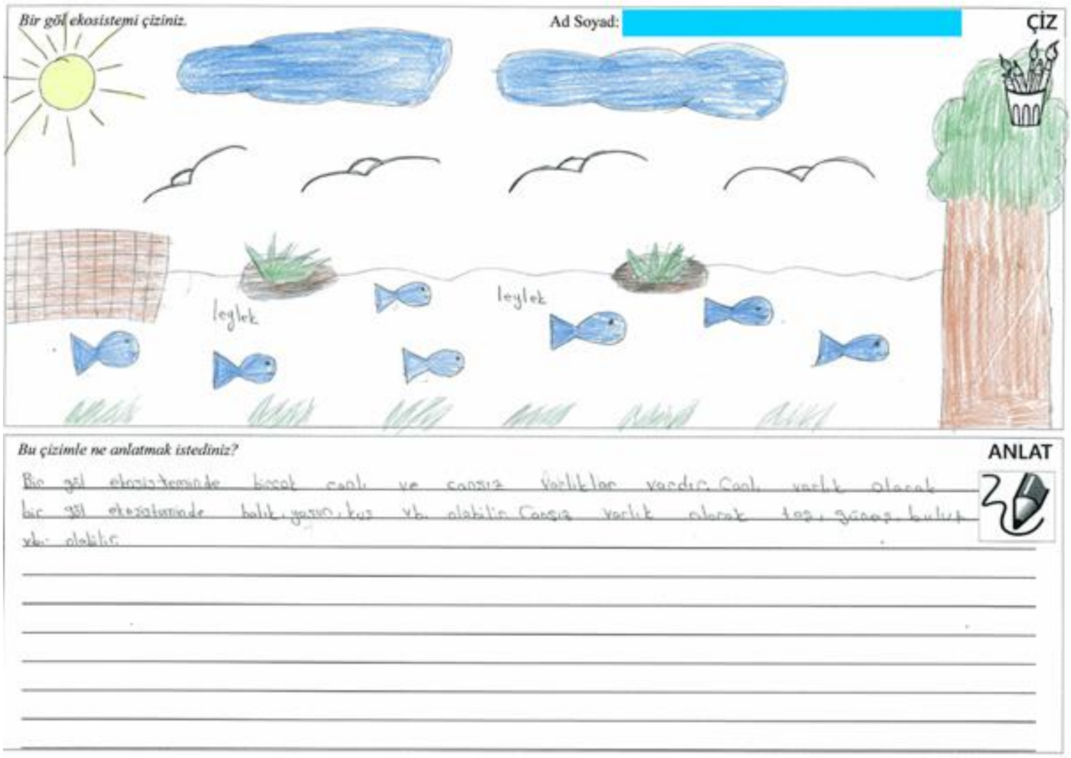


Figure 4.7 Prettest LEDT result of S1

In Student 1 drawing in Figure 4.7, students drew sun and clouds in the air, birds labelled as stork (leylek) in the air. There are no specific named fish in water. Water lily at the surface of the lake, and pondweed were the bottom of the lake. A tree and port were drawn near to the lake. The explanation of Student 1 in LEDT was:

> *There are many living and nonliving things in a lake ecosystem. Living things may be fish, pondweed and bird, etc. Nonliving things may be stone, sun, cloud, etc.*

The codes in the drawing of S1 in pre LEDT were stork, pondweed, water lily, sun, cloud, stone, port and forest.

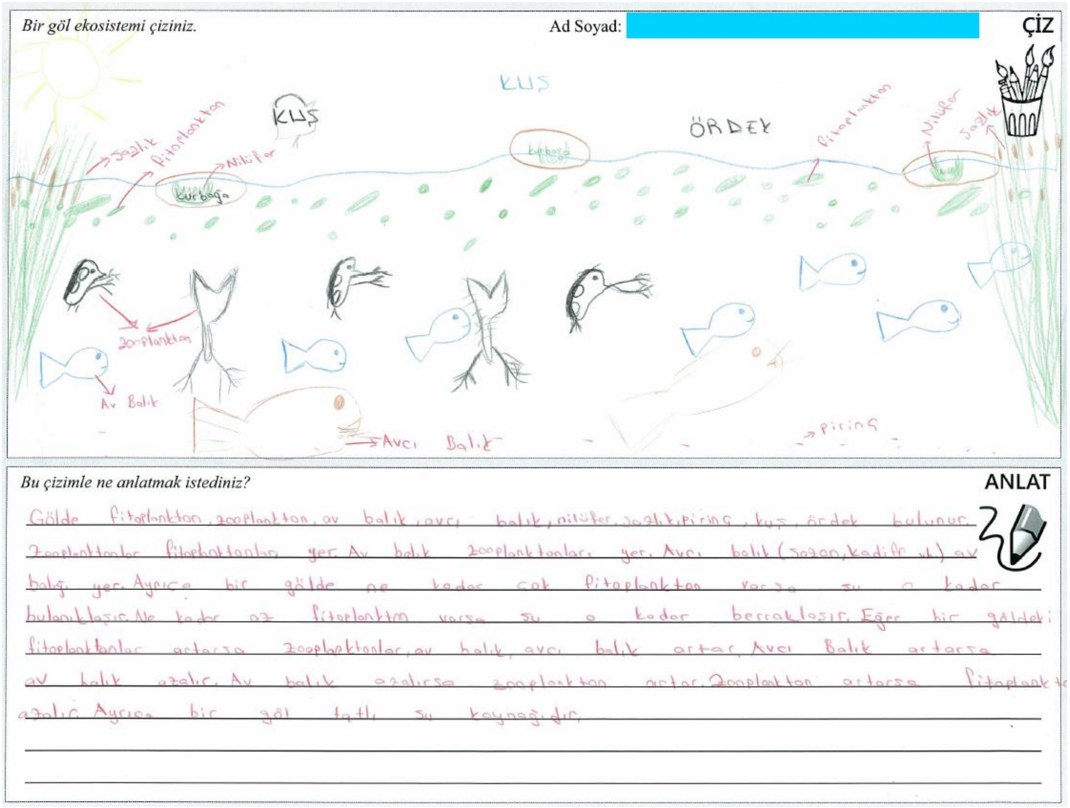


Figure 4.8 Posttest LEDT result of S1

Figure 4.7 displays drawing of the same student, S1, after treatment. There were sun and figures two birds (kuş) in the air. At the surface of the lake, there were water lilies (nilüfer), frogs (kurbağa) on water lilies, a duck (ördek) and phytoplanktons (fitoplankton). There were two types of zooplanktons, prey fishes (av balık), predator fishes (avcı balık), in the lake. Roots of the reeds (sazlık) are in the lake and their tops are in the air. Besides, rice (pirinç) is in this drawing. Student described her drawing:

> *In the lake, there are phytoplankton, zooplankton, prey fish, predator fish, water lily, reeds, rice, bird and duck. Zooplanktons eat phytoplanktons. Prey fish eat zooplanktons. Predator fish (carp, tench, etc.) eat prey fish. Also, the more phytoplanktons are in a lake, the more turbid the lake becomes. The less phytoplanktons are in a lake, the clearer the lake becomes. If the number of phytoplanktons in a lake ecosystem increases; the number of zooplanktons, prey fish and predator fish will increase. If the number of predator fish increases, the number of prey fish will decrease. If the number of prey fish decreases, zooplankton will increase. If the number of zooplanktons increases, phytoplanktons will decrease. Besides, lake is a freshwater source.*

Posttest LEDT result of S1 were coded as prey fish, predator fish, carp, tench, zooplankton, water flea, phytoplankton, frog, duck, reeds, water lily, sun, rice and freshwater under biotic or abiotic themes. The interaction was coded as phytoplankton eaten by zooplankton, phytoplankton eaten by fish, zooplankton eaten by fish and prey fish eaten by predator fish under biotic-biotic relationship.

4.1.4.2 LEDT Results of Student 2

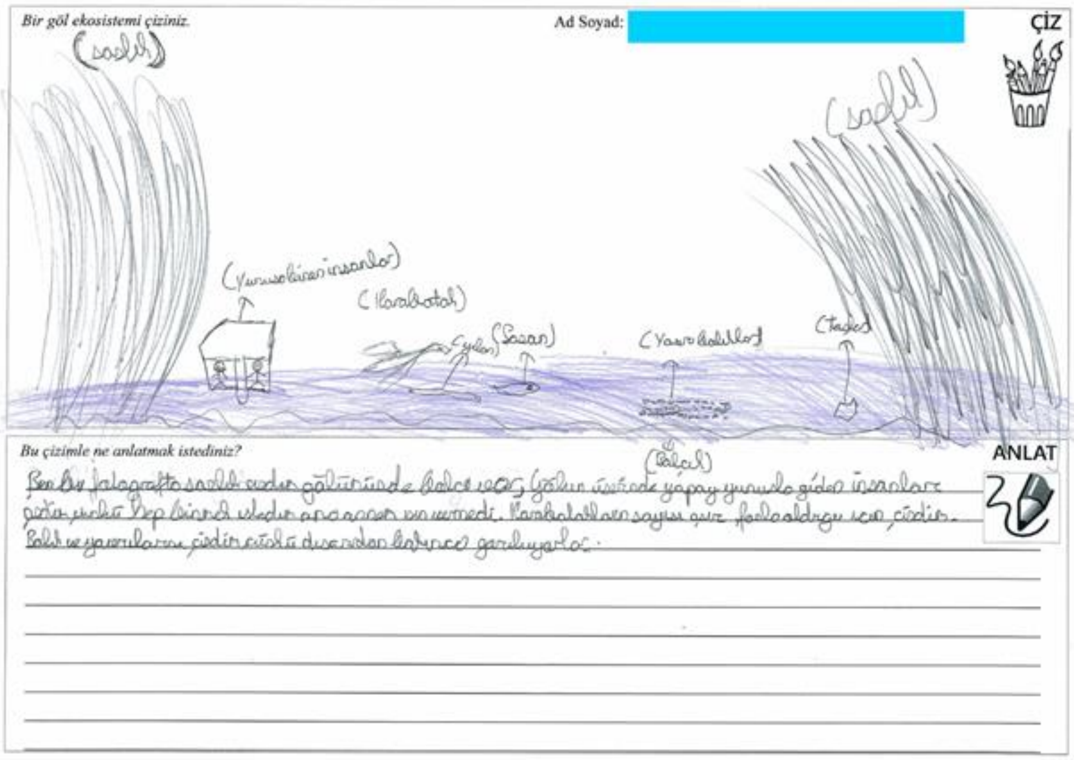


Figure 4.9 Pre-drawing LEDT result of S2

In Figure 4.9. Student 2 drew reeds (sazlık) which roots of them are in the lake sediment and top of them are in the air. There are humans doing water cycling (yunusa binen insanlar), cormorant (karabatak), snake (yılan), carp (sazan), minnow (yavru balıklar) and stones (taşlar) in the lake water; and balçık (mud) at the bottom of the lake.

S2 explained this drawing:

> *... I drew people doing water cycling on water because I always wanted it but my mother did not allow me to board. The number of cormorants is a lot. I drew a fish and its minnows because they seem when looking from outside.*

Determined codes for pre-drawing LEDT result of S2 were reeds, snake, carp, cormorant, mud, stone, human and water cycling.

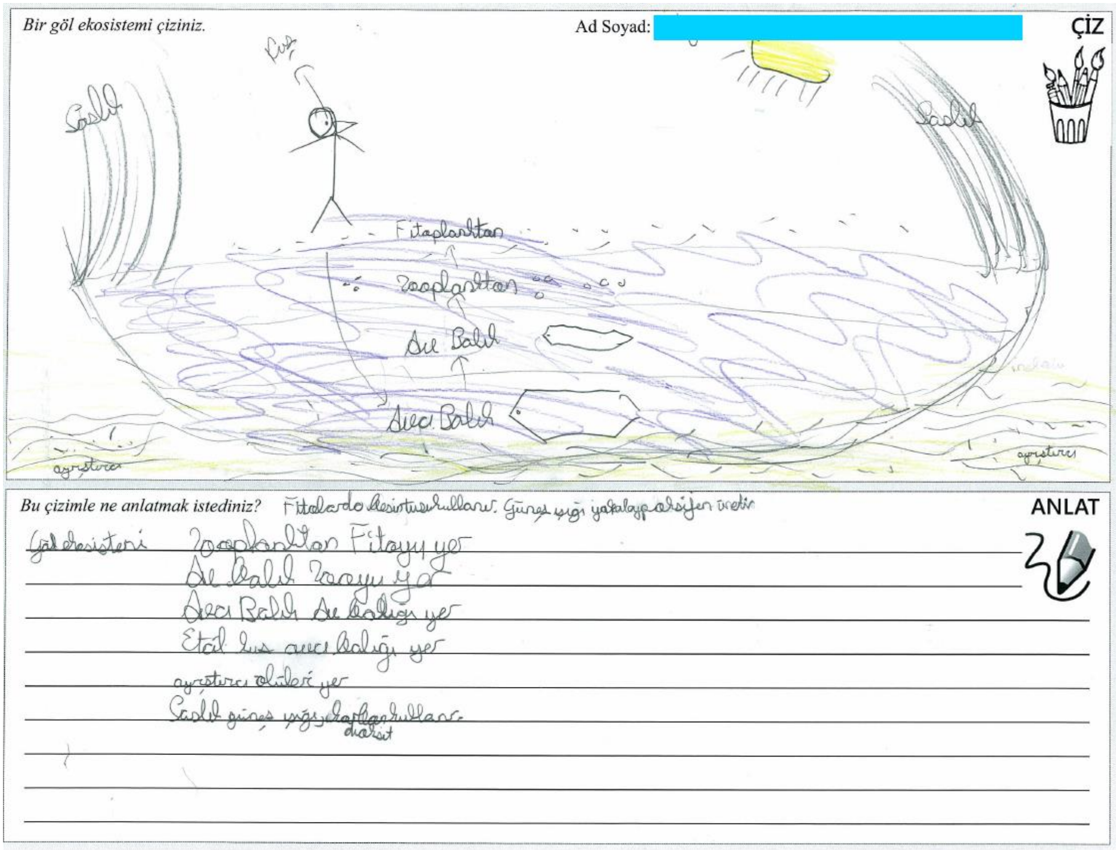


Figure 4.10 Posttest LEDT result of S2

After treatment, S2 again drew reeds in the lake. There are a bird (kuş) labelled drawing at the surface of the lake. Besides, there are phytoplankton (fitoplankton), zooplankton, prey fish (av balık), predator fish (avcı balık) in water. There was sun in the air and decomposer (ayrıştırıcı) at the bottom of the lake.

In the note student wrote:

> *Zooplankton eats phytoplankton. Prey fish eats zooplankton. Predator fish eats prey fish. Carnivore bird eats predator fish. Decomposers eat dead organisms; reeds use sunlight and carbon dioxide. Phytoplankton uses nutrients; and produce oxygen by catching sunlight.*

The codes in Figure 5.12 were reeds, phytoplankton, zooplankton, prey fish, predator fish, bird, no specific named decomposer, no specific named nutrients, oxygen, carbon dioxide, oxygen cycle, sun and sun effect. Interactions between biotic components and between biotic and abiotic components in the lake ecosystem were coded as producers produce oxygen, producers consume carbon dioxide, nutrients taken by producers, and decomposers eat dead organisms.

4.1.4.3 LEDT Results of Student 3

Figure 4.11 Pre-drawing LEDT result of S3

There are two no specific named fishes in the lake water and one frog on one of water lilies. As another biotic factor, S3 drew reed maces in the lake and the shore of the lake and as an abiotic factor she drew a flower between rocks touching the water in the shore. The explanation sentence of S3 for her drawing is.

I wanted to explain a lake ecosystem and the houses of organisms living in a lake.

This drawing contains the codes including fish, frog, reed mace, no named aquatic plant and rock.

Figure 4.12 Posttest LEDT result of S3

S3 drew a human standing on the edge of port and there is a fence around the lake. There is boat on water and pondweed upon the feet of port. In addition to reed maces and a frog on one of the water lilies in her pretest drawing, there are phytoplankton (fitoplankton), zooplankton, water flea (su piresi) and bug (böcek) was drawn as biotic factors at posttest as presented in the Figure 5.12. There is also sun image where sunlight coming to the lake. S3 explained this drawing:

I pictured how organisms in the lake ecosystem live in this drawing. I drew sun light heating the water as well. Also, I drew water layers in this drawing.

The codes for Figure 5.12 were phytoplankton, water flea, no specific named zooplankton, bug, frog, reed mace, water lily, pondweed and human as biotic factors. The codes for abiotic factors were sun, port and fence. Light coming from sun and heat causing stratification were coded under abiotic-abiotic interaction theme. Human activity was determined as standing and situated under biotic-abiotic interaction theme.

