THE EFFECT OF CONCEPTUAL CHANGE INSTRUCTION ON UNDERSTANDING OF ECOLOGY CONCEPTS

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ABSTRACT

THE EFFECT OF CONCEPTUAL CHANGE INSTRUCTION ON
UNDERSTANDING OF ECOLOGY CONCEPTS

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The purpose of this study was to investigate the effects of conceptual change text oriented instruction accompanied by demonstrations in small groups (CCTI) on ninth grade students' achievement and understanding levels of ecology, attitudes towards biology, and attitudes towards environment.

The instruments used in this study were the Test of Ecological Concepts (TEC), the Attitude Scale towards Biology (ASB), the Attitude Scale towards Environment (ASE), and the Test of Logical Thinking (TOLT). All data were collected from the public high school in Balıkesir in the Spring Semester of 2001-

2002. 88 students from four classes and two teachers were included in this study. Two of the classes were called control group and two of them were called experimental group. While the TEC, ASE and ASB were administered to all of the students as pre- and post-tests, the TOLT were conducted as pre-test.

Data related to the TEC, ASB, and ASE were analyzed by multivariate analysis of covariance (MANCOVA). The results of the MANCOVA showed that there was significant effect of the treatment which was the conceptual change texts oriented instruction accompanied by demonstrations in small groups on the TEC, while there were no significant effect of the treatment on the attitudes towards biology and attitudes towards environment.

Keywords: Ecology, Conceptual Change Oriented Instruction, Conceptual Change Text, Demonstration, Small Group Work, Attitude towards Biology, Attitude towards Environment, and Logical Thinking Ability.

ÖZ

KAVRAM DEĞİŞTİRME ÖĞRETİMİNİN EKOLOJİ KAVRAMLARINI ANLAMA ÜZERİNE ETKİSİ

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Bu çalışmanın amacı, küçük gruplarda demonstrasyon destekli kavramsal değişim metinlerine dayalı öğretimin (KDMÖ), dokuzuncu sınıf öğrencilerinin ekoloji başarıları ve anlama düzeylerine, biyolojiye karşı tutumlarına ve çevreye karşı tutumlarına etkilerini incelemektedir.

Bu çalışmada, Ekoloji Kavramları Testi (EKT), Biyoloji Tutum Ölçeği (BTÖ), Çevre Tutum Ölçeği (ÇTÖ) ve Mantıksal Düşünme Yetenek Testi (MDYT) kullanılmıştır. Tüm veriler, 2001-2002 Bahar Döneminde Balıkesir' de

bulunan bir devlet lisesinden toplanmıştır. Bu çalışmaya dört sınıftan 88 öğrenci ve iki öğretmen katılmıştır. Sınıflardan ikisi kontrol grubu ve diğer ikisi de deneysel grup olarak adlandırılmıştır. EKT, BTÖ ve ÇTÖ tüm gruplara öntest ve sontest olarak verilirken, MDYT ise öntest olarak uygulanmıştır.

EKT, BTÖ, ve ÇTÖ verileri Ortak Değişkenli Çok Yönlü Varyans Analizi ile analiz edilmiştir. Bu analiz sonuçları, küçük gruplarda demonstrasyon destekli kavramsal değiştirme metinlerine dayalı öğretimin EKT üzerine etkisinin anlamlı olduğunu gösterirken, öğrencilerin biyolojiye karşı tutumları ve çevreye karşı tutumları üzerine etkisinin anlamlı olmadığını göstermektedir.

Anahtar Kelimeler: Ekoloji, Kavram Değiştirme Öğretimi, Kavram Değiştirme Metni, Demonstrasyon, Küçük Grup Çalışması, Biyolojiye Karşı Tutum, Çevreye Karşı Tutum ve Mantıksal Düşünme Yeteneği.

To My Family

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SYMBOLS

TEC	: Test of Ecological Concepts
ASB	: Attitude Scale towards Biology
ASE	: Attitude Scale towards Environment
pre-TEC	: Students' Ecological Concepts Pre-test
pre-ASB	: Students' Biology Attitude Pre-test
pre-ASE	: Students' Environmental Attitude Pre-test
post-TEC	: Students' Ecological Concepts Post-test
post-ASB	: Students' Biology Attitude Post-test
post-ASE	: Students' Environmental Attitude Post-test
SAB	: Students' Average Grades of Two Biology Midterm Exams
TOLT	: Test of Logical Thinking
TRE	: Treatment

TI	: Traditionally Designed Teaching Instruction
CCTI	: Conceptual Change Text Oriented Instruction Accompanied by Demonstrations in Small Groups
EG	: Experimental Group
CG	: Control Group
PrEG	: pre-TEC in the Experimental Group
PsEG	: post-TEC in the Experimental Group
PrCG	: pre-TEC in the Control Group
PsCG	: post-TEC in the Control Group
MANCOVA	: Multivariate Analysis of Covariance
ANCOVA	: Analysis of Covariance
MRC	: Multiple Regression Correlation
N/n	: Sample Size
F	: F Statistic
df	: Degree of Freedom
p	: Significance Value
SU	: Sound Understanding
PU	: Partial Understanding
PUM	: Partial Understanding Which Includes Misunderstanding

MS	: Misunderstanding
NU	: No Understanding
NR	: No Response

CHAPTER 1

INTRODUCTION

Students' minds are not empty; they are full of prior knowledge and have several ideas before coming to science classes. They may have some alternative conceptions and scientifically acceptable conceptions in the same content area in science (Palmer, 1999). Students' alternative ideas can be referred to as alternative frameworks or misconceptions in the literature. They are considered as fairly different from scientific views. They are resistant to change with scientific ones and students may reject accepting new ideas. In other words, misconceptions are obstacles for students in learning and meaningful understanding of some concepts in science. Students' alternative conceptions in science can be originated from different sources; such as school experiences, social practices, daily life experiences, instruction, prior knowledge, teacher, peer interaction, and textbooks, etc.

When students enter the classroom with informal ideas (alternative conceptions) about scientific phenomena; these alternative ideas would affect how the corresponding scientific explanations are learned (Hewson and Hewson, 1983; Driver, Squires, Rushworth, and Wood-Robinson, 1994). Therefore, students' alternative conceptions in science can be a problem for teachers. Students' alternative ideas can influence science achievement and they should be overcome through instruction (Beeth, 1998). In recent years many studies of students' conceptions have been carried out in different disciplines (science, biology, physics, and chemistry) at different levels from elementary school to colleges (Gilbert and Watts, 1983; Driver et al., 1994; Gil-Perez and Carrascosa, 1990) for example, energy and processes of change (Stylianidou, 1997), pre-service elementary teachers' self-efficacy beliefs and their conceptions of photosynthesis and inheritance (Çakıroğlu and Boone, 2002), and high school students' understanding of resistance in simple series electric circuits (Mullet, 2002), etc.

In short, students have still some problems in science concepts and specifically the concept of ecology. Students' misconceptions cannot be eliminated easily by traditional methods. Traditional instruction does not help to encourage students to work together, to share ideas and information freely with each other. Traditional methods mainly use lecture strategy rather than several instruments to extend students' intellectual capabilities and have not brought more successful results for expected aims of science education. One possible solution for this problem is to make students more active learners in science classrooms. Students should be able to apply what they learn in school to their daily life situations. Weaver (1998) pointed out that students found topics more interesting when they have some relevance to their daily lives or experience.

One alternative way is to change the instruction from teacher-centered to student-centered using a constructivist approach. Constructivism is mainly linked to students' alternative conceptions and their own experience. In constructivist perspective, students' alternative conceptions are interpreted. Students enter the classroom with their own ideas and experiences and they shape their formal knowledge based on their existing ideas and experiences at school. Their preconceptions can be valid, invalid, or incomplete. When the new information or experiences are presented to the students in the classroom, they will either reject or reformulate their existing cognitive structures whether their knowledge and experiences are connected to their background information. Finally, students' own perceptions and new ideas should be integrated as a useful part of their memory.

In contrast, the memorized facts or information that do not depend upon students' existing experiences will be forgotten easily. Therefore, the new ideas or concepts should be attached to students' old experiences accordingly. In that case, it will help students construct the meaningful information in their existing mental framework (Hanley, 1994).

A lesson in a 'constructivist approach' differs greatly from the traditional teacher-as-lecturer class type. The focus is on the acquisition of understanding, not on rote memorization. The teacher is not mostly active in the class as in traditional classrooms and the activities are student-centered. The role of the teacher has changed, and the teacher can be considered as a guide. Teacher should help the students in budding new insights and connecting them with their prior knowledge. S/he should organize information around conceptual clusters of problems, questions in order to engage student interest on a topic that has a broad concept. Ideas should be given as broad concepts first, and then they should be broken down into parts. Students should be supported to ask questions, carry out experiments, and come to their own conclusions (Hanley, 1994).

The constructivist strategies are consistent with inquiry approach, discovery approach, cooperative learning, and discrepant events. Those instructional approaches can be effective classroom tools and facilitate conceptual change (Chang and Mao, 1999a; Chang and Mao, 1999b). To provide conceptual change and meaningful learning of science concepts, there is a need for using effective techniques for overcoming those misconceptions in science. One of the most effective strategies for eliminating students' misconceptions in science is 'conceptual change approach'. In conceptual change approach, students should be dissatisfied with their existing ideas first of all. Then, students presented new concepts and it is explained that these concepts should be parallel to the knowledge in other areas. Finally, they should be led to new insights (Posner et al., 1982).

To overcome students' alternative conceptions, large amount of researches have explored the effects of conceptual change approaches and several instructional tools in science such as; concept maps (Novak, 1990; Wallace and Mintzes, 1990; Jegede et al., 1990), conceptual change texts (Chambers and Andre, 1997; Mirjamaija, 2001; Yürük and Geban, 2001; Çakır et al., 2001; Çakır et al., 2002), refutational texts (Hynd, Mcwhorter, Phares, and Suttles, 1994), analogy (Stavy, 1991), cooperative learning strategy (Lonning, 1993; Jansen and Finley, 1995; Lazarowitz et al., 1994; Chang and Mao, 1999a); story telling

(Banister and Ryan, 2001), portfolio (Valdez, 2001), teaching experiments (Niaz, 2002).

Conceptual change texts are assumed as one of the effective conceptual change tools in science education. Each conceptual change text starts with a question. Later some common students' alternative conceptions in science are presented. Then, scientifically correct statements are given. Chambers and Andre (1997) proved that the conceptual change texts led to better conceptual understanding of electrical concepts than the traditional didactic text. Sungur (2000) used conceptual change texts and concept maps together in her study, and she stressed that this instruction was significantly effective to students' understanding of human circulatory system than the traditional methods.

On the other hand, refutational texts are used for eliminating students' common misconceptions in science education. Palmer (2003) stated that both refutational texts and conceptual change texts were able to induce accommodation in a large proportion of the students about the concept of ecological role in nature.

Students may find that some biological concepts such as genetics, photosynthesis, and food web are abstract, difficult, confusing, and complicated. Thus, students have some common misconceptions about biological concepts. They are obstacles for students realizing biological concepts. Therefore, students may not construct meaningful learning in biology. Some research studies based on misconceptions about the biological concepts are; about the concepts of cellular respiration (Çakır et al., 2001), amino acids and translation (Fisher, 1985), human circulatory system (Sungur, 2000), natural selection (Anderson, Fisher, and

Norman, 2002), evolution (Jensen, and Finley, 1995), photosynthesis and respiration (Çapa, 2000), photosynthesis and inheritance (Çakıroğlu and Boone, 2002), genetics and ecology (Okebukola, 1990; Bahar et al., 1999b), ecosystem and ecology (Okeke and Wood-Robinson, 1980; Griffiths and Grant, 1985), nutrient cycling in ecosystems (Hogan and Fisherkeller, 1996), and food chain and food web (Web and Bolt, 1990).