4.1.4.4 LEDT Results of Student 4

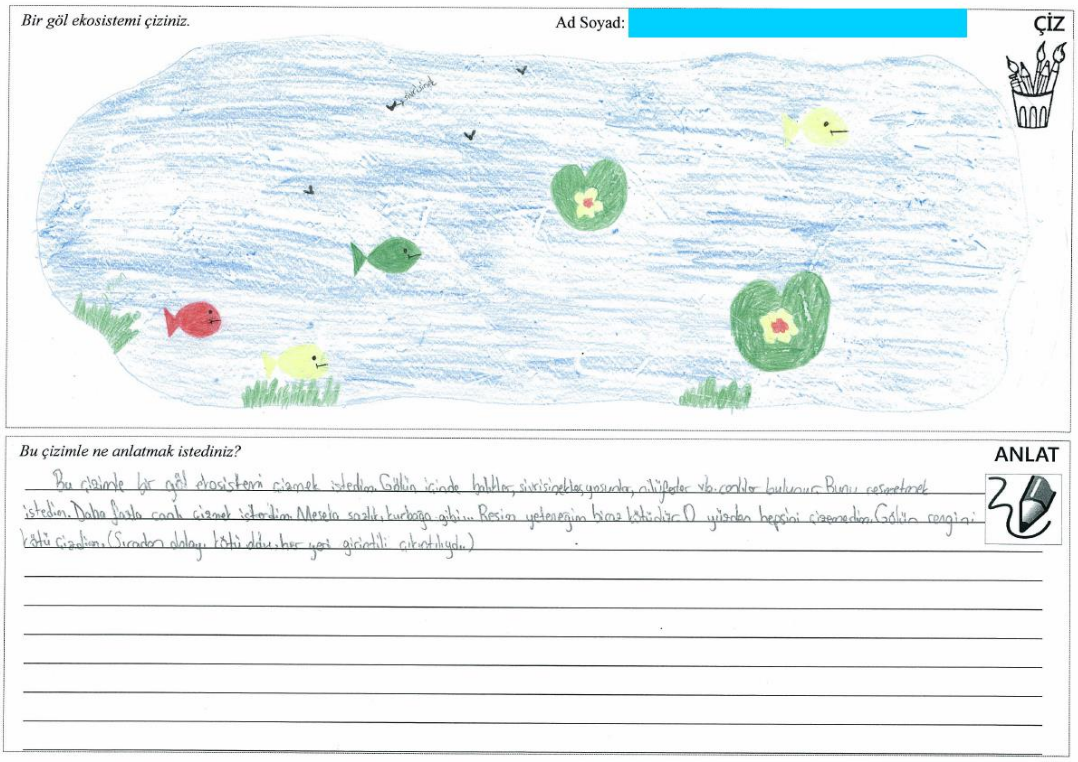


Figure 4.13 Pretest LEDT result of S4

There are fishes, water lilies, pondweeds and mosquitoes (sivrisinek) drawn by S4 before treatment (Figure 5.13). The student wrote under explain section:

> *I wanted to explain a lake ecosystem by that drawing. There are fishes, mosquitoes, pondweeds and water lilies, etc. I wanted to image this. I would want drawing more such as reeds, frogs… My drawing skill is little bad. So, I could not draw all. I colored the lake bad (because the desk was rough).*

The codes for S4 drawing were fish, water lily pondweed and mosquito.

In the Figure 5.13, there are human, bird, prey fish (av balık), predator fish (avcı balık), mosquitoes, phytoplankton (phytoplankton), zooplankton, decomposers, reeds, water lilies, nutrients and oxygen. Predator fishes was drawn with teeth, while prey fish has no teeth.

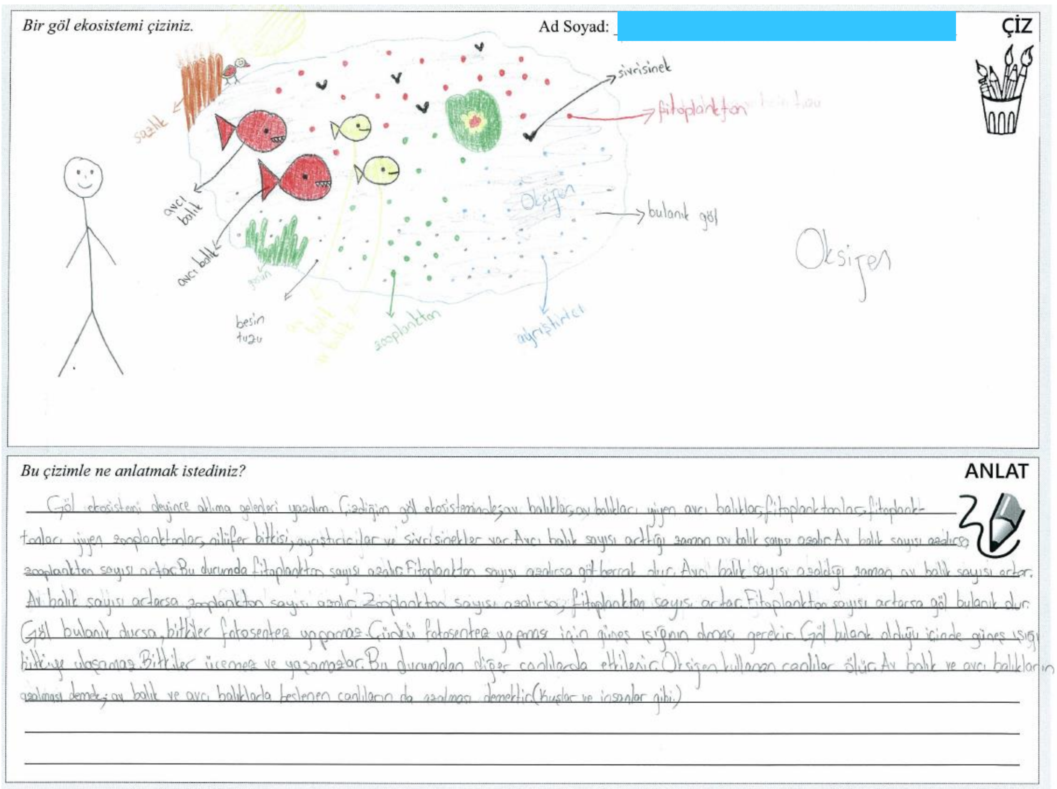


Figure 4.14. Post-drawing LEDT result of S4

Student explained what is drawn:

> *I drew what comes to my mind when 'a lake ecosystem' was called. In the lake ecosystem that I drew, there are prey fish, and predator fishes eating prey fish; phytoplanktons, and zooplanktons eating phytoplanktons, water lily, decomposers and mosquitoes. When the number of predator fish increases, the number of prey fish decreases. When the number of prey fish decreases, the number of zooplankton increases. In this case, the number of phytoplankton decrease. When the number of phytoplankton decreases, the lake will become clearer. When the number of predator fish decreases, the number of prey fish increases. When the number of prey fish increases, the number of zooplankton decreases. When the number of zooplankton decreases, the number of phytoplankton increases. When the number of phytoplankton increases, the lake becomes more turbid. When the lake becomes more turbid, plants cannot make photosynthesis because sunlight is necessary for photosynthesis. If the lake is turbid, the sunlight cannot reach to plants. Plants cannot reproduce and live. Other organisms are affected by this situation. The organisms consuming oxygen die. Decreasing of prey and predator fish means decreasing the organisms consuming prey and predator fish (such as birds and humans.*

The codes determined for posttest results of S4 were human, no specific named bird, prey fish, predator fish, mosquitoes, phytoplankton, zooplankton, decomposers, reeds and water lily under biotic components theme. Human activity in the lake ecosystem in the understanding of S4 was determined as standing. Sun, oxygen and no specific named nutrients codes were considered as abiotic factors. Eutrophication threat, phytoplankton eaten by zooplankton, zooplankton eaten by fish, prey fish eaten by predator fish, fish eaten by bird, fish eaten by human were the codes located under biotic-biotic interaction category; while light coming from sun is under abiotic-abiotic interaction category. Under biotic-abiotic category, sunlight taken by producers, eutrophication caused by phytoplankton increase, and oxygen taken by consumers were coded.

4.2 Inferential Statistics Analyses

There were two parts of inferential statistics analyses. Initially, preliminary data analyses were performed in order to conduct a statistical test. Then, the hypotheses of the current study were tested in statistical data analyses section.

4.2.1 Preliminary Data Analyses

After data had been labelled, missing data had been detected and missing data analysis had been performed in descriptive statistics analyses; normality of data distributions and required assumptions of paired sample t-test were checked in this section.

Independence of observation assumption of was gathered by the researcher being in the classroom with the teacher during all data collection of pretests and posttests. The pretest and posttest results of four students directly removed from the data analysis of SPST and EBQ as described at descriptive statistics analyses.

There were no outliers at pretest and posttest of EBQ and SPST according to box plot diagram (Figure 4.9 & Figure 4.10). Normality of data distribution of EBQ and SPST was checked by histograms, normal Q-Q plots, tests for normality and assessing skewness and kurtosis values. The skewness and kurtosis values were between -2 and +2 acceptable range for normality (George & Mallery, 2003), except one value among all. Besides skewness and kurtosis values, histogram and Q-Q plot graphics were recommended to check normality (Tabachnick & Fidell, 2007). The histograms and Q-Q plot were given below to visualize the normality of data distribution for EBQ and SPST (From Figure 4.11 to 4.18).

According to the results of normality test of Kolmogorov-Smirnov, it was failed to reject the null hypotheses that with the 95% confidence interval the data of SPST pretest ($df= 48$, $p>.05$), SPST posttest ($df= 48$, $p>.05$) and EBQ pretest ($df= 48$, $p>.05$) distributed normally (Table 4.12). However, EBQ pretest did not distributed normally according to Kolmogorov-Smirnov test ($df= 48$, $p<.05$), although the skewness and kurtosis values and Q-Q plot claimed that the data of EBQ pretest had normal distribution. Taking into account all preliminary analyses mentioned, parametric tests were determined to be conducted for both SPST and EBQ.

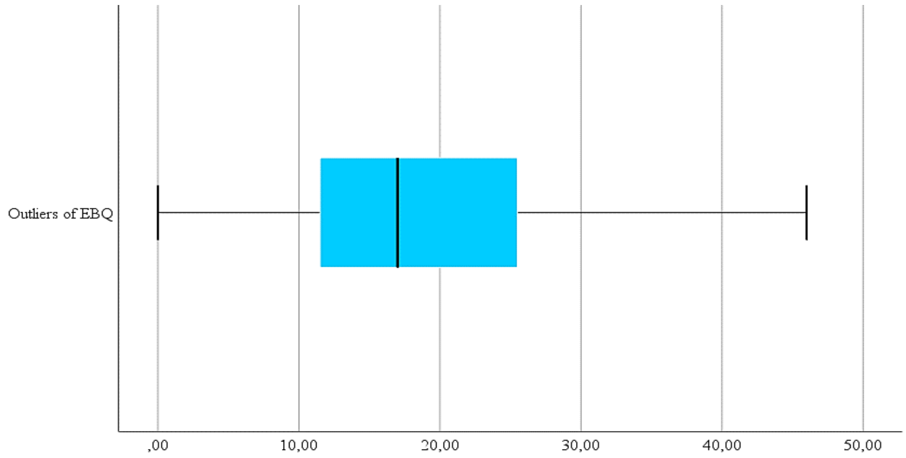


Figure 4.15 Box Plot Diagram of Outliers in EBQ

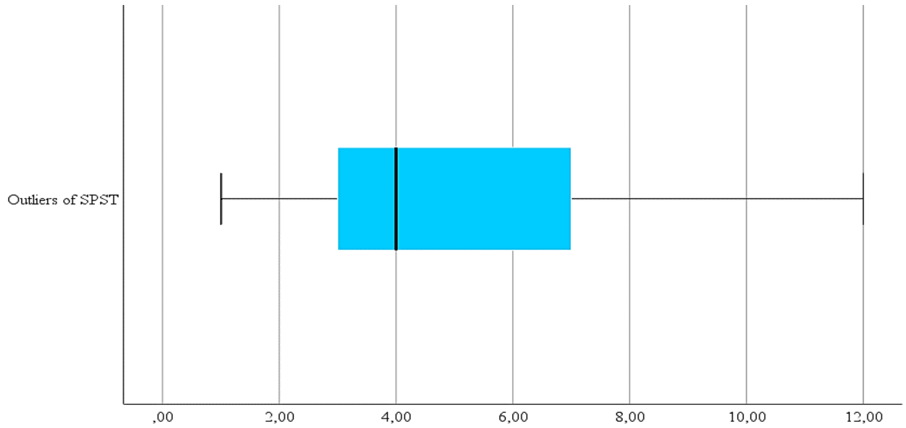


Figure 4.16 Box Plot Diagram of Outliers in SPST

Table 4.13 Normality tests of SPST and EBQ

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
EBQ Pretest	,102	48	,200*	,972	48	,290
EBQ Posttest	,217	48	,000	,812	48	,000
SPST Pretest	,123	48	,069	,946	48	,027
SPST Posttest	,097	48	,200*	,940	48	,017