Ecology takes an important place in these studies. The concepts of food chain, food web, and decomposition can be considered as three essential ecological concepts. Researchers determined that many students have misconceptions in ecological concepts (Adeneyi, 1985; Hellden, 1992a; Gallegos, Jerezano, and Flores, 1994; Khatete, 1995; Leach, 1995; Eyster and Tashiro, 1997; Çetin, 1998).

Adeyini (1985) studied students' alternative conceptions on food chain, decomposition, energy flow, energy pyramid, and the carbon cycle with junior secondary school students. The findings of the study showed that a few of them still appeared after the instruction. Similarly, the results of the studies of Helden (1992b) and Khatete (1995) revealed that students have still some misconceptions about decomposition even after the instruction. Çetin (1998) also indicated that English and Turkish students have some common misconceptions about food chain, food web, and decomposition.

Though many researchers used different instructional materials such as analogy, fieldwork and project work for ecology teaching in order to remove students' misconceptions, there are fewer studies which involve conceptual change texts. Conceptual change texts can be used to both emphasize students' misconceptions and remove them later. Özkan (2001) found out that the conceptual change texts based instruction was more effective in remediation of seventh grade students' misconceptions about ecology than the traditionally designed instruction.

Venville and Treagust (1998) explored conceptual change in genetics using a multidimensional interpretive framework. They collected the data by student worksheets, observations of lessons, videotape, audiotape to classroom discourse and detailed student interviews. The results of the study provided evidence that the conceptual change approach for the concept of the gene were less effective than it was expected.

Besides the conceptual change text, several additional methods could be used such as laboratory work, demonstration, small group work, and hands-on activities.

Worksheets that are parts of the conceptual change texts can include some demonstrations and then students discuss some questions in small groups if the class size is small. The teacher could do some demonstrations, and then s/he could guide a whole class discussion. That is, it would be better to support conceptual change texts with some demonstrations in small groups, instead of only presenting some misconceptions to students and then giving the scientifically correct statements in conceptual change texts. Hence, conceptual change texts supported by demonstrations in small group oriented instruction was used in this study.

In Turkey, students learn ecological concepts at fourth, seventh, and ninth grades. Ecological concepts are given gradually to teach those concepts, and students are expected to apply them to their everyday life. However, students' misconceptions are main obstacles for realizing ecological concepts, getting a better understanding, and achievement of ecological concepts.

Alternative ideas affect science achievement, as do several factors such as gender differences (Sungur and Tekkaya, 2003), logical thinking ability, attitude towards science (George, 2000; Willson, Ackerman, and Malave, 2000), teachers' expectations, students' expectations, and classroom environment.

Sungur and Tekkaya (2003) examined the effects of gender and reasoning ability on the human circulatory system concepts for the students' achievement and attitudes towards biology. They found that there was a statistically significant mean difference between concrete students and formal students for students' achievement and students' attitudes towards biology, although there was no statistically significant mean difference between boys and girls for students' achievement and attitude towards biology.

George (2000) stressed that the students' attitudes towards science generally deteriorated over the middle and high school years and science self-concept was the strongest predictor of attitude towards science. Willson, Ackerman and Malave (2000) also found a positive relationship between the interactive model of conceptual understanding and achievement in college freshman physics. However, they did not find any positive relationship between students' achievement and students' attitudes towards science.

The purpose of this study was to investigate the effects of the conceptual change approach based instruction over traditional instruction and gender at ninth graders' achievement and understanding levels of ecology, and attitudes towards biology and environment. The contributions of students' logical thinking abilities to their ecology achievement and levels of understanding of ecology, and attitudes toward biology and environment would be examined.

Significance of the Study

There are many researches on students' common misconceptions and their remediation in science by different conceptual change methodologies such as conceptual change texts, concept maps, analogy, and preparing portfolio, etc. Conceptual change texts are one of the powerful tools in science education. Conceptual change texts include some common misconceptions and related corrected scientific conceptions about science concepts. Many studies showed that conceptual change text oriented instruction increased the students' science achievement (Chambers and Andre, 1997; Sharon, and Chambers, 1997; Mirjamaija, 2001; Sungur, Tekkaya and Geban, 2001; Çakır et al., 2002).

While there is a lot of literature on students' common misconceptions and their remediation in ecology by several conceptual change instructional tools, the conceptual change oriented texts on ecology are used rarely as instructional tools. Therefore, there are some gaps in using of conceptual change texts about ecology in the literature. On the other hand, there was not any study investigating the effects of the conceptual change text oriented instruction accompanied by demonstrations in small groups (CCTI) on students' achievement and understanding levels of ecology, attitudes towards biology and environment in the ninth level in the literature. However, some ecological terms are abstract and students have some misconceptions about ecology. To use some instructional tools with conceptual change texts in this study can bring more successful results than would only conceptual change text oriented instruction do. Then, the researcher preferred to conduct a study using the conceptual change text oriented instruction accompanied by demonstrations in small groups in this study.

The results of this study will provide insight into the effects of CCTI on students' ecology achievement, attitudes towards biology and environment. Also, this study would present an example for incorporating a CCTI to ecology unit for teachers, students, curriculum designers, curriculum developers, and other researchers.

The findings of the study will give some information to science teachers, particularly biology teachers about how students understand ecological concepts. Actually, this study will provide some information about the CCTI; how it can be conducted on ecology topics, how it affects students' achievement and understanding levels of ecology, attitudes towards biology and environment. It is hoped that the results of the study will guide the future studies about the implementation of the CCTI in the other science areas.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Alternative ideas of students have an impact on science achievement. Other factors such as; gender, attitude, and logical thinking ability can also influence students' performance in science. This overview will cover some relevant literature on alternative ideas in science, conceptual change approaches in science, science achievement, students' attitude towards science, especially students' attitudes towards biology and environment. This chapter will also provide a theoretical and practical background for the current study.

2.1 Misconceptions

Students learn from their environment and at school. They have several alternative conceptions about everyday contexts, scientific knowledge, and facts. Students' alternative conceptions can be referred to as alternative ideas, alternative frameworks, children's science, or misconceptions.

Driver (1981) indicated that a main source for studying children's ideas is generally Piaget's work. Children's ideas are assumed as quite different from scientific views. The main characteristic of students' alternative ideas is that these are resistant to change with scientific ideas. Students may reject new ideas even after the teaching process.

Students' misconceptions seemed to reflect an inadequacy of the curriculum or instruction, or both. Misconceptions may originate from several reasons such as previous learning, teacher expectations, everyday life experiences, and school activities. Çapa (2000) found that social practices and school experiences caused ninth graders' misconceptions about photosynthesis and respiration in plants. Misconceptions may also occur because of teacher's misconceptions in science topics and misconceptions in the textbooks (Storey, 1989; Duit, 1991; Storey, 1992; Gauld, 1997; Galley, 2001).

Storey (1992) studied textbook errors and misconceptions in cell physiology about enzyme catalyzed reactions, RNA as a catalyst, protein levels in cells, amino acids, organic acids, glucose and fructose, gluconeogenesis, fatty acids and ketone bodies, diffusion, and transport across membranes.

Science teachers and curriculum designers need to know which alternative framework is specifically found in science. If students' misconceptions or misunderstandings in certain science concepts were known beforehand, it would be helpful for teachers. Thus, a teacher can prepare a teaching scheme to remove those kinds of misconceptions and improve students' understanding of those science concepts (Griffiths and Grant, 1985; O-Saki and Samiroden, 1990; BouJaoude, 1992).

There are many studies specifically investigating children's understanding of several biological concepts. Research studies on students' conceptions or misconceptions in biology focused on mainly the concepts of human circulatory system (Sungur et al., 2001), diffusion and osmosis (Christianson and Fisher, 1999; Odom and Barrow, 1995), osmosis (Westbrook and Marek, 1991), genetics (Wood-Robinson, Lewis and Leach., 2000), cellular respiration (Çakır et al., 2001), photosynthesis and respiration (Çapa, 2000), genetics and ecosystem (Bahar et al., 1999a), nutrient cycling in ecosystems (Okeke and Wood-Robinson, 1980), nutrient cycling (Hogan and Fisherkeller, 1996), and natural selection (Anderson, Fisher, and Norman, 2002).

Finley et al. (1982) asked biology teachers to rate important and difficult concepts. Photosynthesis, mitosis/meiosis and cellular respiration were considered as the top three important and difficult concepts among 15 biological concepts for the students. The teachers perceived the concept of food chain/food web as important, but not a difficult concept among biological concepts. Odom and Barrow (1995) investigated college biology students' understanding of diffusion and osmosis after the instruction. They developed a two-tier diagnostic test relating student misconceptions. The first tier examined content knowledge and the second tier examined understanding of that knowledge. Wood-Robinson et al. (2000) pointed out that the students (15-16 years) have many confusion over the nature of genetic information in cell, and the mechanism of transferring genetic information from one cell to another and between generations.

2.2 Misconceptions Related to Ecology

Students' understanding and misconceptions concerning the key concept of ecology have been the subject of considerable research recently. McComas (2002) summarized the misconceptions about ecology. The food chain, food web, and decomposition can be considered as three main and abstract concepts among the ecological concepts (Griffiths and Grant, 1985; Webb and Bolt, 1990; Hellden, 1992b; Khatete, 1995; Leach, 1995; Çetin, 1998; Khalid, 1999).

Griffiths and Grant (1985) studied the high school students' understanding of food webs using pre-test and post-test design with accompanying reasoning items. They reported the following common misconceptions held by students:

1. In a food web, a change in one population will only affect another population if they are directly related as predator and prey.
2. A population located higher on a given food chain within a food web is a predator of all populations located below it in the chain.
3. A change in the size of a prey population would have no effect on its predator population.
4. If the size of one population in a food web is altered, all other populations in the web will be altered in the same way.

Barman, Griffiths, and Okebukola (1995) examined the views of high school students from the USA, Australia, and Canada with regard to food chains and food webs. They found that most of the students from the three countries had some difficulties about food chains and food webs. This study resulted in similar findings by Griffiths and Grant (1985) with regard to the Canadian students' understanding of food webs. However, they determined one more additional misconception that was not identified by Griffiths and Grant (1985) such as; "a change in the population of a first order consumer would affect one or more producer populations".

Webb and Bolt (1990) identified the students' ability to respond to questions based on relationships in food chains and food webs. They reported that students aged 15-17 could not predict likely outcomes when the effects of a change in one population in a community expended in many directions. Furthermore, from the data provided by student groups at different ages, they suggested that if the pupils do not conceptualize clearly the concept of food web in early school years, the students will have a tendency to resist change to their ideas even at university level.

Gallegos et al. (1994) examined the students' misconceptions about food chain and they found that:

1. Animals are carnivorous if they are big and ferocious.
2. Animals are herbivorous if they are passive or smaller than the carnivorous animals.

On the other hand, Khatete (1995) studied decomposition, food spoilage, and the scientific basis of food preservation with Kenyan children in everyday life contexts. He examined how these ideas changed through year 5 to 12. He identified that students still had some misconceptions about decomposition at 12.

Helden (1992b) studied the pupils' understanding of ecological processes and found out some students' misconceptions about decomposition. Several students perceived decomposition as a process in which no organisms took part. This study resulted in showing that the teaching had not challenged the pupils' notions sufficiently to create a change in the understanding of ecological concepts.

Some researchers analyzed students' responses under some categories. Westbrook and Marek (1991) explored seventh grade life science students', tenth grade biology students', and college zoology students' understanding of the concept of diffusion. All responses were evaluated according to six categories; complete understanding, sound understanding, partial understanding, partial understanding with specific misconception, specific understanding, and no understanding. The study claimed that there was no significant difference in understanding of the concept of diffusion among seventh graders, tenth graders and college zoology students.

Similarly, Simpson and Marek (1988), Keng, (1997), and Çetin, (1998) analyzed students' responses under four levels of understanding: sound understanding, partial understanding, misunderstanding, and no understanding. Çetin (1998) investigated English and Turkish eighth graders' understanding levels and misconceptions related to food chain, food web, and decomposition. An ecology test was constructed for this study. It consisted of two parts: multiple-choice part and reasoning part for each item. She used the following categories for the students' levels of understanding of ecology:

1. Sound Understanding: If the students' responses included the scientifically acceptable explanations about a concept, they were considered to have sound understanding.

2. Partial Understanding: If the students' responses were partly correct and did not include the full range of the scientifically acceptable explanations about a concept, they were considered to have partial understanding.

3. Misunderstanding: If the students' responses did not include acceptable explanations, it implied that the students have some misinterpretations or misjudgments of a concept. Some students' responses, which were also clearly different from the scientific view, were grouped as misunderstandings.

4. No Understanding: If the students could not give an explanation from the scientific point of view for the response made in the multiple choice questions nor could give proper answers to the open-ended questions, they were considered to have no understanding at all. The category 'No Understanding' contained those responses below:

- Nonsense responses: Irrelevant responses or responses which could not be coded meaningfully.
- Rewrite responses: Responses that restated the instruction or question.
- No responses: Cases where the space was left empty or with the response "I don't know".

Çetin (1998) found that the students' understanding of ecological concepts at eighth grade level are:

1. Students had difficulty in explaining the origin of flow of energy in a food chain.
2. Students explained the concepts of producer and food web well.
3. Students were familiar with the decay of apples and oranges at home or in nature, and the decomposition of the tin cans in nature.
4. Some students considered the producer or consumer responsible for the decay in an ecosystem.

Adeyini (1985) reported the students' common misconceptions on food chain, energy flow, energy pyramid, and carbon cycle. He observed that the teachers in the classroom, took notes about them, and audio taped lessons. He developed an interview protocol to assess students' knowledge about ecology. He also concluded that although some of these misconceptions might have existed before the instruction, a few of them appeared after the instruction, and their prior misconceptions tended to block the understanding of new concepts and generalizations.

Rueter and Perrin (1999) used a simulation technique to teach food web dynamics as group work. Using the simulation software in the non-biology majors, especially in grade C was significantly effective on the open-ended essay questions and the group discussions probably enhanced students' learning as much as technology.

Carlsson (2002a) described the structure and general features of the phenomenon of ecological understanding and demonstrated different ways of experiencing the cycling of matter and flow of energy in the context of ecosystems. The results indicated that the idea of transformation was the key to development of ecological understanding. The structure of ecological understanding was expressed to be hierarchical, that is, it has more complex ways of thinking.

In addition, Carlsson (2002b) explored the functional aspects of the ecosystem taking photosynthesis, recycling, and energy as the units of analysis. She interviewed ten student teachers. According to the results of the study, the idea of transformation was crucial to more complex ways of understanding of photosynthesis and this idea divided the categories into a consumptional and a transformational group. The categories were thought as hierarchical, that is, they were required complex ways of thinking.

There is an increasing concern for environmental issues. There are some studies about radioactivity (Ronneau, 1990), greenhouse effect (Koulaidis and Christidou, 1999), ozone layer (Potts et al., 1996), greenhouse effect, ozone layer depletion, and acid rain (Khalid, 1999). Khalid (1999) studied pre-service elementary teachers' alternative conceptions regarding three ecological issues: greenhouse effect, ozone layer depletion, and acid rain. The results demonstrated that the majority of pre-service elementary teachers held a group of incorrect ideas about the causes and effects of the greenhouse effect, ozone layer depletion, and acid rain.

Boyes et al. (1999) explored Greek students' ideas (aged 11-16) on ozone layer. Greek students had a good understanding of the position and the purpose of the ozone layer related to the protection from harmful ultraviolet rays. However, some students held misconceptions about the ozone layer that helps keeping the world warm or protects it from acid rain. Students seemed aware that ozone layer is in danger because of different pollutions. They also thought that further ozone layer depletion might cause different problems, e.g. skin cancer or eye cataract. In contrast to the UK curriculum, the Greek curriculum did not include the ozone layer, green house effect, and radioactivity. Greek students' knowledge came from the media, family, and peer-group discussion. Although the UK students showed better understanding about the causes of ozone layer depletion, some of them had confusion about the ozone layer depletion with greenhouse effect.

Koulaidis and Christidou (1999) studied the primary school students' (aged 11 and 12) for their conceptions about greenhouse effect by interviewing. As they found, the students' alternative conceptions were about:

1. The concept of uniform diffusion of atmospheric gases,
2. Conceptual distinction between ultraviolet and other forms of solar radiation,
3. Conceptual distinction between sunlight and terrestrial radiation,
4. Conceptual distinction between the roles of the ozone layer and greenhouse gases in the atmosphere,
5. Greenhouse effect seen as atmospheric pollution.

2.3.Conceptual Change Approach

Like misconceptions, several factors such as pre-existing conceptions, prior achievement, prior attitude, post attitude, motivation, and logical thinking ability, etc. can affect students' science understanding and achievement. Barnett and Morran (2002) addressed the students' pre-existing ideas in her study of "children's alternative frameworks of the Moon's phases and eclipses". The study focused on supporting students in identifying their own existing understanding and reflecting on how their understanding evolves over time rather than directly addressing students' alternative frameworks. The results of the study suggested that elementary school students could develop complex understandings of astronomy concepts and the direct engagement of students' alternative frameworks might not be necessary if the students were covered by learning activities that provided students opportunities to examine and reflect on their understanding.

Gilbert, Osborne, and Fensham (1982) suggested that students brought their views to science lessons. These are logical to students and have a considerable influence on how and what they learn from their classroom experiences.

For meaningful learning, one alternative way is to change the instruction from teacher-centered to student-centered using a constructivist approach. Current reforms in education in many countries generally suggest a move away from traditional, teacher-centered, direct instruction, where students are passive, towards more student-centered understanding based teaching (constructivism) that focuses on exploration and experimentation (Smerdon and Burkam, 1999).

Students need assistance to constructing new information or interpretation relevant to students' prior knowledge and experiences (Appleton, 1993). Constructivist approach can help students to gain meaningful learning.

In order to improve students' science achievement, several teaching strategies like investigative-oriented laboratory approach (Ertepınar and Geban, 1996), lecture and lab combined format (McCormick, MacKinnon, and Jones, 1999), case-based method (Çakır, 2002), hands-on instruction (Pyle and Akins-Moffatt, 1999; Hardal, 2003), or multiple intelligence-based instruction (Furnham, Reeves, and Budhani, S., 2002; Aşcı, 2003; Chan, 2003; Lewicki, 2003; Nolen, 2003) are used. For instance, Pyle and Akins-Moffatt (1999) examined the effects of visually enhanced instructional environments on students' conceptual growth. The results showed that the use of visual enhancements was an effective extension strategy for hands-on learning. Christianson and Fisher (1999) compared the university students' learning about diffusion and osmosis in constructivist and traditional classrooms. They found that students understood diffusion and osmosis most deeply in the small discussion/laboratory course.

Aşcı (2003) investigated the effects of multiple intelligence-based instruction at on ecology achievement, attitudes towards ecology, and multiple intelligences. She found that multiple intelligence-based instruction was effective in increasing students' achievement in ecology and multiple intelligences.

However, it did not show a significant increase in students' attitudes towards ecology.

Furthermore, some researchers suggested using mixed methodologies in science teaching. McCormick, MacKinnon, and Jones (1999) recommended using lecture and lab combined format for the effectiveness and feasibility of teaching introductory biology. The results of this study may contribute to the development of a model for student-centered science instruction from elementary to graduate levels.

If teachers are familiar with constructivist ideas and those ideas fit in their value system, and constructivist ideas can be taught to students at school context (Duit, 1991). Based on the constructivist research's suggestion that no matter what is on the list of critical content, students will not learn unless teaching practices are designed to promote learning. Yager and Lutz (1994) pointed out the importance of appropriate teaching and giving more importance to how we teach than what we teach.

Duschl and Gitomer (1991) indicated that the constructivist instruction in science emphasizes knowledge formation including learning cycle, conceptual change teaching model, generative model, and using of analogies, etc.

There can be several constructivist formats to use in science classrooms. For example, Lord (1994) preferred to use the '5E' constructivist model that involved engage, explore, explain, elaborate, and evaluate phases in a lesson on cell division. He stated that cooperative group learning has a crucial role in constructivism. The teacher role has changed from 'presenter' to 'facilitator'.

Teacher plans the activities that challenge and promote the students work collaboratively. According to Lord (1994), the constructivist model encourages students to remain on task to be accountable for their learning, and to retain the information longer than they would in traditionally taught classes. He added that students enjoy their classes taught using constructivism more than lectures.

Constructivist teaching requires different approaches. A constructivist teacher will

- encourage and accept student autonomy, initiation, and leadership,
- allow student thinking to shift content and instructional strategy based on student responses,
- ask students to elaborate on their responses,
- allow wait time when asking questions,
- encourage students to interact with each other and with the teacher,
- ask thoughtful and open-ended questions,
- encourage students to reflect on experiences and predict future outcomes,
- ask students to articulate their theories about concepts before the teacher presents his/her understanding of the concepts,
- look for students' alternative conceptions and design lessons to address any misconceptions (Yager and Luts, 1994).

In order to help to overcome students' alternative ideas or difficulties in science and to provide meaningful learning in science, one of the most effective strategies is the conceptual change approach. This strategy originated from constructivist framework in general. Thus, the conceptual change approach is mainly used for removing students' misconceptions in science and increasing students' understanding of science.

Posner et al. (1982) developed a model of conceptual change and Hewson and Hewson (1983) elaborated it. Posner et al. (1982) presented four conditions for conceptual change: dissatisfaction, intelligibility, plausability, and fruitfulness. That is, students are dissatisfied with their own existing ideas first of all. Then, new conception should be intelligible. Students are presented new concepts and they are given some explanations (intelligibility). However, these new concepts should correspond to the knowledge in other areas (plausability). Finally, they should be fruitful. They should guide to new insights (fruitfulness). If students use their existing concepts to deal with new phenomena, it is the first phase of conceptual change and it is named as assimilation. However, if students' current concepts are inadequate to accomplish new conceptions, in that case students should replace or reorganize their existing ideas. That is they accommodate their ideas with the existing ones.

Hewson and Hewson (1983) used the conceptual change model to examine the effects of the students' prior knowledge and conceptual change strategies on science learning. In this work, pre- and post-tests relating the concepts of mass, volume and density were used to assess the conceptual change of students. They reported that the experimental group students showed significant improvement in the acquisition of scientific conceptions.

Hewson and Thorley (1989) indicated that a model of conceptual change includes two major components; the conditions and the person's conceptual ecology. In order to experience a person's conceptual change, the conditions should be satisfied. On the other hand, a person's conceptual ecology supplies the context as to arise conceptual change. They also stressed that change in the status of conceptions play a central role in the model of conceptual change. They stated that 'discrepant event' demonstrations or anomalies are mainly used in conceptual change teaching but teachers should pay attention to two other things, diagnose the conceptions and monitor the status of old and new conceptions that occur in students' mind.

Stofflett (1994) applied the conceptual change constructs to teacher education. The results revealed that the new strategies made teacher candidates dissatisfied with their pre-existing ideas. Teacher candidates expressed that new strategies were intelligible, plausible, and fruitful.

Eryılmaz (2002) investigated the effects of conceptual assignments and conceptual change discussions on students' misconceptions and achievement regarding force and motion. The treatment time period of the study was 8-weeks. The study involved 6 physics teachers and their 18 classes, consisting of 396 high school physics students. All students were administered the Force Misconception and Force Achievement Tests as pre-test and post-test. The results of the study indicated that the conceptual change discussion was an effective tool for reducing the number of misconceptions students held about force and motion. Additionally, the conceptual change discussion was found significantly effective in improving students' achievement in force and motion.