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

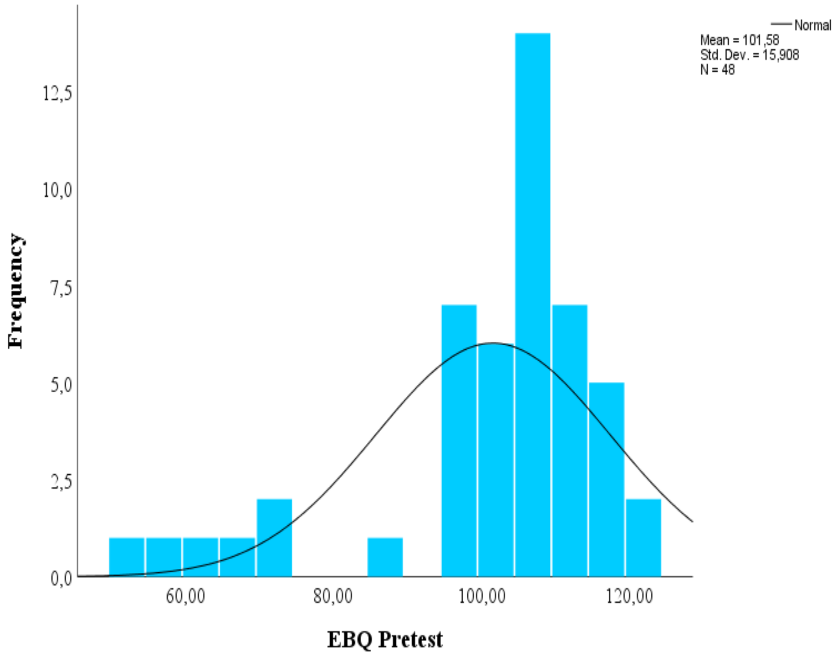


Figure 4.17 Histogram chart of Pretest Values in EBQ

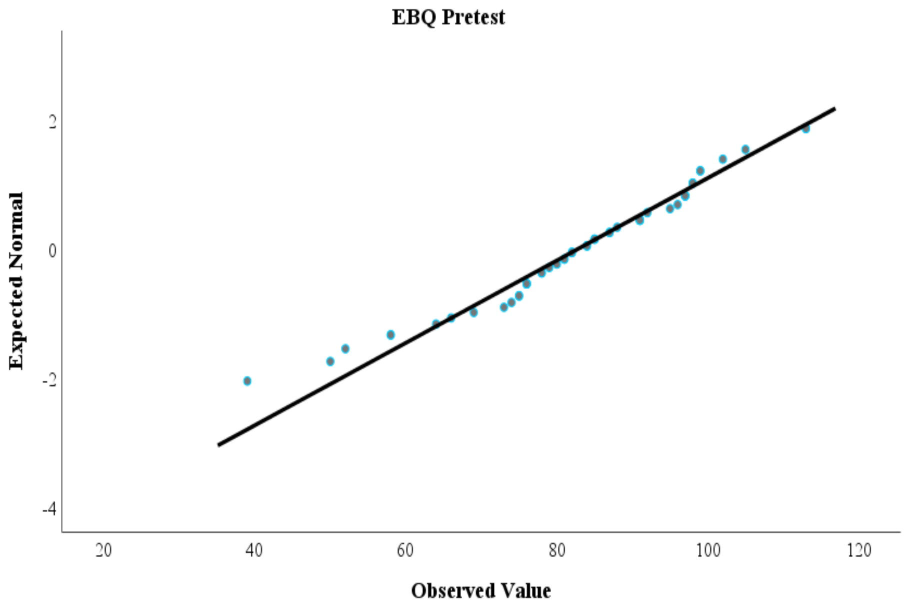


Figure 4.18 Q-Q Plot Chart of Pretest Values in EBQ

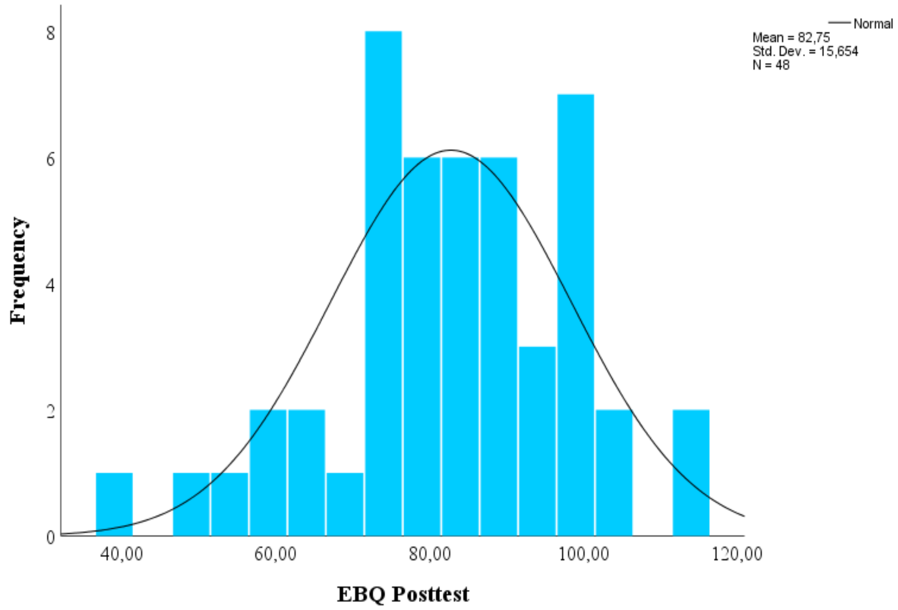


Figure 4.19 Histogram chart of Posttest Values in EBQ

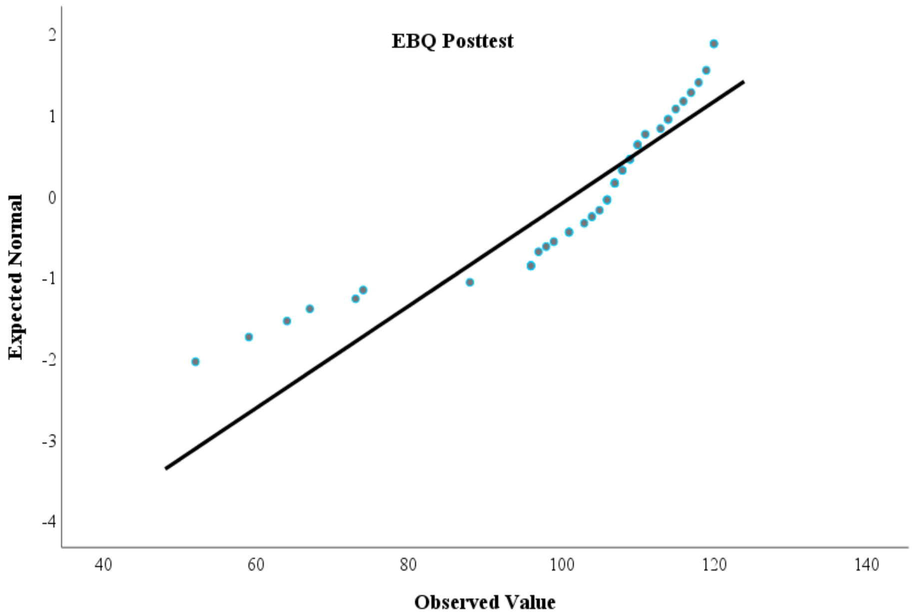


Figure 4.20 Q-Q Plot Chart of Posttest Values in EBQ

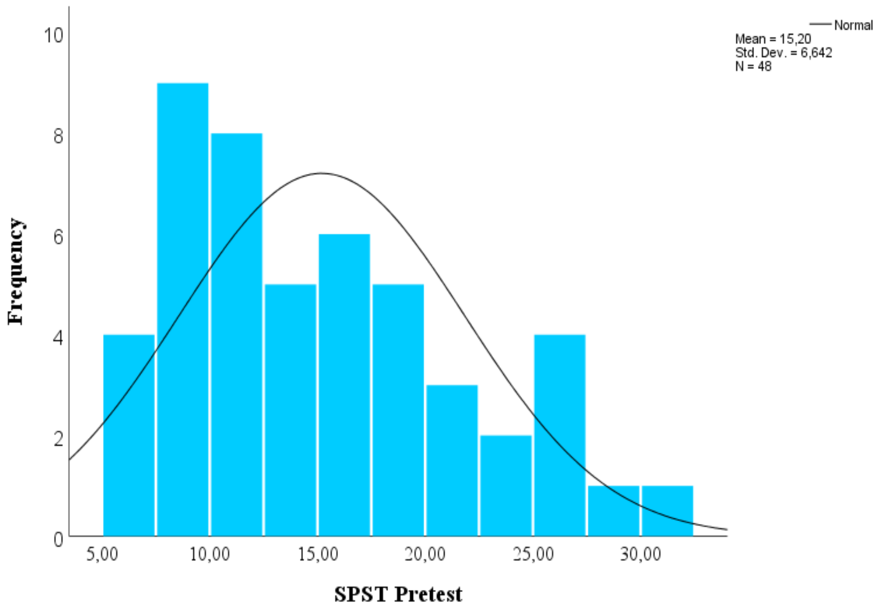


Figure 4.21 Histogram chart of Pretest Values in SPST

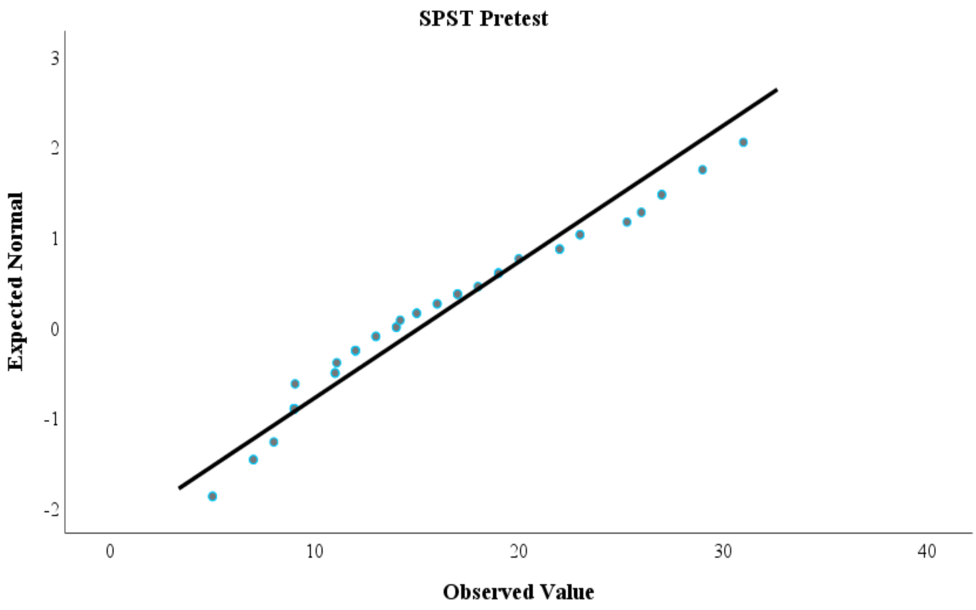


Figure 4.22 Q-Q Plot Chart of Pretest Values in SPST

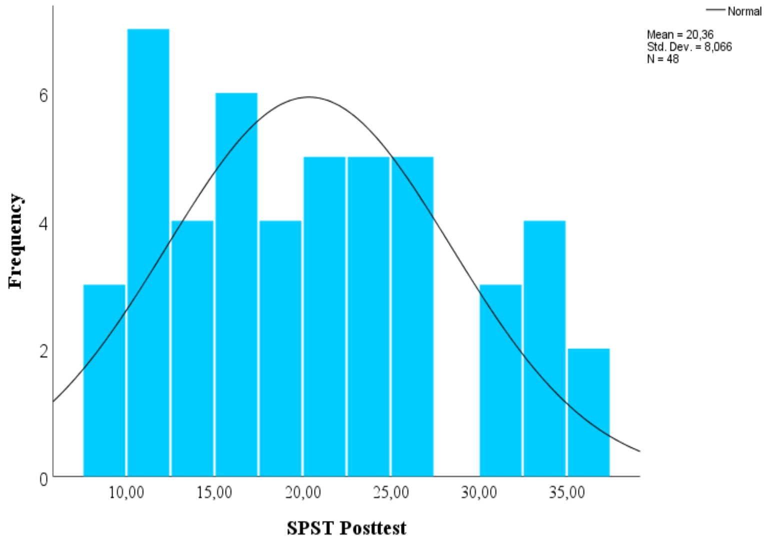


Figure 4.23 Histogram chart of Posttest Values in SPST

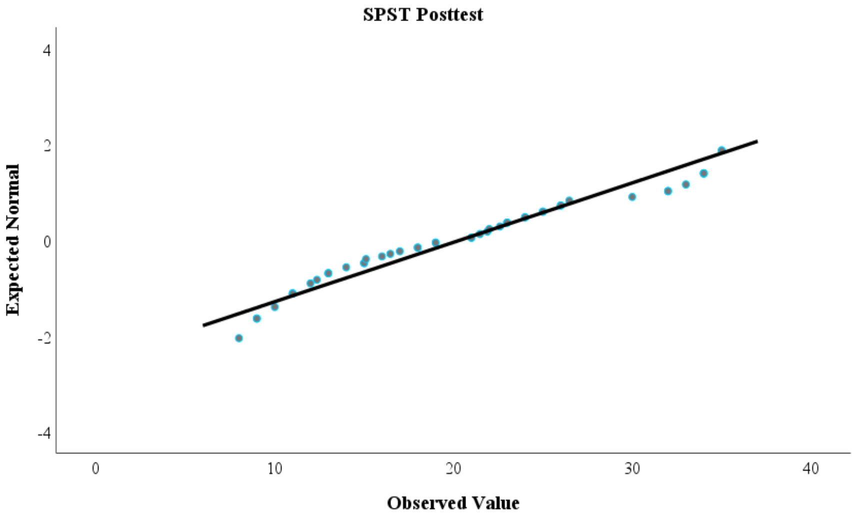


Figure 4.24Q-Q Plot Chart of Posttest Values in SPST

4.2.2 Statistical Data Analyses

After data was prepared for analysis and assumptions were checked for inferential statistics, paired sample t-test was determined to be run for SPST and EBQ data.

4.2.2.1 Statistical Data Analyses for SPST

The first hypothesis $H_0 1$ was rejected with respect to the results of paired sample t-test (Table 4.143 & Table 4.15).

Table 4.14 Paired Sample Statistics of SPST

	Mean	N	Std. Deviation	Std. Error Mean
SPST Posttest	20.36	48	8.07	1.16
SPST Pretest	15.20	48	6.64	0.96

Table 4.15 Paired Sample T-test Results for SPST

				95% Confidence Interval of the Difference				
	Mean	**Std. Deviation**	**Std. Error Mean**	**Lower**	**Upper**	**t**	**df**	**Sig. (2-tailed)**
SPST Posttest -Pretest	5.16	3.01	0.43	6.04	4.29	11.874	47	0.000

There was a significant difference between the scores of science process skills of 7th grade students before (μ= 15.20, SD= 6.64) and after (μ= 20.36, SD= 8.07) treatment; $t(47)$= 11.87, p= 0.000. This result indicates that LEEP was effective to make a change on science process skills of 7th grade students.

The difference in scores of SPST was checked in terms of dimensions of SPST. The results for dimensions of SPST emerged in accordance with the results for total SPST scores of students (Table 4.16, &Table 4.17).

There was a significant difference between the scores of science process skills of 7th grade students in terms of its five dimensions. The Identifying Variables dimension before (μ= 4.67, SD= 2.63) and after (μ= 6.23, SD= 3.24) treatment; t(47)= 2.19, p= 0.000, Operationally Defining dimension before (μ= 2.57, SD= 1.48) and after (μ=

3.17, SD= 1.58) treatment; t(47)= 7.75, p= 0.000; *Operationally Defining* dimension before (μ= 2.57, SD= 1.48) and after (μ= 3.17, SD= 1.58) treatment; *t*(47)= 7.75, p= 0.008; *Identifying Testable Hypotheses* dimension before (μ= 3.53, SD= 2.06) and after (μ= 4.91, SD= 2.35) treatment; *t*(47)= 5.61, p= 0.000; *Data and Graph Interpretation* dimension before (μ= 2.85, SD= 1.34) and after (μ= 4.18, SD= 1.46) treatment; *t*(47)= 7.48, p= 0.000; and *Experimental Design* dimension before (μ= 1.58, SD= 1.09) and after (μ= 1.88, SD= 1.12) treatment; *t*(47)= 2.19, p= 0.000. These results indicated that LEEP was effective to make a change on all dimensions in science process skills of 7th grade students.

Table 4.16 Paired Sample Statistics of Dimensions of SPST

SPST Dimension	**Mean**	**N**	**Std. Deviation**	**Std. Error Mean**
Identifying Variables				
Posttest	6.23	48	3.24	0.47
Pretest	4.67	48	2.63	0.38
Operationally Defining				
Posttest	3.17	48	1.48	0.21
Pretest	2.57	48	1.58	0.23
Identifying Testable Hypotheses				
Posttest	4.91	48	2.35	0.34
Pretest	3.53	48	2.06	0.30
Data and Graph Interpretation				
Posttest	4.18	48	1.46	0.21
Pretest	2.85	48	1.34	0.19
Experimental Design				
Posttest	1.88	48	1.12	0.16
Pretest	1.58	48	1.09	0.16

Table 4.17 Paired Sample T-test Results for Dimensions in SPST

SPST Dimension		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Identifying Variables									
	Posttest-Pretest	5.16	2.01	0.29	0.98	2.15	5.37	47	0.000
Operationally Defining									
	Posttest-Pretest	0.60	1.51	0.22	0.16	1.04	2.75	47	0.008
Identifying Testable Hypotheses									
	Posttest-Pretest	1.38	1.70	0.25	0.89	1.87	5.60	47	0.000
Data and Graph Interpretation									
	Posttest-Pretest	1.33	1.19	0.17	0.99	1.68	7.75	47	0.000
Experimental Design									
	Posttest-Pretest	0.29	0.92	0.13	0.02	0.56	2.19	47	0.033

4.2.2.2 Statistical Data Analyses for EBQ

The second hypothesis H_02 was rejected with respect to the results of paired sample t-test (Table 4.18 & Table 4.19).

Table 4.18 Paired Sample Statistics of EBQ

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
EBQ Posttest	101.58	48	15.91	2.30
EBQ Pretest	82.75	48	15.65	2.26

Table 4.19 Paired Sample T-test Results for EBQ

				95% Confidence Interval of the Difference				
	Mean	**Std. Deviation**	**Std. Error Mean**	**Lower**	**Upper**	**t**	**df**	**Sig. (2-tailed)**
EBQ Posttest-Pretest	18.83	10.93	1.58	15.66	22.01	11.940	47	0.000

There was a significant difference between the scores of epistemological beliefs of 7th grade students before (μ= 82.75, SD= 15.91) and after (μ= 101.58, SD= 15.91) treatment; $t(47)$= 11.94, p= 0.000. This result indicates that LEEP was effective to make a change on epistemological beliefs of 7th grade students.

The difference in scores of EBQ was checked in terms of dimensions of EBQ. The results for dimensions of EBQ emerged in accordance with the results for total EBQ scores of students (Table 4.20 and Table 4.21).

Table 4.20 Paired Sample Statistics of Dimensions of EBQ

EBQ Dimension	**Mean**	**N**	**Std. Deviation**	**Std. Error Mean**
Justification				
Posttest	40.25	48	4.34	0.63
Pretest	35.44	48	6.36	0.92
Development				
Posttest	25.81	48	5.09	0.73
Pretest	19.98	48	5.10	0.74
Source/Certainty				
Posttest	35.52	48	8.06	1.16
Pretest	27.33	48	7.74	1.12

Table 4.21 Paired Sample T-test Results for Dimensions of EBQ

EBQ Dimension	**Mean**	**Std. Dev.**	**Std. Error Mean**	**95% Confidence Interval of the Difference**		**t**	**df**	**Sig. (2-tailed)**
				Lower	**Upper**			
Justification								
Posttest-Pretest	4.81	4.73	0.68	3.44	6.19	7.05	47	.000
Development								
Posttest-Pretest	5.83	3.80	0.55	4.73	6.94	10.65	47	.000
Source/Certainty								
Posttest-Pretest	8.19	6.32	0.91	6.35	10.0	8.98	47	.000

There was a significant difference between the scores of epistemological beliefs of 7th grade students in terms of its three dimensions. The Justification dimension before (μ= 35.44, SD= 6.36) and after (μ= 40.25, SD= 4.34) treatment; t(47)= 7.05, p= 0.000, Development dimension before (μ= 19.98, SD= 5.10) and after (μ= 25.81, SD= 19.98) treatment; t(47)= 10.65, p= 0.000; and Development dimension before (μ= 27.33, SD= 7.74) and after (μ= 35.52, SD= 8.06) treatment; t(47)= 8.19, p= 0.000.

4.3 Conclusion

The results of this study were summed up as follows.

- Lake Eymir Education Program had a statistically significant effect on science process skills of 7th grade students. The treatment was effective specifically for each dimension of science process skills. These dimensions were identifying variables, operationally defining, identifying testable hypotheses data and graph interpretation and experimental design.

- There was a statistically significant change on epistemological beliefs of 7th grade students. The treatment improved their epistemological beliefs in a positive way. Besides, there were positive changes in the means of each dimension of epistemological beliefs; justification, development and source/certainty were observed.

- Students' views about the treatment was positive. Students enjoyed by indoor activities, fieldworks and meet-the scientist seminars and found them interesting. They wanted to make more scientific activities, learning more about the lake ecosystem, go outdoor for doing activities at Lake Eymir, Limnology Laboratory in Middle East Technical University. The treatment was thought appropriate in terms of grade level of students and helpful in students' current and future life. It was suggested to implement with other students by the sample of this study and doing more scientific and recreational activities and learning deeper content knowledge about the topic were recommended by students.

- The understandings of students about the lake ecosystem were improved by the treatment. Students perceived the lake ecosystem as where biotic and abiotic factors are living together. After LEEP, they perceived the lake ecosystem where all biotic and abiotic factors are directly or indirectly interacting with each other. Moreover, the number of biotic components in a lake ecosystem increased in a great amount. Furthermore, there was no algae, but only plants drawing, labelling or explanation before treatment. After LEEP, students perceived a lake ecosystem as having phytoplanktons which make photosynthesis. Likewise, there was no decomposer. After LEEP, students depicted decomposers and more specifically they mentioned fungi and bacteria as decomposers. Besides, the species in food chain and the branches in food web increased in their drawings. Students' understandings of nutrients including phosphorus, nitrogen and carbon was established. Also, students' understandings of energy in a lake ecosystem was only about kinetic energy before LEEP. After treatment, they perceived the lake ecosystem with light and heat energy as well as kinetic energy. In addition to these, the number of human and human activities increased after treatment. Students' understandings of human interaction with a lake ecosystem and catchment field and its results were improved by LEEP.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

The final chapter of this thesis included three sections; discussions drawn based on the results of the study, the results' implications and recommendations for further studies were represented.