2.4 Instructional Tools for Conceptual Change

In the conceptual change based instruction, several instructional tools or strategies can be used frequently for eliminating misconceptions in science such as concept maps (Lehman et al., 1985; Wallace and Mintzes, 1990; Jegede et al., 1990; Okebukola, 1990), conceptual change texts (Sharon and Chambers, 1997), refutational texts (Hynd et al., 1994; Sönmez, 2002), story telling (Banister and Ryan, 2001), analogy (Stavy, 1991), word association tests and grid questions (Bahar et al., 2000), diagnostic trees (Bahar, 2003a), portfolio (Valdez, 2001), and cooperative learning strategy (Lonning, 1993; Lazarowitz et al., 1994), etc.

2.4.1 Concept Maps

A concept map may have several concepts related to each other. Concept map is an educational tool used for exploring prior knowledge and misconceptions, encouraging meaningful learning to improve students' achievement, and measure the understanding of the concept.

Concept maps can be used in four areas: as a learning strategy, as an instructional strategy, as a strategy for planning curriculum, and to students' understanding of science concepts (Novak, 1990). For example, concept maps were used as an assessment of student learning in science classrooms (Rice, Ryan and Samson, 1998; McClure, Sonak and Suen, 1999). Wallace and Mintzes

(1990) used the concept maps for exploring conceptual change in biology. Sungur et al. (2001) used the concept maps for recognizing and modifying students' misconceptions. Binzat (2000) also reported that the concept mapping contributed significantly to the better understanding of human excretory system. Moreover, using the concept mapping or other metacognitive tools in teacher education programs may be useful because;

1. these tools may help in-service teachers to have more meaningful practices and then their students may form a conceptual understanding of the subject.
2. teachers may become skillful by using metacognitive tools including computer-mediated tools. Then they can help their students learn how to use computers (Novak, 1990).

Songer and Mintzes (1994) explored understanding of cellular respiration for the first and last year biology students. They used concept maps and clinical interviews to examine the conceptual change of the students. Study was conducted before and after the instruction of cellular respiration for first year students. A wide range of conceptual difficulties were found in first year biology students, and similar difficulties were found in last year students too. Okebukola (1990) conducted a study attaining meaningful learning of concepts in genetics and ecology and used concept mapping with 138 pre-degree biology students. The experimental group who employed the concept mapping technique showed significantly better results than the control group.

2.4.2 Conceptual Change Texts

Conceptual change texts are also used to improve students' science achievement. Each conceptual change text starts with a question relating a science concept to students. After the first question, some common misconceptions regarding this question are presented to students at first. Then, students are introduced to scientifically correct explanations of the given concept in the text. After that, the first question is answered. The text continues with the second question. The aim of the conceptual change text is to make students realize the scientifically wrong statements and changing them with the scientifically correct ones.

Tianyu and Thomas (1991) investigated the effects of the conceptual change texts and the application questions in 139 college students' learning electricity concepts. According to the results of the study, the conceptual change texts and the application questions improved the acquisition of qualitative concepts of the students. Erdmann (2001) examined the effect of conceptual change text design on fifth grade learners' comprehension of photosynthesis. The study found that the children who studied the conceptual change text design performed statistically better than the traditional ones in eliminating common misconceptions about photosynthesis and improving understanding of photosynthesis.

Similarly, Sharon and Chambers (1997) explored relationships between gender, interest and experience in electricity, and the conceptual change text manipulations on learning basic direct current concepts. The conceptual change text provided a better conceptual understanding of electrical concepts than the traditional didactic text. This finding supports the hypothesis that prior interest level, experience, and knowledge mediate apparent gender differences in learning about electricity. This suggests that the conceptual change text manipulations are likely to be effective in both males and females.

Çakır et al. (2001) examined the effectiveness of the conceptual change text oriented instruction on the students' understanding of cellular respiration concepts. The study consisted of 84 eleventh grade students from the four classes of a high school. Two of the classes were randomly assigned as the control group and they were instructed by the traditional instruction. The other two classes were randomly assigned as the experimental group and they were taught using the conceptual change text oriented instruction. The results of the study indicated that students exposed to the conceptual change text oriented instruction had better understanding of cellular respiration concepts than those exposed to the traditional instruction. However, the students in the experimental and the control groups showed similar attitude towards biology.

Özkan (2001) conducted a research on remediation of the seventh grade students' misconceptions related to ecological concepts and students' environmental attitudes through the conceptual change approach. In the study, conceptual change texts were used. This study indicated that the experimental group achieved significantly better than the control group. Furthermore, no significant difference was found between the experimental and the control groups related to their attitudes towards environment. The misconceptions were identified through an Test of Ecological Concept related to the concepts of the environment, ecosystem, decomposer, population, energy resources in ecosystems, food chain, and food web.

2.4.3 Refutational Texts

Refutational texts are also conceptual change oriented instructional tools and used to improve students' science achievement. Basically, refutational texts have same logic with conceptual change texts. Refutational texts also include one or more questions. Each text starts with a question and then some common misconceptions are refuted in the text immediately. Students are expected to be confused with those refutations at first. Later, some scientifically correct explanations are given to the students. Finally, the question asked in the beginning of the text is responded. Text continues with the second question, if there is one. The aim of refutational texts is to make students refute the misconceptions and change them with the scientifically correct ones.

Hynd et al. (1994) examined the role of instructional variables (a variety of demonstrations and discussions) in conceptual change in high school physics (Newton's laws of motion). In this study, the refutational texts were used and they contained Newton's ideas regarding motion and unrelated ideas about atoms. Treatment involved pre-test, instruction and post-test. According to the study outcomes, it was confirmed that the refutational texts were effective for instruction.

Similarly, Sönmez (2002) found that the instruction of refutational texts supported with discussion webs about electric current was more successful for eliminating misconceptions and improving the students' understanding than the traditional methods.

2.4.4 Other Instructional Tools for Conceptual Change Approach

To support conceptual change texts oriented instruction with other tool(s) may bring more successful results to the study. Some researchers used a mixed conceptual change methodology in their studies. For instance, Çakır et al. (2002) compared the effectiveness of the concept mapping based instruction, conceptual change texts oriented instruction, and conventional methods based instruction on tenth grade students' understanding of acid and base concepts. This study involved 110 students from six classes of a chemistry course taught using the same teacher and these classes were assigned as four experimental group classes and two control group classes. While two experimental group classes were instructed with the concept mapping instruction, the other two experimental group classes were taught using the conceptual change text instruction. The other two classes were assigned as control group and they were instructed with the traditional instruction. All students were administered the Acids and Bases Concept Pre-test and Post-test. According to the results of this study, both the concept mapping based instruction and conceptual change texts oriented instruction caused a significantly better acquisition of scientific conceptions related to acid and base concepts than the conventional methods based instruction.

In addition, the study showed that gender difference had no effect on the understanding of acid and base concepts.

Similarly, Sungur et al. (2001) explored the contribution of the conceptual change text accompanied by concept mapping instruction to the tenth grade students' understanding of the human circulatory system. While 26 students in the experimental group were taught using the conceptual change texts accompanied by concept mapping, 23 students in the control group were taught using the traditional instruction. Besides treatment, other independent variables of the study were their previous learning in biology and science process skills. For statistical analysis, Multiple Regression Correlation analysis was used. It showed that the treatment, science process skill, and previous learning in biology each made a statistically significant contribution to the variation in the students' understanding of the human circulatory system. Additionally, it was found that the conceptual change texts accompanied by concept mapping instruction produced a positive effect on students' understanding of concepts. The mean scores of the experimental group performed better than the control group with respect to the human circulatory system. In this study, 59.8 % of the experimental group and 51.6 % of the control group performed well after the treatment.

Another strategy for conceptual change in science is story telling. Banister and Ryan (2001) proposed story telling as an exciting way to develop student's science ideas and to use their emotions, feelings and attitudes to make their science learning more memorable. They studied development of science concepts of water cycle through story telling in a primary classroom (aged 9-10). The study showed that students' ideas changed and they developed more scientifically correct ideas.

Valdez (2001) suggested that portfolio project can be used as an alternative assessment tool because it has improved student performance. During portfolio project, students are encouraged to foster their creativity and to further their understanding about science concepts through additional reading and writing.

Additionally, analogy can be used to change students' misconceptions about science concepts, (Stavy, 1991; Glynn and Takahashi, 1998). Stavy (1991) used analogy to overcome misconceptions about conservation of matter. The study gave positive outcomes in respect to analogy. Similarly, Glynn and Takahashi (1998) used the analogy-enhanced science text at sixth and eighth grades. The study indicated that analogy played as mediator between the students' existing ideas and the new knowledge in the analogy-enhanced text. As a result, the target concept of animal cell was more understandable and memorable by the analogy of a factory.

In order to overcome misconceptions about ecology, project or fieldwork can be used to make change in students' ideas. Manzanal, Barreiro, and Jiménez (1999) investigated the relationship between ecology fieldwork and Spanish secondary school students' attitudes (aged 14-16) towards environmental protection. According to the explanatory study and the experimental study results, fieldwork contributed to the students' understanding of ecological concepts and to their positive attitudes towards the protection of the ecosystem.

Niaz (2002) constructed a teaching strategy that could facilitate conceptual change in freshman students' understanding of electrochemistry. The study was intended to provide students with the correct response along with alternative responses (teaching experiments) creating a conflicting situation. According to the results of the study, there was a statistically significant difference in the performance of electrochemistry between the experimental and control groups. The teaching experiments facilitated students' understanding of electrochemistry.

Han (2002) used deductive reasoning to promote the change of students' conceptions about force and motion. Students participated in the study almost found the direction of force correctly by using deduction. The results showed that deductive reasoning was utilized by making scientific explanations and predictions to help middle school students change their prior conceptions about force and motion.

2.4.5 Demonstrations

Demonstrations illustrate and reveal a science process or a principle. Not only is demonstration a strategy used as a teacher performing an experiment to the students, but also it may be used as a teacher showing something under microscope, demonstrating a model, poster, film, slides, plants, and animals, etc. to the students. Thus, demonstrations can be interest arousing, entertaining, motivating, and they can cause one to wonder about the science concepts being presented.

Teachers may mostly prefer to perform demonstrations instead of laboratory work, in particular in big classes in conditions when laboratory equipments are insufficient. It may save time, money, materials and efforts. Sometimes a student or a group of students may perform demonstrations in a class. In that case, the teacher should guide the demonstration process.

Demonstrations can be used as teaching and learning aids in science education. They can be used for several purposes such as to start or support the teaching of practical science concepts, to help communicate ideas in science, or as a means of measuring student learning by instructors. For example, they can be used in demonstration-based assessment activities to enhance students' conceptual understanding of chemistry (Bowen and Phelps, 1997).

2.4.6 Small Group Work

Cooperative learning is a structured, systematic instructional strategy. In cooperative learning, students work together towards a general goal in a small group. The best known types of cooperative learning, from the more teacher-centered to more student-centered approaches, are student teams achievement division, jigsaw, constructive controversy (structured debate), and group investigation (Cooper, Robinson, and McKinney, 1994). Small group instruction may involve several instructional strategies such as demonstrations, worksheets, and small group discussions.

Many researchers have conducted a research on the effectiveness and efficiency of cooperative learning on groups of students. Cooperative learning is a teaching strategy where students work together in small teams and use a number of activities to achieve academic objectives and improve their understanding of subject matters.

Cooperative learning strategy may help conceptual change oriented instruction. Cooperative learning is an effective learning method and it can bring more science achievement. Previous studies give some evidences that cooperative learning is an effective learning strategy (Watson, 1991; Basili and Sanford, 1991; Lonning, 1993; Lazarowitz et al., 1994, Jensen and Finley, 1995; Weaver, 1998; Jofili, Geraldo, and Watts, 1999; Bahar, 2003b). For instance, Weaver (1998) found that the students favored laboratory or hands-on activities and this type of activities could promote conceptual change when combined with discussion and reflection.

Small group discussion sessions can be used in large size classes to complement the lecture. It can also be used in small size classes as a mixed strategy of the lecture and discussion format. Discussions can be guided by the teacher (teacher-centred) or by the students (student-centred). In any case, discussions are more dynamic if students are provided with prerequisites.

Alexopoulou and Driver (1996) studied a small-group discussion in physics focusing on peer interaction modes in pairs and in fours. Their study revealed that the students progressed significantly more in their physics reasoning in four people group than the pairs.

Schmidt, De Volder, De Grave, Moust, and Patel (1989) assessed the effects of prior knowledge activation through small-group discussion. Subjects were asked to elaborate on possible explanations of natural phenomena about blood cell and osmosis. The results of the study suggested that such activation of prior knowledge could be a successful instructional strategy.

Basili and Sanford (1991) examined the effectiveness of the conceptual change based instruction in small cooperative groups over traditionally designed instruction on the concepts of the laws of conservation of matter and energy and aspects of the particle nature of gases, liquids, and solids. The study provided that cooperative groups had more success in overcoming misconceptions in chemistry than the control group. Lonning (1993) investigated the effects of conceptual change instructional model with cooperative learning on students' verbal interaction patterns and achievement in tenth grade general science. These conceptual change instructional models on particle model of solids, liquids, and gases include; orientation, elicitation, restructuring, modification and extension, and application. The study demonstrated that cooperative learning strategy helped conceptual change instruction.

The results of the study that Jensen and Finley (1995) did, demonstrated that using historical materials in combination with a conceptual change strategy in small group setting was promising to teach Darwinian evolution to students enrolled in Principles of Biology. This study was conducted in only experimental groups. Treatment involved lecture and small group activities. According to the findings of the study after the treatment, there was an overall increase in students' ability to answer questions about evolution in Darwinian terms. Wood-Robinson et al. (2000) used small group discussions on cellular genetics. The discussion task was on the chromosomes in different cells in the body of an organism. The results revealed that while 11/35 students had the correct number of chromosomes in each cell of the series in overall, only six students of thirty-five students differentiated the correct number and color relating cellular genetics.

Nussbaum (2002) examined introverts versus extroverts approach in small group argumentative discussions. The results showed that the more extrovert students made significantly more contradictions during small group discussions with other extroverts, while the more introvert students worked with one another collaboratively to develop creative solutions.

Additionally, Bahar (2003b) investigated the effects of the traditionally designed instruction and the discussion-based group technique on the students' achievement. He also examined the relationship between the instructional techniques and the cognitive styles of the students. In the control group, proteins were instructed by the teacher-based lecture. However, students in the experimental group were randomly grouped as five firstly. Then, one of the students became a chairman and other four students in each group were given four different information sheets about proteins. Students then responded individually to the questions about their topics on the information sheet, and the group members shared their ideas with each other. Finally, all students were given general questions about proteins to discuss altogether. He determined that the students who took the discussion-based group technique showed higher performance than the students in the control group. Furthermore, the study proved that the traditionally designed instruction was more successful for the field independent students than the field dependent students, whereas the discussion-based group technique was successful in both group of the students.

Small group work can also be used with conceptual change approach. Gedik (2001) investigated the effectiveness of the demonstration method based on conceptual change approach on the students' understanding of electrochemistry concept and attitudes towards chemistry at 11^{th} level. Students' science process skill was measured by the Science Process Skills Test at the beginning of the study. According to t-test and ANCOVA, the students who used the demonstration method based on conceptual change approach had significantly higher electrochemistry scores and higher positive attitudes towards chemistry than the students who were taught using the traditionally designed chemistry instruction. Students' science process skills were found to be a strong predictor for the students' electrochemistry achievement.

Gayford (1993) found that the discussion-based group work carried out with 15-year-old science students in England about the environmental issues was an effective method of providing students with the opportunity to develop learning skills and improving motivation.

2.5 Science Achievement, Attitude towards Science, and Attitude towards Environment

As explained above, there are several conceptual change instructional tools used for eliminating misconceptions of science concepts and increasing students' science achievement, especially in ecology. However, like students' alternative ideas or misconceptions, attitude can be another factor affecting students' science achievement.

Many researchers focused on the relationships among instruction, achievement, and attitude in their studies and they supported the idea that there exists a positive relationship among instruction, achievement, and attitude (Duit, 1991; Greenfield, 1996; George, 2000; Papanastasiou and Zembylas, 2002; Kesamang and Taiwo, 2002; Dahindsa, Chung, and Bolkiah, 2003). Greenfield (1996) indicated that the students in grades 3-12 in the USA showed the most positive attitudes towards science and the most positive perceptions of their own science ability and achievement.

George (2000) investigated the change in the students' attitudes towards science over the middle and high school years using data from the Longitudinal Study of American Youth. The results of the study showed that students' attitudes towards science generally decreased over the middle and high school years. While teacher encouragement of science and peer attitudes are also significant predictors of students' attitudes, the effects of the parents were found to be quite small and statistically non-significant, with the exception of the seventh grade in the study.

Jaus (1982) examined the effect of the environmental education instruction on the students' attitudes towards environment. The experimental group exhibited more favorable attitudes towards environment in the study than the control group.

Ignatiuk (1978) examined whether a relationship existed among eleventh grade biology students' attitudes towards science, their experiences of field trip activities, and environmental concepts or not. She observed such a relationship and found statistically significant differences in the students' attitudes after the varying amounts of fieldwork during the 15-week study period. Similarly, Fernández Manzanal et al. (1999) found a relationship between the ecology fieldwork and the students' (aged 14-16) attitudes towards environmental protection. The results showed that the fieldwork helped to clarify ecological concepts and mediate directly in the development of more favorable attitudes towards the defense of the ecosystem.

However, there were some studies that did not support the positive relationships among instruction, achievement, and attitude. The study of Papanastasiou and Zembylas (2002) showed that science achievement and science attitudes could have differential effects on each other depending on the characteristics of the educational systems of the country.

Kesamang and Taiwo (2002) found that among Botswana junior secondary school students there were significant negative relationships between their attitudes towards science and their science achievement, although they were found to be positively willing towards school science in general. Berberoğlu, et al. (2003) examined the factors affecting achievement level of Turkish students in the third international mathematics and science study (TIMSS). In this study, perception of success and socio-economic status were determined as predicting factors in achievement in mathematics and science. The study showed that as classroom activities increased such as project works, classroom discussions, and group work, students' achievement decreased.

2.6 Science Achievement, Gender Differences, and Attitude towards Science and Environment

There is an interest and debate on whether students' gender differences have significant influence on their science achievement. The study of Pearsall et al. (1997) proved that gender was effective on their science achievement. They explored the introductory, college-level biology students' successive and progressive changes regarding the structural complexity of knowledge. They also studied how the students' primary learning and gender affected those changes. In this study, students prepared their concept maps in 4-weeks throughout the term and these maps were evaluated by researchers for structural complexity and changes based on the literature. They found significant relationships among knowledge restructuring, predominant learning, and gender of students. The study showed that the females were more successful than the males. However, Zhang (1999) demonstrated that males had more confidence and positive attitude towards mathematics and science than their female peers.

Jones, Howe, and Rua (2000) conducted a survey study on 437sixth grade students' gender differences concerning students' experiences, interests, and attitudes toward science and scientists. According to the results of the study, there was a significant gender difference as regards science experiences, attitudes, perceptions of science courses, and careers. It was also reported that female students found science more difficult subject than males, while more males reported that science was destructive and dangerous, as well as more suitable for boys than girls.

Gentry, Gable, and Rizza (2002) investigated whether differences existed between the perceptions of class activities for students in grade 3-8 and genders. The study showed that the middle school students found their classroom activities less frequently interesting and enjoyable than the elementary school students. The important result of the study was that girls were significantly more interested in class activities than the boys.

Dahindsa, Chung, and Bolkiah (2003) showed that there were significant differences in male and female students' science achievement and attitudes towards science in single-sex schools and coeducational schools. The girls achieved moderately better in science than the boys despite the fact that girls' attitudes were only marginally better than the boys in single-sex schools, although there were no gender differences in students' science achievement and attitudes towards science in coeducational schools.

Pell and Jarvis (2001) demonstrated that both boys' and girls' (from 5-11 years) enthusiasm for science declines progressively with age alongside a similar decline in their perception that science was difficult. Similarly, Norman, R. (2003) studied the attitudes and perceptions of Scottish girls and boys towards physics over the age range of 10-18 years old. The results revealed that students' attitudes towards science are very positive at the end of primary school. However, those positive attitudes have declined quite markedly, and there was a significant decline of girls' attitudes towards science when compared to boys' attitudes towards science by the end of the second year of secondary school. The positive attitudes of boys and girls towards the Standard Grade Physics Course were observed again in ages 14-16. This increase of students' positive attitudes towards physics was in favor of girls. Although over 90 per cent of the observed fourth year pupils wanted to continue their studies in physics, a noticeable decline in attitude towards the Higher Grade course, especially for boys was observed.

On the contrary, Çakır et al. (2002) emphasized that gender difference was not effective in students' achievement in chemistry concepts. Similarly, Sungur and Tekkaya (2003) made a research to see whether students' gender and reasoning abilities have effects on their achievement in human circulatory system concepts and students' attitudes towards biology. The results of the study showed that there was not a statistically significant mean difference between the boys and girls regarding students' achievement in human circulatory system concepts and attitudes towards biology. Tinklin (2003) found that there was no relationship between their social status and school achievement of boys and girls (aged16 and 18). She demonstrated that cultural factors affected boys and girls equally in all schools.

Worsley and Skrzypiec (1998) studied the environmental attitudes of senior secondary school students in South Australia. In their study, the Questionnaire of Environmental Beliefs was applied to 958 senior secondary students, from a stratified sample across 32 country and metropolitan schools, aged 15-18 years. The results of the study were interpreted according to students' regions, gender, and socioeconomic status. In general, students from both rural and urban regions were quite concerned but they were pessimistic about environmental issues. Girls were less optimistic and less supportive in finding solutions to environmental problems than the boys. Students who have lower socioeconomic status tend to be a more supportive to environmental development and science solutions than other students.

2.7 Science Achievement and Logical Thinking Ability

Students' logical thinking ability can also be an affecting factor in science achievement. The Test of Logical Thinking (TOLT) can be used to determine and control students' logical thinking abilities on the students' science achievement and science attitude at the beginning of the treatment (Çakır, 2002; Sönmez, 2002). Sönmez (2002) carried out a research based on explorations of the refutational text supported with discussion webs in overcoming difficulties with electric current concepts of sixth grade students in her study. She reported that the refutational texts increased the students' understanding of electric current. She also indicated that the students' logical thinking abilities contributed to students' science achievement.

CHAPTER 3

PROBLEMS AND HYPOTHESES

3.1 The Main Problem and Sub-problems

3.1.1 The Main Problem

The main problem of this study:

What are the effects of conceptual change texts oriented instruction accompanied by demonstrations within small groups and gender on ninth grade students' achievement and levels of understanding of ecology, attitudes towards biology, and attitudes towards environment?

3.1.2 The Sub-problems

In this study the following 13 sub-problems have been stated:

1. Is there any significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts

pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

2. Is there any significant effect of gender (males and females) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

3. Is there any significant effect of the interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

4. Is there any significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking

scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

5. Is there any significant effect of gender (males and females) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

6. Is there any significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

7. Is there any significant effect of gender (males and females) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

8. Is there any significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the environmental attitude post-test scores when the effects of students'

average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

9. Is there any significant effect of gender (males and females) on the population means of the environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

10. Is there any significant effect of the interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

11. Is there any significant effect of interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?

12. Is there any significant effect of interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled?
13. What types of responses emerged from students' alternative ideas that reflect the students' levels of understanding of ecological concepts before and after the treatment?