5.1 Summary of the Study

The aim of the research was examining the effects of Lake Eymir Education Program on 7th grade students' science process skills, epistemological beliefs, understandings of a lake ecosystem and thoughts about an inquiry-based training program.

The research method was single subject experimental, pretest and posttest design. Data were collected from 52 students enrolled in Science Application Course in two classes by Demographic Information Survey (DIS) before treatment; Science Process Skills Test (SPST), Epistemological Beliefs Questionnaire (EBQ) and Lake Ecosystem Drawing Test (LEDT) before and after treatment and the data for examining review of students about the training were gathered by Students' Review Questionnaire (SRQ).

The treatment was held eight continuous weeks consisting of 8 in-class activities (2 lesson hours each), 4 fieldworks (4 lesson hours each) and 2 meet-a-scientist seminars (1 lesson hour each). The instructional method was inquiry-based learning. Treatment fidelity and verification was checked by observation checklist. In order to determine whether there was a significant change on science process skills and epistemological beliefs of students before and after the treatment, paired sample t-test was performed, after data preparation and checking assumptions. Students' views about the treatment were analyzed descriptively. For qualitative data analysis, inductive data analyzing methods were used and codes, subcategories, categories and themes were formed in a meaningful context.

5.2 Discussion of the Results

The findings of the study were discussed under each title with related research question.

5.2.1 Discussion of Effectiveness of Lake Eymir Education Program on Science Process Skills

RQ1.1: To what extent does Lake Eymir Education Program influence seventh grade students' science process skills?

The results of data analysis of SPST showed that treatment was significantly effective on improving students' science process skills; $t(47)= 11.87$, $p= 0.000$). Cohen's *d* value (1988) was found 1.71 for SPST by taking the mean difference as numerator and dividing it by pooled variability as denominator. It means that the difference between pre-test (μ= 15.20, SD= 6.64) and post-test (μ= 20.36, SD= 8.07) is bigger than one standard deviation. The Cohen's *d* value above 1.2 and below 2.0 was accepted as very large effect size (Sawilowsky, 2009). This is important result for the study in terms of demonstrating practical significance (Neil, 2008). Although the sample size is limited in this study, this result helps generalization of the power of the treatment on students' science process skills to accessible population.

The effects of treatment were examined by conducting paired sample t-test. The results showed that treatment had effects in general and in each dimension of science process skills. The pretest scores in each dimension from highest to lowest were Identifying Variables, Identifying Testable Hypothesis, Data and Graph

Interpretation and Experimental Design. After treatment that order did not change. However, it was noticeable that the biggest impact was on Data and Graph Interpretation dimension $t(47)= 7.75$, $p< 0.05$). The least impact was on Experimental Design dimension $t(47)= 2.19$, $p< 0.05$).

The results of the study were consistent with previous studies that investigated effectiveness of inquiry-based learning on science process skills (Anderson, 2002; Aydoğdu, 2009; German & Odom, 1996; Tatar, 2006; Şakir, 2013).

During the treatment, students were active in learning process. For example, they measured water quality by using water depth, multiprobes, Secchi disc and Ruttner water sample. They made observed phytoplanktons, zooplanktons, aquatic invertebrates, amphibians, reptiles, birds, fishes in Lake Eymir and Limnology Laboratory. They defined variables, formulated hypotheses, conducted experiments, drew models based on data and drew graph. They also designed tangible products, explained their designs to classmates, tested their designs and revised their design models. All these actions might lead to increase on students' science process skills.

A similar study conducted by Özgelen (2012) that utilized same science process skills instrument by eliminating some items to have higher reliability. He examined science process skills of students in private and public schools in Ankara and reported that mean scores of seventh grade students' science process skills were low; approximately 62% score for private school students; 49% for public school students and 39% for bussed school students. Although these scores do not seem to be low but moderate, this claim supports the result of the current study. The pre-test mean score of students in a public school located in a Golbasi lake basin that is out of center of the city; was calculated as 42%. This mean score was significantly increased into 57% by the inquiry-based lake ecosystem education program during eight weeks. In spite of the percentages look higher than in current study, the current study was found to be more effective with $t(47)= 11.87$, $p<0.05$). The reason might be the sample of students had already lower scores than that of the students in Özgelen's study before treatment.

The results of the current study were consistent with Balım, Türkoğuz and Kaçar's (2013) study in which effect of science and nature project on sixth and seventh grade students' science process skills were examined. In their study, students' science process skills were raised from 52% to 68% with $t(39)=7.61$, $p<0.05$) by 38 activities including fieldworks and laboratory works in three semesters. Despite use of different instruments, pre-test results of Balım et al. (2013) and Özgelen (2012) were similar. The same instrument with current study was used in Karar's research (2011) to investigate science process skills of 650 eighth grade students. It was reported that almost 60% of students had a moderate level of science process skills referring to 37-67% score; while 22% of students had a low level of science process skills referring to 0-37%.

There were at least one or more inquiry-based learning cycles in the lake ecosystem treatment as suggested (Krajcik, Blumenfeld & Soloway, 1998). Based on this, the outcome of the study was supported by earlier studies developing science process skills of students by inquiry-based science education revealed similar results (Bunterm et al., 2014; Ergül et al., 2011; Gök, 2014; Köksal & Berberoğlu, 2012; Kocagül, 2013; Kula, 2009; Şimşek & Kabapınar, 2010; Tatar, 2006; Yager & Akçay, 2010; Yalçın, 2014). Besides, students used scientific methods in limnology laboratory and Lake Eymir activities. For example; in limnology laboratory, they made observations of planktons and fish, they made inferences about species relationships based on their observations. They defined variables for chlorophyll precipitation, distinguished what was observed and what was measured and they interpreted data that scientists gathered. In Lake Eymir, they made observation of species and measurement of water quality by using many scientific tools. They identified variables, they defined them operationally, wrote testable hypotheses, test their hypothesis by making experiments, gathered data, draw graphs, and interpret data and graph. All these activities were considered to have influences on students' development of science process skills as stated in the literature (Hofstein & Lunetta, 2004, Yager & Akçay 2010).

Students' hands-on experiments inside classroom and in fieldwork resulted to rise in science process skills. Hands-on experiments which allow students to observe, manipulate and manage are beneficial for development of science process skills (Lumpe & Oliver 1991; Staver & Small, 1990; Turpin & Cage, 2004).

5.2.2 Discussion of Effectiveness of Lake Eymir Education Program on Epistemological Beliefs

RQ1.2: To what extent does Lake Eymir Education Program influence seventh grade students' epistemological beliefs?

Treatment had a significant effect on students' epistemological beliefs; $t(47)= 11.94$, $p<.05$. Cohen's *d* value was computed 1.72 for EBQ which refers the effect was very strong (Cohen, 1988; Sawilowsky, 2009; Neil, 2008). In other words, the difference between pre-test ($\mu= 82.75$, SD= 15.91) and post-test ($\mu= 101.58$, SD= 15.91) is bigger than one standard deviation. Since the Cohen's *d* value was above 1.20 and below 2.0, it was accepted as very large effect size (Sawilowsky, 2009).

Paired sample t-test was conducted to investigate the effects of treatment. The results of the study indicate that treatment had effects in general and in each dimension of epistemological beliefs. The highest score was in Justification dimension, while Source/Certainty dimension and Development followed it; respectively. This order stayed same after treatment as well. The greatest impact was on Development dimension $t(47)= 10.65$, $p<.05$; and the least impact was on Justification Dimension $t(47)= 7.05$, $p<.05$. The effect on Source/Certainty dimension was found $t(47)= 8.98$, $p<.05$.

The dimensions in epistemological beliefs were grouped into three, four or five depending on the pattern determined by the researchers by designing an instrument or applying the same instrument in other countries with regard to their cultural differences (Schommer-Aikins, 1990; Schommer, 1993; Conley et al., 2004; Chan & Elliott, 2002; Özkan, 2008); in contrast to very earlier researchers who evaluated epistemological beliefs of students in one dimension (King & Kitchner, 1994; Kuhn, 1991). Thus, significant changes in all dimension; were reported sparsely similarly in the study that explore students' epistemological beliefs of students (Choi & Park, 2013).

In the study of Conley et al. (2004) Epistemological Beliefs Questionnaire was implemented to 187 fifth grade students for two time points during nine weeks to explore the students' scientific epistemological beliefs. They reported that Source dimension and Certainty dimension developed, while insignificant changes on other two dimensions. The questionnaire of Özkan (2008) was adopted from the study of Conley et al. (2004) by grouping Source and Certainty dimensions into one dimension.

The pretest mean scores of students in total was calculated as 3.45 which refers medium level of scientific epistemological beliefs; while mean below 2.5 was considered as naive level (Özbay & Köksal, 2016; Yenice et al., 2017). After implementation of treatment, the score was raised into 4.23 which indicates sophisticated level. Pre-test results were consistent with some previous research (Özbay & Köksal; 2016; Prasadini et. al, 2018; Yenice et al., 2017; Uğraş, 2018). For example, Uğraş (2018) found the mean of 207 eight grade students as 3.3 in Turkey. Again, in Turkey, Kızılgüneş, Tekkaya and Sunger (2009) reported the mean score of 1041 sixth grade students reported between 2.44 to 3.30 in four dimensions of epistemological beliefs including Source, Certainty, Development and Justification. The highest score was in Justification dimension, whereas the lowest score in

Certainty. These scores are considered as medium level. With elder students, Prasadini et al. (2018) conducted a study with 415 eleventh grade students in Sri Lanka. The results were reported as medium level which all dimensions were under 3.5 mean score. Additionally, in the study of Yenice et al. (2017), the mean score of 809 high school students in different dimensions of epistemological beliefs were varied in naïve to sophisticated level. This result showed that both middle school students and high school students can have similar level of epistemological beliefs.

In-door activities, fieldworks and meet-a-scientists seminars included discussion of the difference between observation and inferences, the difference between knowledge and scientific knowledge, the difference betweem scientific knowledge which was written or heard, discussion of how technology affecting science, the limitations and objectivity in science. For example, students were watched two different videos of scientists who search an answer for the same question; student compared scientists' variables, hypotheses, observations, inferences and discussed whom to believe. Hence, it was considered that these activities effected students' epistemological beliefs in positive ways. Studies claim that epistemological beliefs can change in a positive way due to use of constructivist learning approach (Kaynar, Tekkaya & Çakıroğlu, 2009; Gök, 2014; Tolhurst; 2007), hands-on experiments (Solomon, Scott & Duveen, 1996; Conley et al., 2004), and having scientific experiences (Elder, 1999).

There are limited studies that explored the effectiveness of inquiry-based learning on students' epistemological beliefs (Sandoval, 2005; Wu & Wu, 2011). For instance, Özgelen (2012) designed an inquiry-based laboratory instruction for preservice science teachers and by using Hofer's (1977) instrument he reported that it was effective on each dimension of scientific epistemological beliefs. The outcome of the result reveals that the largest effect is in Certainty dimension and Source Dimension. While this result is compatible with the result of Conley et al. (2004) conducted with fifth grade students, it is not compatible with the result of the current study. This current study showed that the greater impact was on Development dimension. Cohen's *d* values were computed as 1.53; 1.30 and 1.02 for Development, Source/Certainty and Justification dimension.

5.2.3 Discussion of Effectiveness of Lake Eymir Education Program on Understandings of a Lake Ecosystem

RQ1.3: To what extent does Lake Eymir Education Program influence seventh grade students' science process skills?

Three themes emerged from data analysis of LEDT; biotic components, abiotic components and interaction between them. The results show that there is a development in different aspects under these main themes; although students learned ecosystem topic in science course before treatment. Almost all students perceived a lake ecosystem with more biotic components than abiotic components in both pretest and posttest. This result is consistent with the study of Prokop, Tuncer and Kvasnicak (2007) who conducted one-day fieldwork to three different ecosystems with sixth grade students. In similar studies, it was reported that the level of development in biotic factors was higher than abiotic components (Yücel, & Özkan, 2018) and students defined ecosystems with generally biotic components (Jordan et al., 2009).

Among biotic components, the number of consumers was the highest compared to producers and decomposers both in pre-test and post-test. Types of consumers were more than types of producers. This is relatable with the experiences of students with animals more than plants. Students have seen many animals in their daily life in home or media (Tunnicliffe et al., 2008), though learning nature by media can mislead them (Payne, 1998). Fish was the most common consumer and the number of only fish was almost same with total number of aquatic plants in both pretest and posttest. The most known fish was Carp, whilst the most known aquatic bird was duck, then cormorant not only before, but also after treatment. The related literature supports that children's background experiences with animals and plants rather than their education have an effect on their conception and naming of organisms (Bebbington, 2005; Tarlowski, 2006). By providing students' experiences with education program, students' perceptions of biodiversity were widened. In addition, direct experiences might help students understand and explain a meaning of word as well as knowing the word. Students mentioned fish as prey or predator after treatment since they had experiences with aldehyde-fixed fishes in fieldworks. Therefore, overall understandings of students about a lake ecosystem were extended.

Although there was an increase of image of aquatic plants, aquatic plants were prevalent in a lake ecosystem before treatment as well. It was an opposite finding to students' misconception that there are no producers in aquatic ecosystems (Adeniyi, 1985). No misconception in initial predrawings might be explained again by students already living a lake basin. On the other hand, students did not draw or mention any algae before treatment. Defining an ecosystem just with visible components like in the findings of the current study is a misconception. Kattmann (2006) reached the same result that there is an orientation towards visible components in ecosystem conception by concept nets and problem-centered interviews with 16 to 17-year-old students. This misconception was observed in current study because students did not mention any decomposers but dead organisms in Lake Ecosystem Drawing Test before treatment. Middle school students have already problems in diversity of living organism (Kellert, 1985). Students might think soil has the function of decomposers before treatment as shown in the study of Yörek, et al. (2010). Decomposers were not known or little known by even biology students in university (Shirley et al., 1986). Further, perceiving no gases and nutrients in a lake ecosystem in pretest is again related to visibility of components in a lake ecosystem (Kattmann, 2006). After treatment, the understandings of invisible factors including algae, decomposition, gases and nutrients were formed.

The understandings of human in a lake ecosystem was slightly developed by the treatment. In spite of the fact that humans are not vital part of every lake ecosystem, humans are treated as a part of an ecosystem (Pickett et al., 2011). Although some studies stated that students are tended to perceive themselves separately from nature (Chapman & Sharma, 2001; Loughland, Reid, Walker & Petocz, 2003), all students should not draw human in a lake ecosystem because it would be a sign of misconceptions that every lake ecosystem has a human; or human is the center of every lake ecosystem. However, human effect directly or indirectly to biological ecosystems cannot be denied; therefore, it was acceptable to see slightly increasing in students' images of human effect after treatment. Students drew human mostly enjoying in the lake ecosystem in pretest and posttest, opposite to other studies that students drew human as a negative factor affecting an environment (Özsoy, 2012; Yardımcı & Kılıç 2010). Scientific tools (water depth meter, water sample, iButton, binoculars, teabag, Secchi disc and temperature and salinity probe) were also observed in posttest results since students conducted many scientific activities at lake. Most students perceived a lake ecosystem together with a forest next to a lake ecosystem. Since children live in a lake basin where there is a forest, this result showed that local area and experiences effect students' understandings about lake ecosystem concepts. Students commonly draw forests and trees, when they are wanted to draw about environment (Özsoy, 2012; Yücel & Özkan, 2014).

Sun and clouds drawings are common in children's conceptions of ecosystems (Barraza, 1999), but almost all students did not perceive sun, wind, wave and rain as an energy source in a lake ecosystem except one student pouring raindrops from a cloud and forming waves on the surface of water which refers mechanical energy. Since energy and matter cycles were more abstract than other interactions, the students' understanding of them were generally very low in related literature before and after treatments (Garb, Fisher, & Faletti, 1985; Pfundt & Duit, 2002; Shepardson, 2005; Lin & Hu, 2003; Yu, 2003). Beyond these studies, although energy related concepts are difficult to identify by even biology students studying in a college

(Kattman, 2006), there was an undeniable bigger change in understandings of energy after treatment. Nevertheless, the understanding of cycle was improved very slightly. It is important finding to reveal that cycle is more difficult than energy concept to perceive.

In an expected way, students' drawings predominantly contained various animals, plants, sun and clouds and humans. Students perceived an ecosystem just like a lake environment before the treatment. In other words, they perceived as if environment and ecosystems are same concept before treatment. In fact, a biological ecosystem concept is different from environment concept in terms of three critical differences. The first critical difference is that all ecosystems have complex and dynamic interactions between biotic and abiotic components (Jordan et al., 2009). On the other hand, environment is a term used to describe the external surroundings in a system (Steward et al., 2009; McIntosh, 1985). In other words; environment means that biotic and abiotic factors are together, but not always in interaction. The second difference is that there is a producer, consumer and decomposer in all ecosystems. If one trophic level is lack, then the ecosystem will run down. Contrarily, an environment has not always this rule. The third difference is that there is a flow of matter and energy in all ecosystems (Patten & Odum, 1981). There is an equilibrium in all ecosystems which affects all dynamism in earth. This equilibrium refers rules and harmony. For example, there should be always energy flow and matter cycles in ecosystems (Odum & Barrett, 2008). These rules cannot be ignored or omitted and they can be different through ecosystems. According to Loughland, Reid and Petocz (2002) the understandings of environment is divided into six categories as: "a place", "a place that contains living things", "a place that contains living things and people", "environment is something that does something for people", "people are part of the environment and are responsible for it", "people and the environment are in a mutually sustaining relationship" by collecting written data from over 2000 primary and middle school students in Australia about students' understanding of environment (p.192).

Students have very limited ecological knowledge in their drawings of environment. For example, Shepardson (2006) asked 81 seventh, eighth and ninth grade students to draw and explain an environment; then he showed students some photographs and expected students to determine which photograph describes an environment. The results showed that students have a limited ecological perspective. Jordan et al. (2009) asked 45 middle school students to draw an ecosystem but most of the students perceived ecosystems as an environment; particularly a habitat where a place organism live.

There are some other studies support the results of children perceiving nature as habitats in science education literature (Phenice & Griffore, 2003; Littledyke, 2004). The current study differentiates it with posttest results by students drawing or explaining interaction more than nonliving components. In the study of Manzanal, Barreiro and Jimenez (1999), the fieldworks provided students direct experience to nature and resulted with higher understanding of ecosystem interactions. Besides this, only interaction among living things were described as ecosystem by seventh grade students as a misconception (Özkan's et al., 2004). There are misconceptions about one-way interaction in ecosystems as well (Eilam, 2012; Sander, et al., 2006). Additionally, high school students have a misconception of changing prey population have effects on predator population (Barman & Mayer, 1994). These studies supported the findings of initial understandings of students and the results of Leach et al. (1992) that children are tended to relate effects of individual animals in an ecosystem rather than populations of animals does not support the findings of neither initial nor final understandings. After current treatment, all these misconceptions in students' understandings were decreased and students perceived all biotic- biotic, abiotic-abiotic and biotic-abiotic interactions in a lake ecosystem in at least a moderate level of understanding after treatment. Students mostly drew generally simple linear interaction in pre-test. For example, a big fish eating small fish. It means they thought big fish has effect on small fish, but small fish has no effect on big fish. After treatment they perceived interactions as one effect causes another affect indirectly. For example, a change in the number of phytoplankton affects not only the number of zooplankton which eats phytoplankton; but also fish eating zooplankton and bird eating fish.

Alternatively stated, the most frequent pattern of students' understandings of interactions was developed moderately from no or little "simple linear causality" where only one cause and its one direct effect to "domino causality" where one effect causes another effect indirectly (Bell-Basca et al., 2000; Grotzer, 1989, 1993, 1997; Perkins & Grotzer, 2000).

It was reported that the change in perception of interaction improved dramatically even more than the change in abiotic factors. The most rapid growth was in biotic-abiotic interactions, although no students perceived a natural interaction between biotic and abiotic factors before treatment. Students had limited understandings of feeding relationships. Only predation and competition were taught to the sample of students with treatment, not symbiotic relationships including mutualism, commensalism and parasitism, since students' understanding level was not determined appropriate to learn that much complex biotic-biotic relationships. The pretest result of current study was supported by Hogan's results (2000) that children perceived pollutants are affecting biotics only by contacting with them. Students had no understandings of indirect interactions. They were thinking human affects organisms directly just by throwing pollutants to lake from hand. After treatment, there were two students who developed a perception of urban, cropland and grazing land around lake and revealed the runoff coming from there; while more students described indirect effect of animals and plants for each other. Perceived indirect effects after treatment were not only immediate effects, in contrast to other studies conducted with young students (Grotzer, 1989; 1993) and middle school students (Palmer, 1996). For example, eutrophication concept has complex interactions, still there were a couple of students achieved to describe their high uunderstandings of a lake ecosystem.

According to Shepardson et al. (2007), students' understanding environmental issues and behaviors are related to their mental models of environment. Namely, the development of understandings of students about threats of ecosystem after treatment in the current study is in accord with it. Nevertheless, students reflected only local problems in their lake ecosystem description, instead global problems; albeit even the lake metabolism, and carbon sink or source dynamic in lakes were explained, then climate change and global warming connected to lake ecosystems to empower their awareness of the global threats. This result indicated that middle school students are quite young to see larger picture to build a global perspective of ecosystems.

5.2.4 Discussion of Students' Views about Lake Eymir Education Program

RQ2: What are the views of seventh grade students about Lake Eymir Education Program?

Treatment was evaluated as positive with 89% of students. Almost all students 98% claimed that they have learned something new about a lake ecosystem and they suggested this training be given to others. The most favorable part of students was written as scientific activities by almost 40% of students. Since students are at the center of teaching in constructivist learning, students might like the program.

While students have learning experiences, teacher did not falsify anyone but give the same correct information to anyone; therefore, students assessed themselves through classroom discussions. This helped students learn by having "mastery experiences" (Bandura, 1977) and when they found incorrect answers, the whole classroom together made justification of incorrect thought by revealing proofs. Teacher had a chance of identifying misconception of students; while students have reasoning patterns to debate (Lawson, 1988) and at the end of discussions, teacher gave the corrective feedbacks (Kanfush, 2013). Further, mistakes in scientific methods were connected with scientists' mistakes that can do even so that students epistemological beliefs develop. These sources were "verbal persuasion" as a self-efficacy information (Bandura, 1977). In elaboration phase of learning cycle, students were allowed to use they perform a similar task within the exploration phase. After two months, students get used to doing frequent scientific activities, understood mistakes are normal in scientific experiment and they felt more freedom to express their ideas. As an observer of themselves in two months and observer of other students, they felt encouragement as in Bandura's definition of "vicarious experiences" and "emotional arousal" (1977). These might lead students think that this education program is fun in general.

The second favorable part of treatment was chosen by Lake Eymir fieldworks by more than %20 students. Performing scientific activities in Lake Eymir increased students' scientific process skills, especially observing and classification. Students made scientific experiments by hands-on rich experiences such as touching plants, animals and using various types of scientific tools for investigating the interactions in Lake Eymir.

Students labelling or mentioning the names of plants and animals they have observed in Lake Eymir fieldworks shows that current study increased students' understanding of nature. Research on understanding of nature based on inquiry-based fieldworks supports this result (Chiappetta & Adams, 2004). Spending time in nature and interacting with nature motivated physically for learning and felt themselves closer to nature. This result is supported by some studies (Chapman & Sharma, 2001; Dillon et al., 2006; Tillling, 2004).

The lake ecosystem topic was noted as favorite thing in treatment by 14% of students. This is noteworthy that students have had already learned ecosystem topic in their Science Course before pretests. The interest and engagement of students towards the lake ecosystem topic might be explained by learning the ecosystem topic in Science Course before treatment because researchers claim that learners'interests are triggered internally as well (Hidi & Renninger, 2006). Half of the students did not want any change in education program, although another half wanted mostly longer and more activities including demands to get on a boat for a drive at Lake Eymir. These suggestions were not that applicable depending on timeline and resources of the study. Over and above, outdoor activities were designed in terms of supporting all in-class activities so that cognitive load was prevented (Paas, Gog & Sweller, 2010; Randler, 2008).

5.3 Implications

- Lesson plans developed for this study meet the objectives of Science Application Course and student had positive views about them. Hence, these lesson plans are advised for teachers complaining about lack of teaching material in Science Application Course. Also, curriculum developers can focus to design educational sources for nature education containing the objectives of Science Application course.

- Researchers, curriculum developers and teachers should emphasize the difference between ecosystem and environment, ecosystem and habitat. The complex interactions and connections between biotic-biotic, abiotic-abiotic and biotic-abiotic components; ecosystem processes including oxygen, water, nutrient cycles, and energy dynamics within the ecosystems should be exemplified by daily life examples in more details.

- Despite of the fact that human is not vital component for ecosystems, direct and indirect effect of humans on ecosystems should be also revealed to students by teachers and curriculum developers.

- Every human can do something to prevent damage to nature. The results of the study pave the way of a call for programs for increasing awareness of natural threats; firstly, in local aspects, and later in the global aspect. Setting a possible fieldwork to understand a lake ecosystem, make scientific experiments there, this inquiry-based lake ecosystem education program is suggested to be implemented in other lake ecosystems.

- All students enrolled in Science Application course should meet with at least one scientist every year by a seminar. Students should come to listen seminar by preparing questions about a scientific topic they have already known and they should be able to ask these questions by communicating with the scientist after presentation.

- Nature education should be supported by fieldwork activities as well as in-class activities.

- Families of students in local areas should be encouraged to attend in fieldworks of ecosystems just as observers of education. This can make awareness of conservation of ecosystems.

- Daily conservation actions and environmental citizenship behaviors (Collado et al., 2013) can be investigated and compared after treatment.

5.4 Recommendations for Further Research

- Lake Eymir Education Program can be applied by researchers who work with other middle schools in Golbasi district or any lake basin in Turkey, in order to increase generalizability of the results of the study.

- The sample and population can be chosen students in different school types (private school and public school) and different grade level (middle school and high school) students. Pre-service science teachers also can be chosen as participants.

- The same treatment can be applied on a comparison group and the overall understandings of ecosystem can be analyzed.

- Students' results of water monitoring can be used to improve national and global citizenscience acitvities to bring science and students together and make contributions to lake monitoring.

- After ecological aspects, economoical and society aspects and their relationships can be integrated into lesson plans aiming Education for Sustainable Development

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APPENDICES

A. SCIENCE PROCESS SKILLS TEST

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 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 arabanın gittiği mesafe ile.
c. Kullanılan benzin miktarı ile.
d. Kullanılan katkı maddesinin miktarı ile.

3. Bir araba üreticisi daha ekonomik arabalar yapmak istemektedir. Araştırmacılar arabanın litre başına alabileceği mesafeyi etkileyebilecek değişkenleri 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.

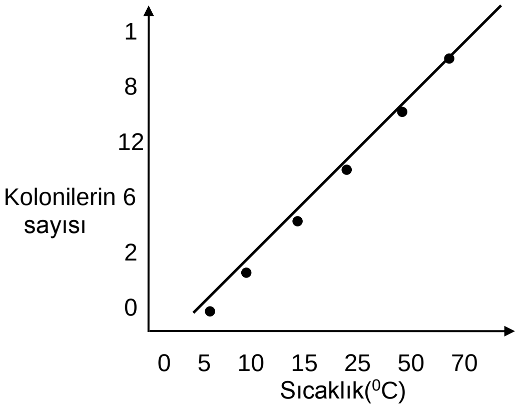
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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.



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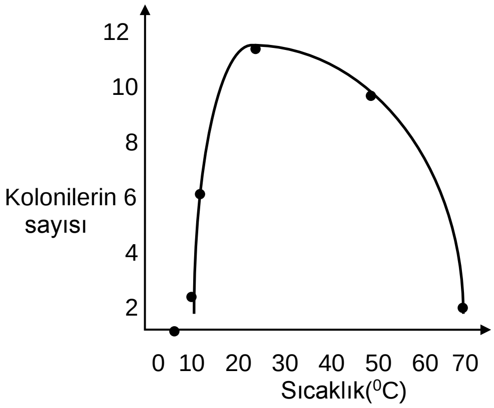
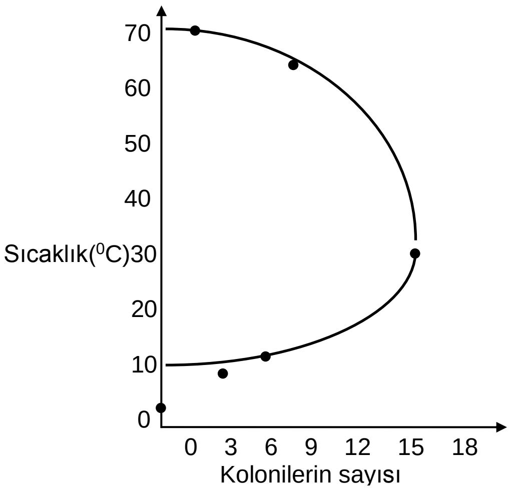
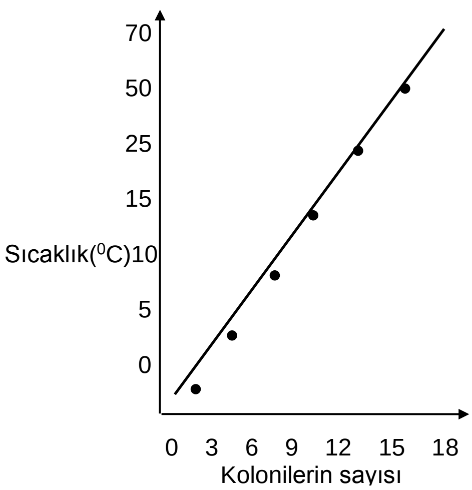


c.



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?

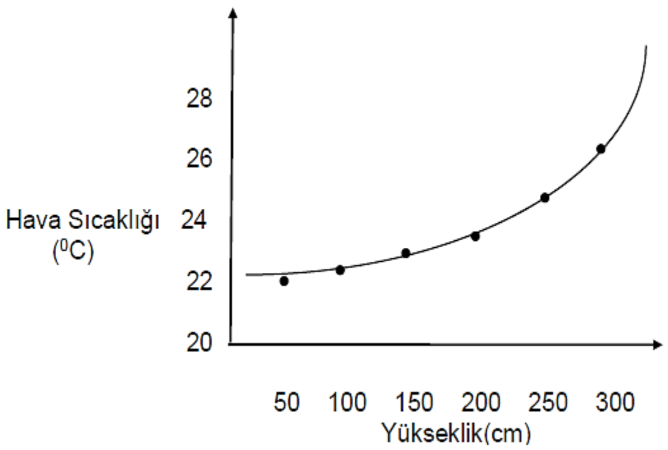
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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.

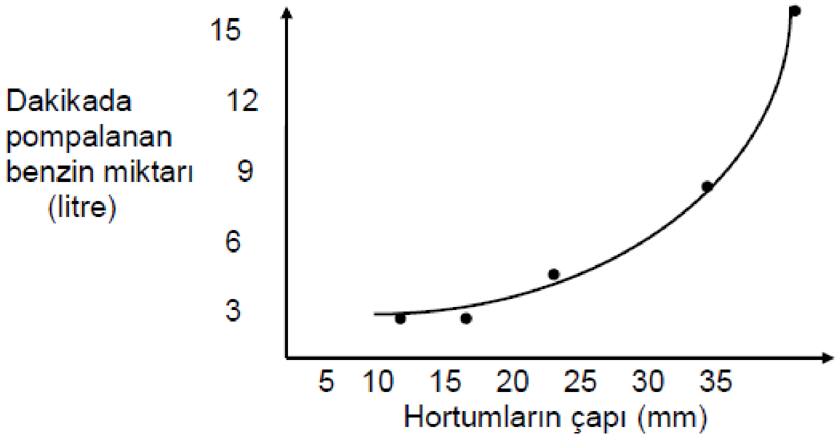
9. Bir odanın tabandan itibaren değişik yüzeylerdeki sıcaklıklarla ilgli bir çalışma yapılmış ve elde edilen veriler aşağıdaki grafikte gösterilmiştir. Değişkenler arasındaki ilişki nedir?



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

10. Ahmet, basketbol topunun içindeki hava arttıkça, topun daha yükseğe sıçracağını düşünmektedir. Bu hipotezi araştırmak için, birkaç basketbol topu alır ve içlerine farklı miktarda hava pompalar. Ahmet hipotezini nasıl sınamalıdır?
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.
b. İçlerinde farlı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.
c. İçlerinde aynı miktarlarda hava olan topları, zeminle farklı açılardan yere vurur.
d. İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

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

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

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

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

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

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

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

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

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

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

c. Güneş farklı maddelari farklı derecelerde ısıtır.

d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanın güneş altında kalma süresi.

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

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gürenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

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

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

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

17. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

d. Kullanolan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştımanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

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

a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.

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

c. Farklı alnlardaki bitkilere verilen su miktarını ölçer.

d. Her alana ektiği tohum sayısına bakar.

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

a. Kullanılan toz ya da spreyin miktarı ölçülür.

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

c. Her fidede oluşan kabağın ağırlığı ölçülür.

d. Bitkilerin üzerinde kalan bitler sayılır.

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

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

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

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

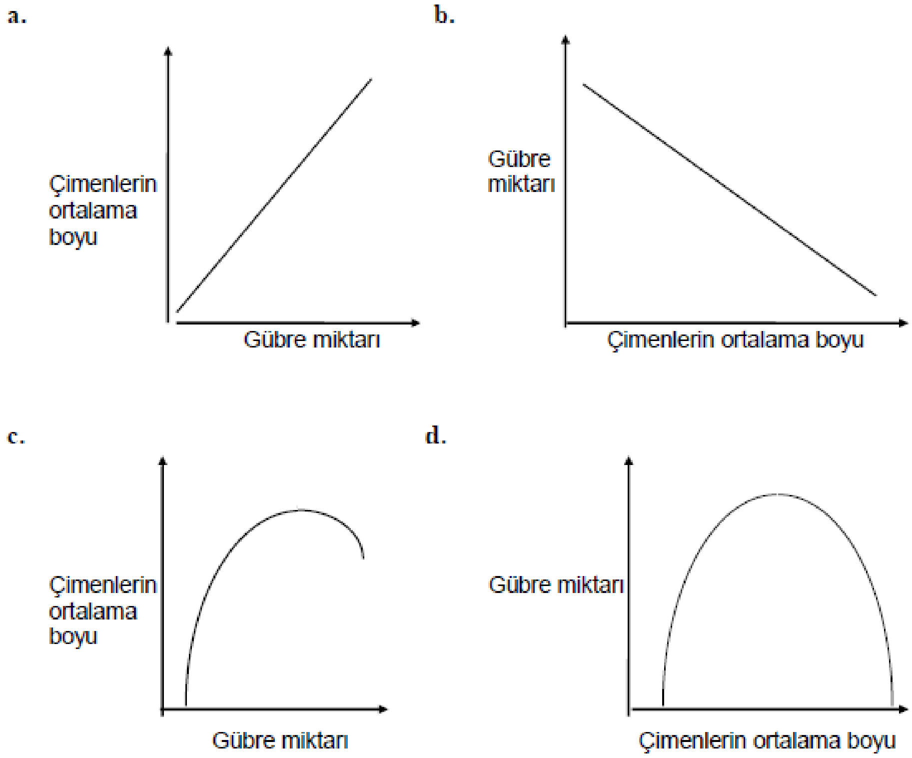
24. Ahmet, buz parçacıklarının erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarının büyüklüğü, odanın sıcaklığı ve buz parçalarının şekli gibi faktörlerin erime süresini etkileyebileceğini düşünür. Daha sonra şu hipotezi sınamaya karar verir: Buz parçalarının şekli erime süresini etkiler.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

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

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

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

Tablodaki verilerin grafiği aşağıdakilerden (bir sonraki sayfada) hangisidir?