3.2 Hypotheses

The following 12 hypotheses have been stated above to test first 12 sub-problems. All hypotheses were written as null hypotheses.

3.2.1 Null Hypothesis 1

There is no significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.2 Null Hypothesis 2

There is no significant effect of gender (males and females) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.3 Null Hypothesis 3

There is no significant effect of the interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.4 Null Hypothesis 4

There is no significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.5 Null Hypothesis 5

There is no significant effect of gender (males and females) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.6 Null Hypothesis 6

There is no significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.7 Null Hypothesis 7

There is no significant effect of gender (males and females) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.8 Null Hypothesis 8

There is no significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.9 Null Hypothesis 9

There is no significant effect of gender (males and females) on the population means of the environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.10 Null Hypothesis 10

There is no significant effect of the interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.11 Null Hypothesis 11

There is no significant effect of the interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

3.2.12 Null Hypothesis 12

There is no significant effect of the interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores are controlled.

CHAPTER 4

METHODS

This chapter presents the following parts: population and sample, description of variables, development of measuring tools, conceptual change texts, treatment, methods for data analyses, power analysis, assumptions of the study, and limitations of the study.

4.1 Population and Sample

The target population of the study is all ninth grade high school students enrolled in a biology course in Turkey. The accessible population contains all ninth grade students at one public high school in Balıkesir, Turkey. The results of the study would be generalized to the accessible population and the target population.

This study was a quasi-experimental study. The sample was chosen from the classes at the public high school by a convenience sampling. The subjects of this study included 82 ninth grade students from four classes of two teachers in the Spring Semester of 2001-2002. There were 26 female students and 56 male students. Students' ages ranged from 15 to 16. Each teacher had two classes: one experimental class and one control class. Two teaching methods were randomly assigned to one class of each teacher. The experimental group was taught using conceptual change text oriented instruction accompanied by demonstrations within small group work while the control group was taught using traditional methods. There were 37 students in the control group and 45 students in the experimental group. Both teachers allowed the researcher to observe the experimental and the control groups during the treatment.

Prior to the treatment, pilot Test of Ecological Concepts and pilot interviews were conducted. The sample of the TEC was chosen according to stratified and convenience sampling. The pilot TEC was administered to 165 ninth grade students from eight high schools in the Spring Semester of 2000-2001.

After the pilot test, convenience sampling was used to conduct the pilot interviews with the teachers and the students. In order to maximize the variability of the data, three students were selected from eight high schools according to students' average grades of two biology midterm exams; one from high achievers, one from medium achievers, and low achievers) and pilot TEC achievement. While five teachers who instructed the ecology unit at five high schools were interviewed, 24 students were interviewed from eight high schools.

4.2 Variables

This current study included ten variables. Three of them were dependent variables (DVs) and seven of them were independent variables (Ivs). The three independent variables were determined as covariates. Characteristics of the variables have been shown in Table 4.1.

Table 4.1. Characteristics of the Variables

TYPE OF VARIABLE	NAME	TYPE OF VALUE	TYPE OF SCALE
DV	post-TEC	Continuous	Interval
DV	post-ASB	Continuous	Interval
DV	post-ASE	Continuous	Interval
IV	pre-TEC	Continuous	Interval
IV	pre-ASB	Continuous	Interval
IV	pre-ASE	Continuous	Interval
IV	SAB	Continuous	Interval
IV	TOLT	Continuous	Interval
IV	TRE	Discrete	Nominal
IV	Gender	Discrete	Nominal

4.2.1 Dependent Variables

In this study, three variables were dependent variables: students' ecological concepts post-test scores (post-TEC), students' biology attitude post-test scores (post-ASB), and students' environmental attitude post-test scores (post-ASE). Post-TEC and post-ASB were measured by the Test of Ecological Concepts (TEC) and the Attitude Scale towards Biology (ASB), respectively. Post-ASE was also measured by the Attitude Scale towards Environment (ASE).

Students' scores on those test ranged as follows: possible range was 0-51; for post-TEC; 0-75 for post-ASB, and 0-110 for post-ASE, respectively.

4.2.2 Independent Variables

In this study, there were seven independent variables: students' ecological concepts pre-test scores (pre-TEC), students' biology attitude pre-test scores (pre-ASB), students' environmental attitude pre-test scores (pre-ASE), students' test of logical thinking scores (TOLT), students' average grades of two biology midterm exams (SAB), treatment (conceptual change approach oriented instruction over traditional approach based instruction), and gender. pre-TEC, pre-ASB, pre-ASE, TOLT, and SAB were considered as continuous variables and they were measured on interval scale. Students' SAB scores were coded as 0-5. Treatment and gender were considered as discrete variables and these were measured on nominal scale. Treatment was named as 0 for the control group and 1 for the experimental group. Students' gender was coded as 1 for female and 2 for male students.

4.3 Measuring Tools

Data was collected by six means. These were the Test of Ecological Concepts (TEC), the Attitude Scale towards Biology (ATB), the Attitude Scale towards Environment (ATE), and the Test of Logical Thinking (TOLT). While group interviews were conducted with the students in the experimental group, semi-structured interviews were conducted with the teachers. Non-systematic classroom observations carried out in the experimental and the control groups by the researcher.

4.3.1 The Classroom Observations

The researcher observed the treatment process in the experimental and the control groups and took notes as much as possible. The main purpose of the observation was to determine how the conceptual change text based instruction and traditional instruction in four groups were presented. The second purpose was to determine the interactions between the teacher and students in four classes. The teaching and learning environment was observed during the lessons with a naturalistic approach (non-systematic approach).

4.3.2 The Interview Scales

4.3.2.1 Pilot Interviews

In this study, pilot semi-structured interview technique was used to gather information about the ninth grade students' and biology teachers' ideas as well as misconceptions about the ecological concepts. After administering the pilot test to students, pilot interview scales for the teachers and the students were developed and implemented.

The pilot teacher interview sessions were performed with five teachers at five high schools in Balıkesir in the Spring Semester of 1999-2000. Three types of teacher interview schedules were used. In the first type, the main aim was to obtain teachers' opinions about the biology course and their students' opinions about biology course in general, particularly the ecology lessons. In the second type, teachers' opinions about their students' commonly held misconceptions of ecological concepts determined from the pilot test were asked. In the third type, teachers were asked about their own teaching styles in the ecology lessons.

Three students from eight high schools (total 24) in Balıkesir in the Spring Semester of 1999-2000 were selected for the pilot interviews. These three students were chosen according to the students' average grades of two biology midterm exams; one from high achievers, one from medium achievers, and low achievers). Two types of student interview schedules were used. In the first, the main aim was to get students' ideas about biology courses in general and ecology lessons in particular. In the second, the main aim was to get students' opinions about commonly held misconceptions related to ecological concepts obtained from the results' of the pilot TEC. During the pilot interview sessions, notes were taken and a tape recorder was used as much as possible.

4.3.2.2 Core Interviews

After the treatment and administering the post-tests to the all students participated in this study, two teachers and many students in the experimental group were interviewed. Semi-structured interview technique for teacher interviews was used to get some more evidences regarding the treatment. Two teachers responded with their opinions about the students' common misconceptions and effectiveness of the conceptual change text oriented instruction in their classes. The researcher developed semi-structured interview questions for the teachers. Follow-up questions naturally emerged during the interview, with the participants. Each interview session took nearly one hour. Notes were taken and a tape recorder was used.

A group interviewing technique was used with the students in the experimental group in two classes. These group interviews were interactive and were not in a structured form. The researcher conducted group interviews with students by posing appropriate questions to keep the focus. The focus was to get the students' opinion about the effectiveness of the conceptual change text oriented instruction in their classes. Each interview session took nearly 45 minutes and notes were taken.

4.3.3 The Test of Ecological Concepts

4.3.3.1 Pilot Test of Ecological Concepts

In this study, pilot Test of Ecological Concepts (Appendix B) developed by the researcher was used. The aim of the pilot TEC was to identify misconceptions and students' levels of understanding of ecology, and to measure students' ecology achievement before and after the treatment. The content of ecology unit covered biotic and abiotic factors of environment, producer, consumer and decomposer relationships in matter and energy flow, symbiotic relationships, food chain and food web, cycles of materials, population, community, ecosystem, environmental pollution, environmental conservation, and erosion.

During the development of the pilot TEC, the researcher examined the ninth grade biology curriculum proposed by the Turkish Ministry of Education and its instructional objectives related to ecology unit at first (See Appendix A). To make a list of ecological concepts, the ninth grade biology curriculum and the ninth grade biology textbook approved by the Turkish Ministry of Education (Börü et al., 2000) were also examined. The questions in the TEC developed by Çetin (1998) at eighth grade were revised and some questions were added during the development of the questions in the TEC. Other sources used to write the questions were: varieties of secondary science textbooks, ninth grade biology textbooks, university ecology textbooks, questions asked in the University Entrance Exam and related literature about ecology. Initially, the TEC had 25 questions. The TEC was piloted to 165 ninth grade students at eight high schools in Balıkesir in the Spring Semester of 1999-2000.

4.3.3.2 Core Test of Ecological Concepts

After the piloting of the TEC, the format and items in the test were examined by the science teachers and a group of experts in science education to check whether the items were appropriate for the purpose of the study. Then, the TEC was administered as pre-test and post-test to the ninth grade students in the experimental and the control groups in this study.

The TEC consisted of ten multiple-choice questions requiring explanations and seven open-ended questions. The final version of the TEC was provided in Appendix B. Multiple-choice questions were scored between 0 and 3. If the student responded to the multiple-choice part correctly and provided an explanation with sound understanding, then the score “3” was given to the student for that item. If the student responded the multiple-choice part correctly and provided an explanation with partial understanding, then the score “2” was given. When the student made a correct choice in the multiple-choice part and provided no explanation for that item, the score “1” was coded. The score “1” was also used if the student made a correct choice in the first part and provided an explanation that showed partial understanding which includes misunderstanding.

If the student responded to the multiple-choice part correctly and provided an explanation with misunderstanding, then the score "0" was given. When the student responded to the multiple-choice part wrongly, the score "0" was given without accounting for the response provided in the second part. If the student gave no response to both parts for the item asked, then the score "0" was used.

Open-ended questions were coded between 0 and 3. If the students gave full explanations with sound understanding for the open-ended questions, the score "3" was used. If the student responded the open-ended questions with partial understanding, then the score "2" was given. The score "1" was used if the student provided an explanation that showed partial understanding which includes misunderstanding. If the student provided an explanation with misunderstanding, then the score "0" was given. If the student gave no response to open-ended questions, the score "0" was also used.

As a result, students' TEC scores ranged from 0 to 51. Time duration of the TEC was approximately one hour. The internal reliabilities were calculated as .51 for the pre-TEC and .69 for the post-TEC.

4.3.4 The Attitude Scale towards Biology

In this study, the Attitude Scale towards Biology (ASB) was used to determine students' attitude towards biology (Appendix C). Geban et al. (1994) developed the Attitude Scale towards Science. It was adapted to biology by Binzat and its reliability was found as .93 (Binzat, 2000).

The ASB has 15 items with a 5-point likert type scale: strongly agree, agree, neutral, disagree, and strongly disagree. It covered both positive and negative statements. When scoring the negative statements, they were translated to the scores of positive statements. Total possible ASB scores could range from 15-75. While higher scores showed positive attitudes towards biology, lower scores showed negative attitudes towards biology. The ASB took approximately 10-15 minutes to complete for students. The ASB was administered as pre-test and post-test to all subjects in this study. In this current study, reliability was found as .91 for the pre-ASB and .90 for post-ASB.

4.3.5 The Attitude Scale towards Environment

In this study, the Attitude Scale towards Environment (ASE) was used to determine students' attitude towards environment (Appendix D). The ASE was developed by Özkan and its reliability was found as .79 (Özkan, 2001).