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

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Hergün fareleri tartar.

d. Hergün farelerin yiyeceği vitaminleri tartar.

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

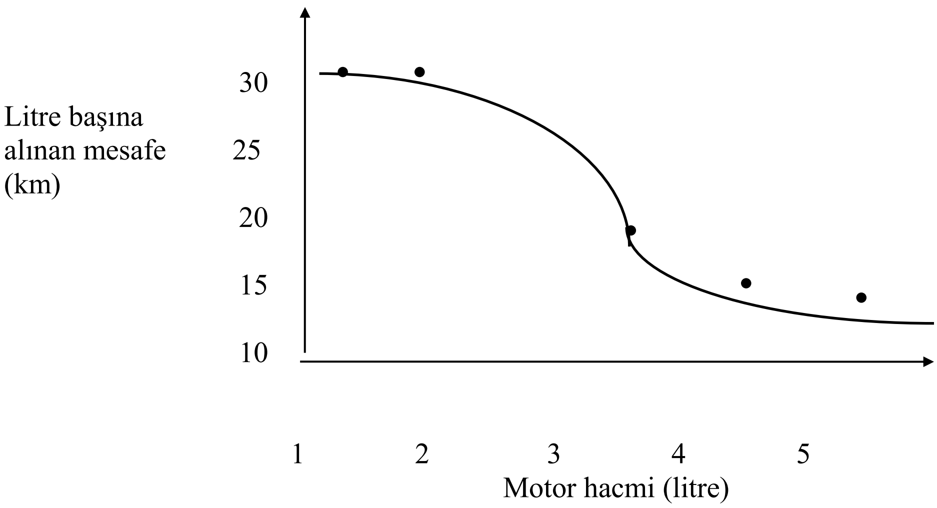
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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

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

d. Su ısındıkça şeker daha uzun sürede çözünür.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

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

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

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

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

29. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü üle.

b. Demir tozalrını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

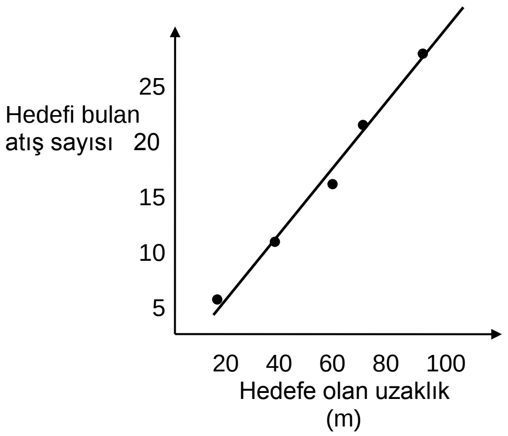
d. Çekilen demir tozlarının ağırlığı ile.

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

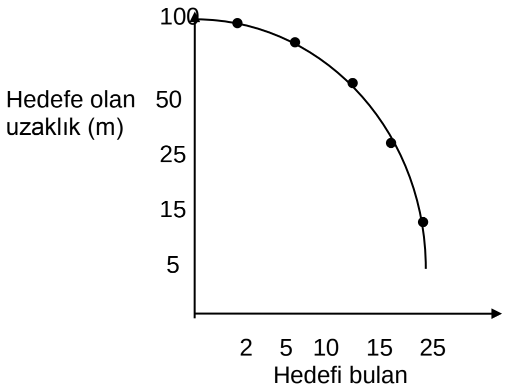
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

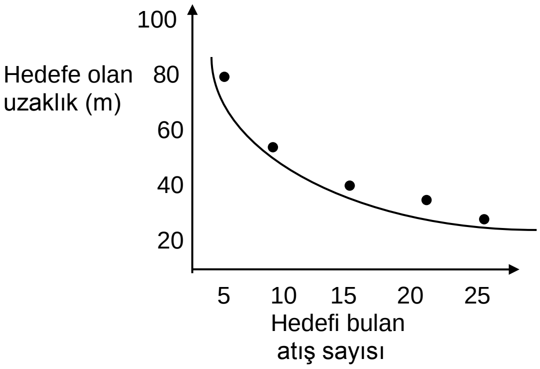
a.



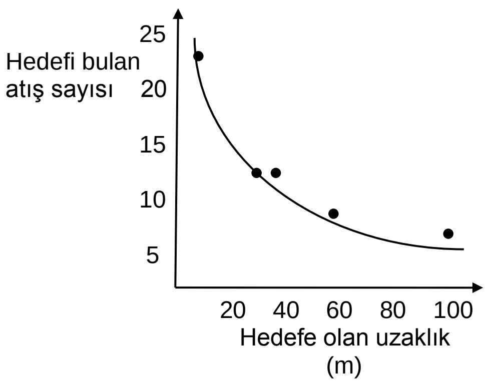
b.



c.



d.



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

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

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

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

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

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

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

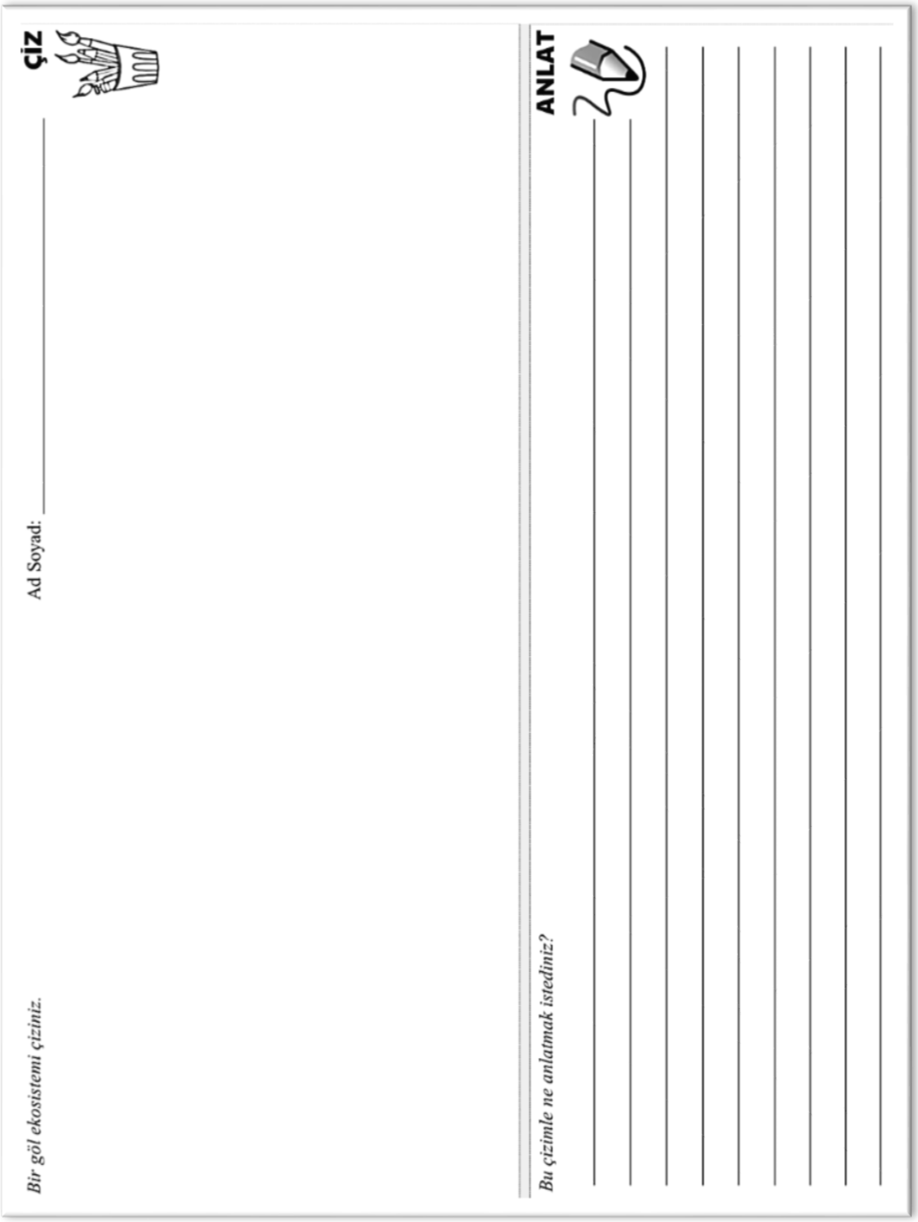
d. a ve c.

B. EPISTEMOLOGICAL BELIEFS QUESTIONNAIRE

EPİSTEMOLOJİK İNANÇLAR ANKETİ	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Tüm insanlar, bilim insanlarının söylediklerine inanmak zorundadır.	1❑	2❑	3❑	4❑	5❑
2. Bilimde, bütün soruların tek bir doğru yanıtı vardır.	1❑	2❑	3❑	4❑	5❑
3. Bilimsel deneylerdeki fikirler, olayların nasıl meydana geldiğini merak edip düşünerek ortaya çıkar.	1❑	2❑	3❑	4❑	5❑
4. Günümüzde bazı bilimsel düşünceler, bilim insanlarının daha önce düşündüklerinden farklıdır.	1❑	2❑	3❑	4❑	5❑
5. Bir deneye başlamadan önce, deneyle ilgili bir fikrinizin olmasında yarar vardır.	1❑	2❑	3❑	4❑	5❑
6. Bilimsel kitaplarda yazanlara inanmak zorundasınız.	1❑	2❑	3❑	4❑	5❑
7. Bilimsel çalışma yapmanın en önemli kısmı, doğru yanıta ulaşmaktır.	1❑	2❑	3❑	4❑	5❑
8. Bilimsel kitaplardaki bilgiler bazen değişir.	1❑	2❑	3❑	4❑	5❑
9. Bilimsel çalışmalarda düşüncelerin test edilebilmesi için birden fazla yol olabilir.	1❑	2❑	3❑	4❑	5❑
10. Fen Bilgisi dersinde, öğretmenin söylediği herşey doğrudur.	1❑	2❑	3❑	4❑	5❑
11. Bilimdeki düşünceler, konu ile ilgili kendi kendinize sorduğunuz sorulardan ve deneysel çalışmalarınızdan ortaya çıkabilir.	1❑	2❑	3❑	4❑	5❑
12. Bilim insanları bilim hakkında hemen hemen her şeyi bilir, yani bilinecek daha fazla bir şey kalmamıştır.	1❑	2❑	3❑	4❑	5❑
13. Bilim insanlarının bile yanıtlayamayacağı bazı sorular vardır.	1❑	2❑	3❑	4❑	5❑
14. Olayların nasıl meydana geldiği hakkında yeni fikirler bulmak için deneyler yapmak, bilimsel çalışmanın önemli bir parçasıdır.	1❑	2❑	3❑	4❑	5❑
15. Bilimsel kitaplardan okuduklarınızın doğru olduğundan emin olabilirsiniz.	1❑	2❑	3❑	4❑	5❑
16. Bilimsel bilgi her zaman doğrudur.	1❑	2❑	3❑	4❑	5❑
17. Bilimsel düşünceler bazen değişir.	1❑	2❑	3❑	4❑	5❑

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
18. Sonuçlardan emin olmak için, deneylerin birden fazla tekrarlanmasında fayda vardır.	1❑	2❑	3❑	4❑	5❑
19. Sadece bilim insanları, bilimde neyin doğru olduğunu kesin olarak bilirler.	1❑	2❑	3❑	4❑	5❑
20. Bilim insanının bir deneyden aldığı sonuç, o deneyin tek yanıtıdır.	1❑	2❑	3❑	4❑	5❑
21. Yeni buluşlar, bilim insanlarının doğru olarak düşündüklerini değiştirir.	1❑	2❑	3❑	4❑	5❑
22. Bilimdeki, parlak fikirler sadece bilim insanlarından değil, herhangi birinden de gelebilir.	1❑	2❑	3❑	4❑	5❑
23. Bilim insanları bilimde neyin doğru olduğu konusunda her zaman hemfikirdirler.	1❑	2❑	3❑	4❑	5❑
24. İyi çıkarımlar, birçok farklı deneyin sonucundan elde edilen kanıtlara dayanır.	1❑	2❑	3❑	4❑	5❑
25. Bilim insanları, bilimde neyin doğru olduğu ile ilgili düşüncelerini bazen değiştirirler.	1❑	2❑	3❑	4❑	5❑
26. Bir şeyin doğru olup olmadığını anlamak için deney yapmak iyi bir yoldur.	1❑	2❑	3❑	4❑	5❑

C. LAKE ECOSYSTEM DRAWING TEST


Bir göl ekosistemi çiziniz.

Ad Soyad: ____________

ÇİZ

Bu çizimle ne anlatmak istediniz?

ANLAT

D. STUDENTS' REVIEW QUESTIONNAIRE

Sevgili Öğrenciler,

Bu anket, size verilen eğitim programını değerlendirmek amacıyla hazırlanmıştır. Sizden aşağıdaki ölçülere göre aldığınız Eymir Gölü Eğitim Programı'nı değerlendirmeniz istenmektedir. Lütfen bu kağıda adınızı yazmayınız ve her soruyu sadece kendi görüşünüzü yansıtacakşekilde ve içtenlikle cevaplayınız.

Teşekkür ederim.

Müşerref Büşra YAĞLI
ODTÜ Matematik Ve Fen Eğitimi Bölümü
Yüksek Lisans Öğrencisi

EĞİTİM PROGRAMININ DEĞERLENDİRİLMESİ	Kesinlikle Katılmıyorum	Katılmıyorum	Emin Değilim	Katılıyorum	Kesinlikle Katılıyorum
1. Eğitim programı sayesinde göl ekosistemi hakkında yeni bilgiler öğrendim.	1❑	2❑	3❑	4❑	5❑
2. Bu eğitimde öğrendiklerimin şimdiki ve ileriki hayatım için yararlı olacağını düşünüyorum.	1❑	2❑	3❑	4❑	5❑
3. Eğitim programı sınıf seviyeme uygundu.	1❑	2❑	3❑	4❑	5❑
4. Eğitimler esnasında kullanılan materyaller (sunum, doküman, deney, belgesel, vb.) ilgi çekiciydi.	1❑	2❑	3❑	4❑	5❑
5. Sınıf içinde yaptığımız aktivitelerin faydalı olduğunu düşünüyorum.	1❑	2❑	3❑	4❑	5❑
6. Alan çalışmalarında yaptığımız aktiviteler, sınıf içinde öğrendiğim bilgilerin daha kalıcı olmasını sağladı.	1❑	2❑	3❑	4❑	5❑
7. Alan çalışmalarında yaptığımız aktivitelerde, o konuda çalışan bilim insanlarıyla tanışarak onlardan bilgi almak faydalıydı.	1❑	2❑	3❑	4❑	5❑
8. Sınıf içi eğitimin toplam süresi (8 hafta) yeterliydi.	1❑	2❑	3❑	4❑	5❑

9. Sınıf dışı eğitimin toplam süresi (4 hafta) yeterliydi.	1❑	2❑	3❑	4❑	5❑
10. Verilen bilim-insanıyla-tanış seminerlerinin sayısı yeterliydi.	1❑	2❑	3❑	4❑	5❑
11. Verilen bilim-insanıyla-tanış seminerleri faydalıydı.	1❑	2❑	3❑	4❑	5❑
12. Verilen bilim-insanıyla-tanış seminerlerinin süresi (2 hafta) yeterliydi.	1❑	2❑	3❑	4❑	5❑
13. Bu programdaki tüm eğitimlerin başkalarına da verilmesini öneriyorum.	1❑	2❑	3❑	4❑	5❑
Bu eğitimde en sevdiğiniz kısım hangisiydi?					
Bu eğitimde neleri değiştirmek isterdiniz?					
Eğer varsa, lütfen diğer görüş ve önerilerinizi belirtiniz:					

- ANKETİN SONU -

TEŞEKKÜRLER

E. APPROVAL BY APPLIED ETHICS RESEARCH CENTER

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

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Sayı: 28620816/[illegible]

10 KASIM 2016

Konu: Değerlendirme Sonucu

Gönderilen: Prof.Dr. Jale ÇAKIROĞLU,

İlköğretim Anabilim Dalı,

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın, Prof.Dr. Jale ÇAKIROĞLU;

Danışmanlığını yaptığınız yüksek lisans öğrencisi Müşerref Büşra YAĞLI' nın "Sorgulamaya dayalı bir göl eğitim paketinin ortaokul öğrencilerinin bilimsel epistemolojik inançlarına, bilim insanı algılarına ve bilimsel süreç becerilerine etkisi" başlıklı araştırması İnsan Araştırmaları Kurulu tarafından uygun görülerek gerekli onay **2016-EGT-156** protokol numarası **18.11.2016-18.08.2017** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Canan SÜMER

İnsan Araştırmaları Etik Kurulu Başkanı

Prof. Dr. Mehmet UTKU

İAEK Üyesi

Prof. Dr. Ayhan SOL

İAEK Üyesi

Prof. Dr. Ayhan Gürbüz DEMİR

İAEK Üyesi

Doç. Dr. Yaşar KONDAKÇI

İAEK Üyesi

Yrd. Doç. Dr. Pınar KAYGAN

İAEK Üyesi

Yrd. Doç. Dr. Emre SELÇUK

İAEK Üyesi

F. APPROVAL BY MINISTRY OF NATIONAL EDUCATION

AY

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

Sayı : 14588481-605.99-E.3366754 — 14.03.2017

Konu : Araştırma İzni

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Biyolojik Bilimler Bölümü)

İlgi: a) MEB Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2012/13 nolu Genelgesi.
b) 09/02/2017 tarihli ve 245 sayılı yazınız.