The ASE has 22 items with a 5-point likert type scale: strongly agree, agree, neutral, disagree, and strongly disagree. It included both positive and negative statements. When scoring negative statements, they were translated to scores of positive statements. The ASE was scored from 5 to 1. Total possible ASE scores could range from 22-110, with higher scores showing positive attitudes towards environment, and lower scores showing negative attitudes towards environment. For the students spent approximately 10-15 minutes to complete the ASE. The ASE time completion by students was approximately 10-15 minutes. It was administered as pre-test and post-test to all subjects in this study. The internal reliabilities were calculated as .80 for the pre-ASE and .83 for the post-ASE.

4.3.6 The Test of Logical Thinking

The Test of Logical Thinking (TOLT) was developed by Tobin and Capie (1981). This test was translated and adapted into Turkish by Geban, Aşkar, and Özkan (1992). The TOLT was administered to all students to determine and control their reasoning abilities before the treatment. The TOLT contains 10 items with 5 sub-scales: identifying and controlling variables, proportional, correlational, probabilistic, and combinational reasoning (See Appendix E). Its reliability was found as .81.

4.4 Conceptual Change Texts

While the CCTI was used in the experimental group, the TI was used in the control group. The conceptual change texts and worksheets were used in the CCTI. Moreover, some demonstrations were performed by the teacher and teacher-guided discussions were conducted.

The main aim of designing conceptual change texts prepared by the researcher was to help students to overcome their misconceptions about ecological concepts, to gain experience in grasping the ecological concepts, and improve students' understanding of ecology at ninth grade. Four conceptual change texts were designed on living organisms and their environment, nutrient cycles, and environment pollution (Appendix G). Some worksheets related to the conceptual change texts were also designed as supporting instructional materials to the conceptual change texts. In the development of the conceptual change texts, Posner's (1982) four conditions for a conceptual change to occur were taken into consideration: intelligibility, plausibility, fruitfulness, and dissatisfaction. A sequence of each conceptual change text prepared for this study as follows:

Each conceptual change text started with a question firstly. Then, it continued with some misconceptions about the current ecological concepts. It was expected that students were dissatisfied with their existing conceptions by giving some misconceptions on specific ecology concepts. Later, it went on by directing students to start the discussion. Finally, some scientific explanations and corrections of the misconceptions were presented in the conceptual change text.

In discussion sessions, some worksheets were administered to the students separately from the conceptual change texts and the teacher made demonstrations with specific phenomenon teacher such as; showing some posters, some dead plant and animals, some models and watching slide projector, and so on. After performing some demonstrations, students were asked to discussed the questions in the worksheets among small groups. These questions were related to the demonstrations. Questions in the worksheets and information in the conceptual change text were discussed among small group work. Finally, the teacher performed a whole class discussion after small group work.

In short, it was expected that the CCTI would activate students' misconceptions by presenting examples and questions, present descriptive evidence in text about these misconceptions were incorrect, and provide a scientifically correct explanation of the situation. Thus, the students would accept the new concepts instead of the old ones.

4.5 Treatment

In this study, the high school was chosen according to convenience sampling. This study used a quasi-experimental design since there was no possibility of assigning the students to classes randomly. A total of 88 students from four biology classes were involved in the study. Class size was 20-25 for each class. In this study, there were two teachers and four classes. Two classes were called the control group and other two classes were called the experimental group. The research design of the current study is presented in Table 4.2.

Table 4.2. Research Design of the Study

Group	Before Treatment	Treatment	After Treatment
EG	TEC, ASB, ASE, TOLT	CCTI	TEC, ASB, ASE
CG	TEC, ASB, ASE, TOLT	TI	TEC, ASB, ASE

In Table 4.2, while CG represents the control group, EG represents the experimental group. Traditional instruction (TI) was given to the control group, and conceptual change text oriented instruction accompanied by demonstrations among small groups (CCTI) was given to the experimental group. While the control group took TI that involved direct lecturing and questioning, the experimental group took conceptual change text oriented instruction accompanied by demonstrations among small groups. The CG used a textbook, the EG used conceptual change texts including worksheets.

TEC is the Test of Ecological Concepts, ASB is the Attitude Scale towards Biology, ASE is the Attitude Scale towards Environment, and TOLT abbreviates the Test of Logical Thinking. To investigate the effect of the treatment on students' understanding levels of ecology, attitudes towards biology and attitudes towards environment, the TEC, ASB, and ASE were administered to all subjects as pre- and post-tests. Moreover, the TOLT was given to all subjects only before the treatment.

Treatment duration was five weeks. Each classroom instruction was two 45-minute sessions per week. Before the treatment, the teachers were informed what the conceptual change text was and how the conceptual change text oriented instruction accompanied by demonstrations could be used among small groups. While the control group took ecology lessons in their class, the experimental group took ecology lessons in the biology laboratory. Before the first ecology lesson, the sitting plan of the student groups in the laboratory was arranged by one of the teachers and the researcher. In the beginning of the treatment, students were divided into four or five groups according to their average mean of biology two middle exams and the class teachers' opinions. Thus, students would work together in small groups and they would discuss the topics given in the worksheets.

At the beginning of the treatment all students in four classes were given the pre-TEC, pre-ASB, pre-ASE, and TOLT as pre-tests. Then, the treatment started. The experimental group was administered the conceptual change texts including worksheets. Three conceptual change texts were designed: living organisms and their environment, nutrient cycles, and environmental pollution. The first conceptual change text was distributed to the experimental group 2-3 days before of the treatment. Later, the students in the experimental group were informed about the new instruction, the nature of the conceptual change texts and the small group discussions, what was expected from them during the courses, how they could use the conceptual change texts, and the worksheets for discussing the ecology topics. Students were asked to read the text before the class hour and bring them to the class. It was crucial because they could see what the common misconceptions were, and to think whether they had any misconception or not, and to see the correct scientific explanations about the ecological concepts. Thus, it was assumed that they could be more active in the small group discussions.

Worksheets were given to the students in the discussion period, and students were expected to write the discussion results on the worksheets. Discussions could provide interaction among students; and teacher and students.

Discussions were the important part of the conceptual change text based instruction. They were designed as the teacher-guided discussions. For example, when the food chain and food web text was taught, students discussed food web topic with some questions written in the worksheet given. Then, teacher made a demonstration about decomposers such as fungus under the microscope and then students would discuss about fungus. Afterwards, the teacher showed and explained an energy pyramid model showed some pictures and explained relating food chains to students by slide projector. In an other lesson: cycles of matter, the posters of carbon, water, oxygen, carbon dioxide, phosphorus, nitrogen cycles were shown and explained by the teacher. Later, the teacher initiated a discussion on questions in the worksheet and students tried to answer all questions in the first activity altogether. Then, the teacher asked to answer each question from one of the student in each small group.

After the demonstrations, students would answer the questions in the worksheets by discussing the questions in small groups. When answering the questions in the worksheets, students used the conceptual change texts and their textbooks though rarely. After following the sequence in the conceptual change text, students were expected to respond the same question which had been asked at the beginning in the conceptual change text comparing with their previous answers. Worksheets were distributed to the students during the course and discussions were made on them. Students' misconceptions by contrasting their preconceptions with specific phenomenon through questions in discussion environment. During the discussion sessions, sometimes teacher explained the abstract concepts or made corrections about some common mistakes.

After completion of the instruction of ecology unit in the control and the experimental groups, both groups were administered the post-TEC, post-ASB, and post-ASE.

4.6 Data Analysis

The data analysis consisted of six parts. In section one, the data analysis of classroom observation in the control and the experimental groups were performed.

In section two, the data analysis of interview with the teacher and the students were performed. In section three, missing data analysis was done before the statistical analysis of data. The statistical data analysis was calculated and presented in section four. The statistical data analysis included descriptive and inferential statistics data analyses. In section five, the data of the TEC were identified and categorized according to the students' levels of understanding of ecology. Finally, in section six, power analysis of the study was performed.

4.6.1 Analysis of the Classroom Observation Data

To validate the data gathered from the study, the researcher conducted non-systematic classroom observations during the ecology lessons in the control and the experimental groups. During the observations, the researcher took some notes concerning the applications of teaching methods in both groups. In order to analyze the data related to the classroom observations in the control and the experimental groups, one observation question was determined, and analyses of the classroom observations were performed the researcher's notes based on the question.

4.6.2 Analysis of the Interview Data

To support the data gathered through the study, the researcher examined the data of semi-structured interviews with two teachers and the data of group interviews with the students in the experimental group. Semi-structured interviews had some open-ended questions and the group interviews had an unstructured form with no preset questions. As regards group interviews, the researcher asked some spontaneous questions related to the conceptual change approach used in the experimental classes to all students. In both interviews, some notes were taken. Apart from that, tape recorder was used for interviewing one of the teachers. Interview tapes and interview notes were useful for analyzing the data of both interviews. In order to analyze the data of both interviews, some interview questions were determined, and interview analyses were performed the responses of teachers and the students based on these questions.

4.6.3 Missing Data Analysis

Before analyzing the data of the TEC, data list was composed and then analyzed in the SPSS program. A data list involved students' gender, SAB, pre-TEC scores, post-TEC scores, pre-ASB scores, post-ASB scores, pre-ASE scores, post-ASE scores, TOLT scores, and TRE. While columns presented variables and rows presented student numbers in the study.

At the beginning of the study, there were 88 students in four classes at the high school. The pre-tests were administered to all students in four classes. While the experimental group was taught according to the CCTI, the control group was taught according to the TI. At the end of the treatment, the post-tests were administered to all subjects in four classes.

Before the descriptive and the inferential statistics, the missing data analysis was performed. There were missing students (6 of 88) for the post-tests: one of the six students left the school and five of them were absent on the date of post-tests. Therefore, data which belonged to six students were excluded from the study completely. In short, whole data was accepted as 82 any more in the study and analyses were performed on them. Four out of 82 students were not present on the date when the pre-tests were held. There were four missing data related to the independent variables of students' ecology concepts pre-test scores (pre-TEC), students' attitude towards biology test scores (pre-ASB), students' environmental attitude scale scores (pre-EASE), and students' test of logical thinking scores (TOLT). The percentage of missing data of pre-tests in this study was 4.8 % as shown in Table 4.3. Since it was less than 5 % of the whole data , the missing data were directly replaced with the series mean of the entire subjects (SMEAN) according to Cohen and Cohen (1983).

There were some missing items in all tests because some students did not answer some items in the tests, probably they might not have known the answer or unwilling to answer these questions. The missing questions in the pre-TEC and post-TEC were accepted as 'No answer' and coded as 0. On the other hand, the missing items in the pre-ASB, pre-ASE, post-ASB, post-ASE, and TOLT were directly replaced with the series mean of the entire subjects (SMEAN). In short, the missing data were directly replaced with the series mean of the entire subjects (SMEAN) according to Cohen and Cohen (1983) because 4.8 % was less than 5 % of the whole data.

Table 4.3. Missing Pre-tests Data Versus Variables

Resultant Variable	Missing Values Replaced	Valid Case	Missing Percentage	Creating Functions
pre-TEC	4	82	4.87	SMEAN (pre-TEC)
pre-ASB	1	82	1.21	SMEAN (pre-ASB)
pre-ASE	1	82	1.21	SMEAN (pre-ASE)
TOLT	2	82	2.43	SMEAN (TOLT)

4.6.4 Analysis of Descriptive and Inferential Data Statistics

Each student was assigned with an identification number before the analyses of the test results. For the data related to the control and the experimental groups, the descriptive statistics, that is, mean, standard deviation, skewness, kurtosis, range, maximum, minimum values, and histograms were performed using the statistical program for social science (SPSS) in this study.