Üniversiteniz Biyolojik Bilimler Bölümü öğrencisi Müşerref Büşra YAĞLI'nın **"Eymir Gölü Elçileri ile Göl Ekolojisi Açık Ders Malzemesi Oluşturulması"** konulu proje kapsamında uygulama talebi Müdürlüğümüzce uygun görülmüş ve uygulamanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Uygulama formunun (4 sayfa) araştırmacı tarafından uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde bir örneğinin (cd ortamında) Müdürlüğümüz Strateji Geliştirme (1) Şubesine gönderilmesini rica ederim.

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G. TURKISH SUMMARY/TÜRKÇE ÖZET

YEDİNCİ SINIF ÖĞRENCİLERİNİN BİLİMSEL EPİSTEMOLOJİK İNANÇLARININ, BİLİMSEL SÜREÇ BECERİLERİNİN VE GÖL EKOSİSTEMİ ANLAMA DÜZEYLERİNİN EYMİR GÖLÜ EĞİTİM PROGRAMI ARACILIĞIYLA GELİŞTİRİLMESİ

GİRİŞ

Ekonomik İşbirliği ve Kalkınma Teşkilatı'nın (OECD, 2016) raporuna göre, 15 yaşındaki çocuklara uygulanan Uluslararası Öğrenci Değerlendirme Programı'nın (PISA) sonuçları, Türk öğrencilerin fen performansının, katılımcı 72 ülkenin öğrencilerinden çok daha düşük olduğunu göstermektedir. Bu endişe verici bulgu aslında 2000 ve 2015 yılları arasındaki beş PISA değerlendirmesinin hepsinde de ortaya çıkmıştır. Bu rapor, bilimsel metotlar ile sorgulamayı kapsayan ve epistemolojik inançlar diye isimlendirilen kategoride de Türkiye'deki öğrencilerin puanlarının ortalamanın altında kaldığını göstermiştir. Değerlendirmeye katılan Türk öğrencilerin çoğunluğu, fen konularının ilgi çekici olduğunu düşündüklerini, fakat fen eğitiminde bilimsel etkinliklere yeterince katılmadıklarını ifade etmişlerdir.

Uluslararası Eğitim Başarılarını Değerlendirme Kuruluşu (IEA, 2015) tarafından her 4 yılda bir 4. ve 8.sınıf düzeyindeki öğrencilere uygulanan Uluslararası Matematik ve Fen Eğilimleri Araştırması'na (TIMMS) göre ise, Türkiye'deki 8. Sınıf öğrencilerin fen alanındaki başarı puanları 1999-2015 yılları arasında kademeli olarak artmış olsa dahi, küresel ortalamanın altında kalmıştır.

Hem öğrencilerin akademik bilgilerini dünyayı anlamak ve günlük hayatta karşılaşılan problemleri çözmek için kullanma yeteneğini değerlendirmeye odaklanan PISA, hem de öğrencilerin akademik bilgilerini değerlendirmeye odaklanan TIMMS dikkate alındığında, Türk öğrencilerin bu sınavlardan düşük puanlar alması Türk ortaokul fen eğitimi programının kalitesinin, öğrencilerin küresel yeterliliklere sahip olacakları şekilde geliştirilmesine ihtiyaç olduğunu gösterir. Bunun için, dünyadaki eğitim politikalarının gidişatını takip etmek esastır.

Son elli yıl boyunca, öğrenme sürecinde öğrencilerin rolü hakkında dünya çapında birçok eğitim reformu yapılmıştır. Bu reformların çoğu, öğrencilerin pasif birer alıcı olmalarından ziyade, öğrenme sürecinde aktif öğrenenler olmalarını amaçlamıştır. Aktif öğrenme, öğrencilerin aktivite gerçekleştirdiği ve ne yapıldığının farkında olduğu eğitim etkinliklerini ifade eder (Bonwell ve Eison, 1991). Öğretmenler, doğrudan öğrencilere bilgi aktarmak yerine, öğrencilerin bilgi edinmeleri, keşfetmeleri, bilgiye kendi kendilerine ulaşmaları ve daha fazla bilgiye ihtiyaç duymalarını sağlar, (Johnson, 1996; Dunlop ve Grabinger, 1996). Bu, öğrencilerin öğrenme merkezinde olmasını ve katılım göstermesini sağlar; dolayısıyla öğrenme daha anlamlı hale gelir (Hake, 1998; Laws ve ark. 1999).

Öğrenci merkezli talimatların trendiyle Avustralya, Kanada, İngiltere, Finlandiya, İrlanda, İsrail, Yeni Zelanda, Singapur, İspanya, Tayvan, Türkiye ve ABD gibi birçok ülkenin müfredat politikaları, yapılandırmacılık yönüne kaydırılmıştır (Bukova ve diğerleri, 2005). Yapılandırmacılık, her çocuğun kendi deneyimleri ile bilgiyi oluşturduğunu iddia eden bir aktif öğrenme teorisidir. Sınıflarda yapılandırmacılık yaklaşımı öğrencileri fiziksel ve zihinsel olarak aktif tutar ve öğretmenin kolaylaştırıcılığı ile, kendi öğrenmelerinden sorumlu hale getirir. Öğrenci, bilgiye hiçbir zihinsel çaba sarfetmeden sadece öğretmen anlattığı için ya da sadece öğretmen kendisinden yapmasını istediği için –yapmak için yaparak- değil; düşünerek ve yaparak ulaşır.

Türkiye Milli Eğitim Bakanlığı tarafından Fen Bilimleri Dersi Öğretim Programı'nda öğrenme yaklaşımı olarak, yapılandırmacılık bağlamındaki araştırma-sorgulamaya dayalı öğrenme esas alınmıştır (MEB, 2013; 2018). Araştırma-sorgulamaya dayalı öğrenme, öğrencilere bir kavramı daha fazla merak etme, kendi kendine cevap bulma, önceki bilgilerini kontrol etme ve günlük yaşamda karşılaşılan sorunları çözme imkanı verir. Müfredatta öğretme ortamları sadece araştırma-sorgulamaya dayalı öğretim yöntemiyle sınırlı değildir; problem, proje, argümantasyon, ve işbirliğine dayalı öğrenme gibi öğrencinin öğrenmenin merkezinde yer aldığı diğer aktif öğrenme stratejileri de alternatif olarak önerilmiştir. Öğrencilerin keşfettiği, sorguladığı, argüman oluşturduğu ve ürün tasarladığı bu öğrenme süreci sayesinde öğrencilerin okulda, iş hayatında ve yaşamında başarılı olmaları beklenmektedir. Öğrencilerin gelişmiş yetkinliklere sahip olması yalnızca kendilerini değil, ayrıca gelecek nesilleri ve dünyayı da etkiler.

2015'te OECD tarafından yapılan son PISA değerlendirmesinden sonra, PISA'da başarılı olmanın sırrı olarak kabul edilen bir bilim insanı gibi düşünmenin yolunu araştırma-sorgulamaya dayalı öğrenme yöntemi aydınlatmaktadır. Araştırma-sorgulamaya dayalı öğrenme ile öğrenciler örneğin; çıkarımlar yapar, hipotezler kurarlar, gözlemlerle veri toplarlar ve kanıtlara dayalı açıklamalar yaparlar (NRC, 2000). Bu öğrenme yöntemi ile öğrenciler, bir bilim insanı gibi sorgulama, hipotez oluşturma, keşif, deney, veri yorumlama, sonuçlandırma, iletişim ve yansıma aşamalarından geçerek hareket eder. Alanyazındaki bir çok çalışma, araştırma-sorgulamaya dayalı öğrenmenin öğrencilerin bilimsel süreç becerilerinin gelişimi üzerindeki etkisini göstermiştir (Adesoji ve İdika, 2015; Anagun ve Yaşar; 2009; Gök ve diğerleri, 2014; Kanlı ve Yağbaşan, 2008; Pabuççu, 2008; Polyem ve arkadaşları, 2011; Yeliz, 2005).

Bilim insanları dünyayı anlamak için bilimsel süreç becerilerini kullanırlar. Bu beceriler, bilim adamları tarafından tahmin etmek, bilimsel olayları açıklamak ve problem çözmek için kullanılır (Carin ve ark. 2005). Bu becerileri Martin (1997) temel süreç becerileri ve bütünleşik süreç becerileri olarak ikiye ayırır. Gözlemlemek, çıkarım yapmak, ölçmek, iletişim kurmak, sınıflandırmak ve tahmin etmek temel süreç becerileridir. Öte yandan, değişkenlerin kontrolü, işlemsel olarak tanımlanması, hipotez oluşturma, veri yorumlama, deneysel tasarım ve modelleme bütünleşik süreç becerileridir (Martin, 1997). Burada şunu belirtmek önemlidir; bilim insanı gibi düşünmek ve benzer bilimsel süreçlerden geçmek, her zaman gelecekte bir bilim insanı olarak kariyer yapmayı ifade etmez. Bilim insanı gibi düşünebilmek, öğrencilerin günlük yaşamda daha iyi karar vermelerini sağlayan 21. Yüzyıl yetkinliklerinden biri olarak önemlidir.

Bilimsel süreç becerilerine ek olarak, bir bilim adamı gibi düşünmek için öğrencilerin "bilimsel bilginin ve bilmenin doğası" hakkındaki inançları da önemlidir. Bu inançlara epistemolojik inançlar denir (Hofer ve Pintrich, 1997). Epistemolojik inançlar, bilginin kaynağı, bilginin gerekçesi, bilginin kesinliği ve bilginin gelişimi hakkındaki inançlardan oluşur (Conley, Pintrich, Vekiri ve Harrison, 2004).

Platon'a dönersek, bilgide gerçeğin yanı sıra inançlar ve gerekçeler vardır; yani başka bir deyişle, tüm edinilen bilgiler doğru değildir. Gerçeğin ve inancın ne olduğunu ayırt edebilmek ise bilim için kesinlikle çok önemli bir noktadır. Bu fark, Glaserfeld (1998) tarafından "bilimde, örneğin, belirli problemleri çözme hedefinin ötesinde, mümkün olduğu kadar deneyimsel dünyanın modelini tutarlı bir şekilde inşa etme hedefi" olduğu ifadesiyle açıklığa kavuşturulmuştur (s.7). Bunları göz önünde bulundurarak, öğrencilerin bilimsel bilgi ve bilme hakkındaki anlayışlarının, bilim insanlarının anlayışından farklıdır.

OECD (2015) aynı zamanda öğrencilerin "bilimsel doğruyu" anlamalarının gerekliliğinin de altını çizmektedir, çünkü mevcut bilimsel bilgiler önceden var olan bilimsel bilgiler ile aynı değildir ve, bilimsel keşifler yapıldığı ve teknoloji geliştiği sürece bilimsel bilgiler gelecekte de asla aynı kalmayacaktır. Ancak, ortaokul öğrencilerinin çoğu düşük düzeylerde epistemolojik inançlara sahiptir (Jones ve Araje, 2002). Öğrencilerin epistemolojik inançları ve öğrenme yöntemleri arasında güçlü bir ilişki vardır (Alvermann ve Qian, 2000). Araştırma-sorgulamaya dayalı öğrenme, öğrencilerin epistemolojik inançlarını geliştirmeye yardımcı olan bir yöntemdir (Chan ve Elliott, 2002; Gök ve diğerleri, 2014; Kaynar ve diğerleri. 2009).

Öğrencilerin bilimsel süreç becerilerini ve bilimsel epistemolojik inançlarını uygulayarak geliştirebilecekleri bilimsel konuların neler olduğunu tanımlamak, her ülkenin müfredatına bağlıdır. Dünya çapındaki önemli bilim kavramları, küresel değerlendirmelere bakarak anlaşılabilir. Yarım milyon öğrenciyi değerlendiren PISA ve TIMMS her zaman belirli konuları kapsar. Biyoloji alanı altındaki bu konulardan biri ekosistemlerdir. Örneğin; TIMMS, öğrencilerin ekosistemler konusunu anlama konusundaki akademik bilgilerini yaklaşık 20 yıldır değerlendirmektedir ve ekosistemlerle ilgili öğrenme kazanımlarının sayısı yıllar boyunca hep birbirine benzerdir. TIMMS 2011, 2015 ve 2019'a bakıldığında, ekolojik süreçler ve etkileşimleri içeren ekosistemler konusunun sekizinci sınıf öğrencileri için biyoloji alanındaki en yüksek kazanım sayısına sahip olduğu görülmektedir.

Oldukça karmaşık bir sistem olan ekosistem, hem kendi içinde hem de diğer tüm ekosistemler ile arasında sürekli ve dolaylı bağlantıda olan canlı ve cansız ögeleri içerir. Ekosistem kavramlarının anlaşılması, fiziksel, kimyasal ve biyolojik dünyayı geniş bir perspektifte görme becerisini gerektirir. Her ne kadar sekizinci sınıf öğrencileri, Canlılar ve Enerji konusunu diğer fen üniteleriyle kıyaslayıp en az zorlandığı ünite olarak algıladıkları iddia etseler de (Tuncel ve Fidan, 2018), bireylerin ekosistem anlama düzeylerini değerlendiren çalışmalar, ortaokul öğrencilerinin, lise öğrencileriinin, öğretmen adaylarının ve hatta fen bilgisi öğretmenlerinin bile ekolojik kavramlar hakkında düşük düzeyde anlayışlara sahip olduğunu ortaya çıkarmıştır (Çetin, Ertepınar ve Geban, 2015; Grotzer ve diğerleri, 2010; Özkan, Tekkaya ve Geban, 2004; Jordan, 2009; Jin ve ark. , 2019, Yörek ve diğerleri, 2010).

Dahası, insan dahil tüm yaşam formlarının hayatta kalması ekosistemlere bağlıdır ve ekosistemleri anlamak bu yüzden çok önemlidir. Ekosistemler, içme suyu, yiyecek, besin döngüsü, tarımsal sulama, iklim düzenlemesi ve rekreasyon gibi çeşitli hizmetleri insan yarararına sunar. Bu da doğal ekosistemleri korumak için toplumu sorumlu kılar. Bununla birlikte, ekosistem hizmetlerinin değeri toplum tarafından tam olarak hakettiği takdiri görememektedir. Milenyum Ekosistem Değerlendirmesi (MA, 2005), son 50 yılda ekosistemdeki insan kaynaklı küresel değişimin, insanlık tarihinin herhangi bir zamanından bile daha hızlı ve geniş kapsamda olduğunu bildirmiştir. Artan insan nüfusu ve ekosistemlerden beklentilerin artması, ekosistemlerin daha fazla bozulmasına neden olmaktadır, dolayısıyla sadece insan refahı değil, tüm biyosfer de tehlike altına girmektedir.

Türkiye'de ortaokul öğrencileri ekosistemleri genellikle örgün eğitim adı altında sınıf içi etkinlikleri ile öğrenirler. Konuyu gerçek hayatta uygulamadan, bir ekosistemin tüm dinamizmini zihinde kavramsallaştırmak, öğrenciler için ne kolay ne de eğlencelidir. Bunun yanında öğretmenler de, öğrencilere beton binaların içindeki doğal bir ekosistemi öğrenmeye motive etmekte zorlanmaktadır. David Orr çalışmasında (1992, s.207), "hayata duyulan saygıyı arttıran ve destekleyen eğitimin, dış mekanlarda ve yerel toplumla daha sık yaşandığını" belirtmiştir. Ona göre, eğitim aynı zamanda insanların ekolojik okuryazar olmalarına ve doğanın nasıl işlediğini anlamalarına yardımcı olmalıdır (Orr, 1992). Benzer şekilde, bilinen eski bir kitabında, Okul ve Toplum: Psikolog olarak Çocuk ve Müfredat, John Dewey (1902), doğadaki uygulamaların konu kadar önemli olduğuna değinmiştir. Bunlara ek olarak, doğadaki eğitimler öğrenciyi sakinleştikleri, rahatlattıkları ve sosyal etkileşime kolayca girmelerini sağladığı için, psikolojiden eğitime kadar geniş bir yelpazede yapılan çeşitli çalışmalar, doğada eğitim vermeyi ve daha yeşil öğrenme ortamlarını desteklemelerini sağlar (Haase ve Hille, 2010; Kuo, Barnes ve Jordan, 2019). Bütün bahsedilen faydalarına rağmen, öğrencileri doğadan ayırarak sınıf içi etkinlikler ile sınırlandırmak ve doğa hakkında bilgi vermek ekosistemler konusunu öğrenmeleri için etkili bir yol değildir. Öğrencilerin sınıfta öğrendiklerini doğadaki deneyimlerle pratik etmeleri gerekir.

Öğrenciler ve öğretmen doğa ile bir araya geldiğinde, ekosistem konusu öğrencilerin deney yapabilecekleri bilimsel aktivitelerle birleştirilebilir. Dış dünyayla olan bu aktif bilimsel ilişki, İngiltere Kalite Güvence Ajansı (QAA, 2002) tarafından alan çalışması olarak tanımlanmıştır. Alan çalışmaları, öğrencilerin bilimsel amaçlar için hiçbir şeyle etkileşime girmeden sadece yürüyüp etrafa bakındığı gezilerin aksine, öğrencilerin bilimsel deneyler yaptıkları açık hava etkinlikleridir. Bu çalışma, öğrencileri başta hayvanlar, bitkiler, toprak ve göl suyu olmak üzere başlıca doğal ekosistem bileşenleriyle temas halinde olmaları ve doğayı bilimsel bir yolla anlamaları için teşvik etmektedir. Ekosistem konusundaki öğretim materyalleri çağrısı da dikkate alarak (Yücel ve Özkan, 2015), bu araştırma, müfredatla uyumlu ve araştırma-sorgulamaya dayalı öğrenme metodunun kullanıldığı sınıf içi ve alan çalışması aktiviteleri ile öğrencilerin ekosistem anlayışlarını geliştirmeye bir örnek sunar. Ayrıca, bu çalışma kapsamında, Eymir Gölü Eğitim Programı ile öğrencilerin bilimsel süreç becerilerinin, epistemolojik inançlarının ve göl ekosistemi konusundaki anlayışlarını geliştirmeyi amaçlayan bir örnek de literatüre katkı sağlamaktadır.

Genelde ekosistem anlayışları öğrencilerden kavram testleri veya görüşmelerle elde edilir. Halbuki çizim yapmak, öğrencilerden şıklardan bir cevabı tahmin etmelerini ve seçmelerini istemek yerine, ekosistemin bileşenlerini ve ilişkilerini nasıl anladıklarını ortaya çıkarmaya yardımcı olur. Çizim testleri, öğrencilerin genel çevre veya ekosistem anlayışlarını incelemek için yapılan birçok çalışma tarafından kullanılmasına rağmen, özellikle öğrencilerin göl ekosistem anlayışlarını çizerek inceleyen bir çalışma bulunamamıştır. Ayrıca, öğrencilerin ekolojik kavramları anlamalarını geliştirmeyi amaçlayan çok sınırlı deneysel çalışmalar vardır. Bu çalışma, öğrencilerin göl ekosistemi konusundaki anlayışlarını çizimlerinden inceleyerek literatüre empirik kanıtlar takdim eder.

Üstelik, bu çalışma öğrencilere göl ekosistemi konusunda gerçek dünyadaki problemleri çözmek için mühendislik tasarımı yapabilecekleri fen bilimleri müfredatına uyumlu araştırmacı tarafından tasarlanan iki etkinliğe de sahiptir. Bu etkinliklerin amacı öğrencilerin gerçek hayatta karşılaşabilecekleri bir soruna birer bilim insanı gözüyle bakabilmelerini ve sorunu çözmek adına somut ürünler geliştirerek onları doğada test edip geliştirmelerini bekler.

Araştırma Soruları

Bu çalışmanın amacı araştırma-sorgulamaya dayalı öğrenme tekniğiyle hazırlanmış Eymir Gölü Eğitim Programı aracılığıyla yedinci sınıf öğrencilerinin bilimsel süreç becerilerini, bilimsel epistemolojik inançlarını ve göl ekosistemi konusunu anlama düzeylerini geliştirmek ve öğrencilerin program hakkındaki görüşlerini almaktır. Bu amaçla belirlenen araştırma soruları aşağıdaki gibidir:

1. Eymir Gölü Eğitim Programı, yedinci sınıf öğrencilerinin bilimsel süreç becerilerini ne ölçüde geliştirir?
2. Eymir Gölü Eğitim Programı, yedinci sınıf öğrencilerinin bilimsel epistemolojik inançlarını ne ölçüde geliştirir?

3. Eymir Gölü Eğitim Programı, yedinci sınıf öğrencilerinin göl ekosistemin konusunu anlama düzeylerini ne ölçüde geliştirir?
4. Eymir Gölü Eğitim Programı hakkındaki görüşleri nelerdir?

YÖNTEM

Araştırma Deseni

Araştırmada tek grup ön test-son test deseni kullanılmıştır. Bu desen kontrol ya da karşılaştırma grubunun seçilmesinin mümkün olmadığı durumlarda, neden-sonuç ilişkisinin varlığını test etmeye yarayan ve eğitim alanında sıkça kullanılan yarı-deneysel çalışmalardan biridir (Silverman, 2019). Farklı fen bilimleri öğretmeni tarafından iki farklı sınıfta öğrenim görmekte olan bir grup öğrenci deney grubu olarak atanmıştır. Veriler toplanmadan ve deney başlatılmadan önce öğretmenlere araştırma-sorgulamaya dayalı öğrenme yöntemi, bilimsel süreç becerileri, epistemolojik inançlar ve göl ekosistemi hakkında eğitimler verilmiş ve devamında ders planları paylaşılmıştır. Öğretmenler tarafından Eymir Gölü Eğitim Programı uygulanmış ve araştırmacı derslerin tümüne katılarak öğretmenlerin tekniği doğru uyguladığını ve konuyu doğru anlattığını tetkik etmiştir.

Örneklem

Araştırmanın örneklem grubu iki ayrı sınıfta öğrenim görmekte olan 52 yedinci sınıf öğrenciden oluşur. Bu öğrenciler ile ilgili bilgi Tablo 1'de yer almaktadır.

Tablo 1. Araştırmanın Örneklemi Hakkındaki Bilgiler

		Frekans (*f*)	**Yüzde (%)**
Cinsiyet			
	Kız	22	42.3
	Erkek	30	57.7
	Toplam	52	100
Sınıf*			
	Sınıf A	26	50
	Sınıf B	26	50
	Toplam	52	100

		Frekans (*f*)	Yüzde (%)
Yaş			
	12	3	5.8
	13	45	86.5
	14	4	7.7
	Toplam	52	100
Annenin Çalışma Durumu			
	Çalışan	14	26.9
	İşsiz	37	71.2
	Bilinmiyor	1	1.9
	Toplam	52	100
Babanın Çalışma Durumu			
	Çalışan	45	86.5
	İşsiz	2	3.8
	Emekli	2	3.8
	Bilinmiyor	3	5.8
	Toplam	52	100
Annenin Eğitim Seviyesi			
	Okuma yazma bilmiyor	3	5.8
	İlkokul	18	34.6
	Ortaokul	13	25
	Lise	15	28.8
	Üniversite	2	3.8
	Bilinmiyor	1	1.9
	Toplam	52	100
Babanın Eğitim Seviyesi			
	İlkokul	11	21.2
	Ortaokul	20	38.5
	Lise	12	23.1
	Üniversite	8	15.4
	Bilinmiyor	1	1.9
	Toplam	52	100

*Sınıflar gerçek isimlerinden bağımsız olarak A ve B diye isimlendirilmiştir.

Veri Toplama Araçları

Veriler hem nicel hem de nitel yöntemlerle toplanmıştır. Veri toplamak için beş araç kullanılmıştır; Demografik Bilgi Anketi (DIS), Bilimsel Süreç Becerileri Testi (SPST), Epistemolojik İnançlar Anketi (EBQ), Göl Ekosistem Çizim Testi (LEDT) ve Eğitim Değerlendirme Anketi (SRQ) ile ölçülmüştür. Ölçekler velilerin izni ve öğrencilerin onayı alınarak öğretmenin olduğu sınıf ortamında, eğitimin başlamasından bir hafta önce öğrencilerden ön-test olarak; eğitimin bitişinden bir hafta sonra ise son-test olarak elde edilmiştir. SPST, EBQ ve SRQ ölçeğinin iç güvenilirlik katsayısı Cronbach alpha sırasıyla 0.85; 0.88 ve 0.76 olarak hesaplanmış ve güvenilir bulunmuştur. LEDT ölçeğinin güvenilirliği ise doktora mezunu uzman bir biyolog ve araştırmacı tarafından denetlenmiştir.

Veri Analizi

Çalışmada hem nitel hem de nicel veriler analiz edilmiştir. SPSS 24.0 programı aracılığıyla DIS ölçeğinden elde edilen verilerin sadece frekans ve yüzdeleri hesaplanmıştır. SPST, EBQ ve SRQ ölçeklerinden elde edilen nicel verilerin betimsel analizi ise, minimum ve maksimum değerleri, ortalamaları, standart sapmaları, çarpıklık ve basıklık değerleri kapsamaktadır. Eymir Gölü Eğitim Programının uygulamasının öncesinde ve sonrasında kullanılan SPST ve EBQ ölçeklerinden elde edilen verilerin çıkarımsal istatistikleri eşleştirilmiş örneklem t-testinin varsayımları sağlanarak analiz edilmiştir. SRQ ölçeği ile elde edilen nitel veriler araştırmacı tarafından kodlanıp kategorilere ayrılmıştır. LEDT ölçeği ile elde edilen veriler ise tümevarımsal yolla araştırmacı ve uzman tarafından kodlanmıştır. Aynı öğrenci hem resimde hem açıklamasında aynı kodu tekrarlıyorsa bu, tek bir kod olarak değerlendirilmiştir.

BULGULAR VE TARTIŞMA

Eymir Gölü Eğitim Programı'nın 7. sınıf öğrencilerinin bilimsel süreç becerileri üzerinde istatistiksel olarak anlamlı etkisi bulumuştur. Uygulama etki büyüklüğü Cohen's *d* 1.71 olarak hesaplanmıştır. Bu sayı araştırmanın çok büyük oranda pozitif yönde etki büyüklüğüne sahip olduğunu gösterir (Sawilowsky, 2009). Uygulama, öğrencilerin bilimsel süreç becerilerini hem genel olarak hem de her alt boyutunda geliştirmekte etkilidir. Bu boyutlar; değişkenleri belirleme, işlemsel olarak tanımlama, test edilebilir hipotezleri belirleme, veri ve grafik yorumlama ve deney tasarlamadır. En çok gelişim veri ve grafik yorumlama boyutunda $t(47)= 7.75$, $p< 0.05$), en az gelişim ise deney tasarlama boyutunda gerçekleşmiştir $t(47)= 2.19$, $p< 0.05$). Sırasıyla en çoktan en aza gelişim gösteren boyutlar; grafik yorumlama ve deney tasarlama, test edilebilir hipotezleri belirleme, değişkenleri belirleme, test edilebilir hipotezleri belirleme ve deney tasarlamadır. Çalışmanın sonuçları benzer çalışmalarla tutarlılık göstermektedir (Cruz, 2015; Tatar; 2006; Şimşek & Kabapınar, 2010; Çelik & Çavaş, 2012; Köksal & Berberoğlu, 2014; Yıldırım, 2012; Kaya & Yılmaz, 2016).

7. sınıf öğrencilerinin epistemolojik inançlarında da istatistiksel olarak anlamlı bir değişiklik olmuştur. Uygulama etki büyüklüğü Cohen's *d* 1.72 olarak hesaplanmıştır; bu sonuç çok büyük olumlu bir etkiyi işaret eder. Ayrıca, epistemolojik inançların her boyutunda da olumlu değişiklikler elde edilmiltir. Bu boyutlar; gerekçelendirme, gelişme ve kaynak/kesinliktir. Sırasıyla en çok gelişimin olduğu boyut, gelişme $t(47)= 10.65$, $p<.05$; kaynak/kesinlik $t(47)= 8.98$, $p<.05$; ve gerekçelendirmedir $t(47)= 7.05$, $p<.05$. Araştırmanın sonucu genel anlamda diğer çalışmasıyla tutarlılık göstermektedir (Smith, Maclin, Houghton, and Hennessey, 2000; Kaynar 2007; Gok, 2014). Fakat alt boyutlara bakıldığında Conley et al. (2004)'un uygulama sonunda gelişme ve gerekçelendirme; Tucel'in (2016) ise kaynak/kesinlik boyutunda gelişme bulamamasıyla çelişmektedir.

Öğrencilerin uygulama hakkındaki görüşleri olumlu bulunmuştur. Sınıf-içi etkinlikler, alan çalışmaları ve bilim insanı seminerlerini öğrenciler ilgi çekici buldukları belirtmişlerdir. Ayrıca öğrenciler, daha çok bilimsel faaliyetler yapmak, göl ekosistemi hakkında daha fazla bilgi edinmek, Orta Doğu Teknik Üniversitesi Limnoloji Laboratuvarı ve Eymir Gölü'nde alan çalışmaları yapmak için dışarı çıkmak istediklerini not etmişlerdir. Uygulama, öğrenciler tarafından seviyelerine uygun olarak değerlendirişmiş ve öğrenciler bu uygulamada öğrenilenlerin şimdiki ve gelecekteki yaşamlarında yardımcı olabileceğini düşünülmüştür. Öğrenciler diğer öğrencilere bu uygulanmanın yapılması, bilimsel ve alan çalışması sayısının arttırılması da öğrenciler tarafından önerilmiştir.

Öğrencilerin göl ekosistemi hakkındaki anlayışları uygulama ile geliştirilmiştir. Bu sonuç alanyazındaki diğer çalışmalarla uyumludur (Özkan, Tekkaya & Geban, 2004; Manoli, 2014; Tuncer & Kvasnicak, 2007). Öğrenciler göl ekosistemini biyotik ve abiyotik faktörlerin bir arada yaşadığı yerler olarak algılarken, uygulamadan sonra, tüm biyotik ve abiyotik faktörlerin doğrudan veya dolaylı olarak birbirleriyle etkileşime girdiği göl ekosistemini anladıklarını çizdikleri resimlerle ve açıklamalarıyla ifade etmişlerdir. Ayrıca, göl ekosistemindeki biyotik bileşenler hakkındaki anlama düzeyleri büyük oranda artmıştır. Benzer çalışmalarda, biyotik faktörlerdeki gelişim düzeyinin abiyotik bileşenlerden daha yüksek olduğu (Yücel ve Özkan, 2018) ve öğrencilerin genellikle biyotik bileşenleri olan ekosistemleri tanımladığı bildirilmiştir (Jordan ve ark. 2009).

Biyotik bileşenler arasında tüketici sayısı, hem uygulama öncesi hem de uygulama sonrası çizilen ve anlatılan resimlerde üreticilere ve ayrıştırıcılara kıyasla en fazla bulunmuştur. Tüketici türleri, üretici türlerinden daha fazladır. Bu, bitkiden ziyade öğrencilerin havanla yaşadığı deneyimlerden kaynaklanıyor olabilir. Öğrenciler, günlük yaşamlarında evde ya da medyada birçok hayvan görürler (Tunnicliffe ve ark., 2008), bu yüzden hayvanları daha çok çizmiş olabilirler.

Balık resimlerdeki en yaygın tüketiciydi ve sadece balığın sayısı hem ön test hem de test sonrasındaki toplam su bitkileri ile neredeyse aynıydı. Öğrenciler tarafından uygulamadan önce ve sonra en çok bilinen balık sazan, en bilinen su kuşu ise ördek ve ardından karabataktır. İlgili literatür, çocukların eğitimden ziyade hayvan ve bitkilerle ilgili geçmiş deneyimlerinin, onların anlayışlarında ve canlıları adlandırmalarında etkili olduğunu desteklemektedir (Bebbington, 2005; Tarlowski, 2006). Öğrencilerin eğitim programı ile ilgili deneyimlerini sağlayarak, öğrencilerin biyoçeşitlilik algıları da ayrıca genişletilmiştir. Ek olarak, öğrenciler alan çalışmalarında aldehitle fikslenmiş balıklarla ilgili deneyim edindikleri ve onların diş yapıları veya boyutları gibi fiziksel özelliklerini gözlemlediği ve gözlemlerine göre sınıflandırdığı için, uygulamadan sonra av veya avcı olarak balıktan bahsetmişlerdir.

Üstelik, uygulamadan sonra öğrenciler göl ekosisteminde fotosentez yapan fitoplanktonları öğrenmişlerdir. Aynı şekilde, uygulama öncesi hiçbir ayrıştırıcıdan bahsetmezken, uygulamadan sonra öğrenciler ayrıştırıcıları resmetmiş ve ayrıştırıcı olarak mantarlardan ve bakterilerden bahsetmişlerdir. Bunlara ek olarak, besin zincirindeki türler ve gıda ağındaki çizdikleri dallanmalar da artmıştır. Öğrencilerin fosfor, azot ve karbon içeren besinleri anlayışları uygualama sayesinde kazandırılmıştır. Öğrencilerin göl ekosistemindeki enerji anlayışları, uygulamadan önce sadece kinetik enerji ile ilgiliyken, uygulamadan sonra göl ekosistemindeki kinetik enerjinin yanı sıra ışık ve ısı enerjisiyle göl ekosistemini anlatmışlardır. Bunlara ek olarak, uygulamadan sonra çizilen ve anlatılan insan ve insan faaliyetlerinin sayısı da artmıştır. Öğrencilerin göl ekosistemi ve havza ile insan etkileşimi hakkındaki anlayışları da olumlu yönde gelişmiştir.

ÖNERİLER

• Eymir Gölü Eğitim Programı, çalışma sonuçlarının genelleştirilebilirliğini arttırmak için Gölbaşı ilçesinde veya Türkiye'deki herhangi bir göl havzasında bulunan diğer orta okul öğrencileriyle çalışan araştırmacılar tarafından uygulanabilir.

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<u>TEZİN TÜRÜ</u> / <u>DEGREE:</u> **Yüksek Lisans** / Master D**oktora** / PhD

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