The inferential statistical computations were also performed in the SPSS. In order to test the null hypotheses of the study, the multivariate analysis of covariance (MANCOVA) model was used because there were three dependent variables in this study (Fraenkel and Wallen, 1996). Table 4.4 shows all variables and variable set entry order that were used in the MANCOVA.

Table 4.4 MANCOVA Variable Set Composition and Statistical Model Entry Order

Variable Set	Entry Order	Variable Name
A (covariates)	1st	X1=SAB
		X2=TOLT
		X3=pre-TEC
		X4=pre-ASB
		X5=pre-ASE
B (group memberships)	2nd	X6=TRE
		X7=Gender
C	3rd	X8=X1*X6
A*B (covariates*group interactions)		X9=X2*X6
		X10=X3*X6
		X11=X4*X6
		X12=X5*X6
		X13=X1*X7
		X14=X2*X7
		X15=X3*X7
		X16=X4*X7
		X17=X5*X7
(A*B)*A (covariates*group memberships interactions)*covariates		X18=(X6*X7)*X1
		X19=(X6*X7)*X2
		X20=(X6*X7)*X3
		X21=(X6*X7)*X4
		X22=(X6*X7)*X5

Firstly, Set A (covariates) was entered into the MANCOVA model. Then, Set B and Set C were entered into the model respectively. In the model, the significant values of A*B (covariates*group memberships interactions) and (A*B)*A [(covariates*group memberships interactions)*covariates] should be non-significant in order to have valid values ($p>.05$). The significant values of A*B and (A*B)*A showed non-significant values for the MANCOVA model. Sets of A*B and (A*B)*A was removed from the model. Thus, inferential statistics in MANCOVA was performed with covariates and independent variables of the study.

4.6.5 Analysis of Students' Levels of Understanding of Ecology

The TEC had two parts: the multiple-choice part required with reasoning and an open-ended part. Students' responses for each item in the TEC were also analyzed according to the students' levels of understanding of ecological concepts. Students' responses for the reasoning of the multiple-choice and the open-ended questions might contain one or more than one group of ideas linked together. As a guide, acceptable scientific explanations were written for each question by the experts and the researcher. Extended lists of ideas in response to each question were set as much as possible in mutually exclusive categories. Thus, the coding schemes were developed and the students' ideas were coded.

Students' responses were classified under six categories: sound understanding, partial understanding, partial understanding which includes misunderstanding, misunderstanding, no understanding, and no response. Similar classifications for similar aims were used in other studies (Simpson and Marek, 1988; Westbrook and Marek, 1991; Keng, 1997; Çetin, 1998). Tables were formed the summary of students' understanding and frequencies of response categories for the questions. It should be emphasized that a students' responses for each question might fall into one or more than one category.

Categories of the students' responses can be indicated as follows:

A. Sound understanding: If the students' responses include the scientifically acceptable explanations about the questions, they are considered having sound understanding.

B. Partial understanding: If the students' responses are partly correct and do not include the full range of the scientifically acceptable explanations about the questions, they will be considered having partial understanding.

C. Partial understanding which includes misunderstanding: If the students' responses are partly correct and do not include the full range of the scientifically acceptable explanations about the questions with some misunderstanding, they will be considered having partial understanding which includes misunderstanding.

D. Misunderstanding: If the students' responses do not include acceptable explanations, it implies that the students have some misinterpretations or misjudgments about the questions. Some responses of the students will be grouped as misunderstandings if they are clearly different from the scientific view.

E. No understanding: If the students cannot make proper explanation(s) from the scientific point of view or restate questions for the multiple-choice questions and the open-ended questions, they will be considered to have no understanding at all. In short, this broad category will contain these responses:

- Rewrite responses: Responses that restate the questions.
- Non-sense or irrelevant responses: Responses cannot be coded meaningfully.

F. No response: Cases where the space was left empty or with the response, “I don’t know”.

4.7 Assumptions of the Study

In the study, the researcher has assumed the followings:

1. Students were expected to have some conceptions, which differ from acceptable scientific views on ecology.
2. The TEC, ASB, ASE, and the TOLT were administered under standard conditions.
3. The classroom observations were performed under standard conditions.
4. Interviews the with teachers and the students were conducted under standard conditions.

5. There were no interaction between the students in the control and the experimental groups. Students did not share the questions of the TEC, ASB, and ASE before and during the application of the instruments.
6. Level of the questions in the tests is appropriate for the ninth grade students. Therefore, each student was considered having the same capacity to answer the questions in measuring instruments because they were all ninth grade students. However, a student's ability to answer the questions successfully depended upon the student's previous knowledge, skills, and experience (Germann and Aram, 1996).
7. All students answered the questions of measuring instruments (the questions of the tests and the questions of the interviews) seriously and sincerely.
8. Both teachers answered the interview questions seriously and sincerely.
9. Both teachers followed the researcher's instructions and were not biased during the treatment.
10. While both teachers only used the conceptual change approach in the experimental group and the traditional approach in the control group to teach ecology.
11. There were no interaction between the students in the experimental and the control groups during the treatment.

4.8 Limitations of the Study

In this study, the following limitations were taken into consideration:

1. The subject of the study was limited to 82 ninth grade students at a public high school in Balıkesir during the Spring Semester of 2001-2002.
2. This study was limited to the “Ecology: World and Environment Media” unit at ninth grade biology. It is also limited to the objectives of ecology lessons and the ecological concepts found in the Turkish ninth grade curriculum proposed by the Ministry of Education.
3. As sample was not selected randomly and sample size is small, generalizations of the results of this quasi-experimental study was limited. However, same conclusions could be arrived at samples that will show same conditions with this study.

CHAPTER 5

RESULTS

In this chapter, the results of the study were presented in six sections. In the section one, the results of classroom observations for the control group and the experimental groups were demonstrated. In section two, the results of interview with teachers and students in the experimental group were presented. In section three, the results of the descriptive statistics related to the students' Test of Ecological Concepts, Attitude Scale towards Biology, and Attitude Scale towards Environment as pre- and post-tests scores were given. Section four presented the results related to the inferential statistics of testing 12 null hypotheses. In section five, the results of students' levels of understanding of ecology were explained. A brief summary of the findings of the study was given in section six.

5.1 The Classroom Observations

In this study, the experimental and the control groups were observed to reveal "how the treatment was implemented in the experimental and the control groups".

The treatment was conducted in four classes at a public high school in Balıkesir. The researcher observed ten hours for the experimental and the control classrooms during the treatment. The researcher sat silently at the corner of each classroom and took some notes during the observations.

Both teachers completed all ecology topics in ten class hours over five weeks and they had similar teaching styles in the experimental and the control groups. While the traditional approach was conducted in the control classrooms, the conceptual change approach was performed in the experimental classrooms. The teachers used direct lecturing, questioning methods, and gave examples from everyday life in the control group. However, the teachers used conceptual change texts and performed some demonstrations like showing posters, plants, and dead animals in small groups in the experimental group. Since the teachers and the students experienced small group work and discussion for the first time, both the teachers and the students had some difficulties during the ecology lessons in the experimental classrooms. The teachers had more management problems such as noise and lack of interest in their classrooms, when the students were discussing the ecology topics than the control classrooms. In order to avoid these problems, the teachers sometimes warned them to keep quite and the students warned each other about the noise. In addition, some of the students did not like their group-mates and they preferred not to interact with each other when completing their worksheets.

The teachers and the students in the experimental group found the texts and the discussion activities too long. Therefore, the students lost their motivation towards the end of these activities. In general, it was observed that most students came to classes without reading the given text, although each text was given to them in advance. On the other hand, the students seemed to enjoy these activities, but on the other hand, they seemed to be bored with these activities because of the length of the texts and activities. In addition to this, students showed interest in the teaching materials employed in the classrooms even in the breaks. The teacher guided and monitored small group discussions (See Appendix H). It was observed that the teachers made more efforts in the experimental classrooms when compared to the control classrooms.

Base on the observation results, it could be assumed that both teachers conducted the ecology lessons by using the conceptual change text oriented instruction accompanied by demonstrations in small groups in the experimental group, and they followed the textbook by using direct lecturing, questioning methods, and giving examples from everyday life in the control group as it was planned.

The students in the experimental group were more noisy but more active than the students in the control group. As a result of observations, it can be concluded that the CCTI was a more effective learning method in the experimental classes than the TI in the control classes.

5.2 The Interviews

Interview sessions were conducted with two teachers and several students (group interviewing) in the experimental group. In the following parts, the results of them were given.

5.2.1 Interviews with the Teachers

In this study, two teachers were interviewed individually to reveal the reasons behind the students' misconceptions, and to take teachers' opinions about the conceptual change instruction after the treatment. The examples of excerpts from the interviews conducted with two teachers are presented below:

Q1. What are the reasons behind the students' misconceptions considering the items in the Test of Ecological Concepts?

Interviewer: Do you think your students answered the questions in the Test of Ecological Concepts properly?

Teacher 1: My students would respond to them properly, but if they cannot respond to the questions, the reasons might be lack of their knowledge about the concepts related to the question or inappropriate teaching of the subject.

Teacher 2: My students could answer the questions but I believe that some misconceptions would appear. Also the students might give wrong explanations even though they answered correctly to the multiple-choice test items.

Interviewer: What do you think about how the students' misconceptions on ecology occurred?

Teacher 1: Students' misconceptions could occur because of students' expectations about their future aims and graduation plans. Their only aim is to graduate from high school, therefore, they do not take science courses seriously.

Teacher 2: Students could have misconceptions because some students are not interested in the subject. There are several reasons for that:

- *In the national curriculum, teaching of the ecology subject is planned to be covered at the end of the semester. Therefore the students lost their interest at the end of the term.*
- *Students are affected by the predetermined misconceptions given in the texts [conceptual change texts] during the lessons.*
- *Being at the ninth grade, the students have not decided their tracks yet. So, some students in class do not have interest in Science and Mathematics.*

Teacher 1 was confident about her teaching and she thought that her students would be successful in the TEC, but if the students could not the answer them, it could be caused by the students' attitudes towards science or the teaching style of the teacher. On the other hand, Teacher 2 believed that her students would answer the questions, but some misconceptions would appear. Teacher 1 stressed that students' misconceptions could be originated by their expectations about the school and about their future plans. Teacher 2 indicated that it was caused by the time of the teaching and students' lack of interest in the lessons, and the predetermined misconceptions given in the conceptual change texts. Also, this teacher reported that students have not decided on their tracks yet as they were ninth grade students.

Q2. What are the opinions of the teachers about the instruction used in the experimental group?

Interviewer: What do you think about teaching ecology with this new method (conceptual change text oriented instruction accompanied by demonstrations in small groups)?

Teacher 1: It was a difficult and different method for me. Students were not accustomed to this instruction and it made me tired. The students did not want to read the textbook and were not willing to read the texts [conceptual change texts], then, misconceptions given in the texts [conceptual change texts] might not be useful. It would be better to give the truths in the texts [conceptual change texts], teach the topics, and give the worksheets.

Teacher 2: Biology course at the ninth grade is a two hour per week course. To conduct this instruction has lasted more than two hours per week. In this system, it is hard to apply this method because students focus on the university entrance examination and want to get higher grades rather than learn ecology. Students are not used to such methods so, there are some difficulties in applying such methods. If all the biology topics were taught using this method, it would be easier to follow the lessons for the students. In this method, the class size should be kept small for the group work and class management.

Interviewer: Which parts of the new method did you like most and which parts of the new method did you dislike most?

Teacher 1: I liked worksheets at most. I could apply small group work in teaching. In the future on some occasions I want to design worksheets in accordance with small group work, but preparing materials is time consuming. We do not have diagrams, and posters in our school. However, I can ask students to prepare diagrams and posters, then, we can produce our materials [demonstration materials].

Teacher 2: At the beginning of the text [conceptual change text], it is not good to give the students some misconceptions related to ecology. Attention span of the students are generally 20 minutes, this can even last a shorter time for some students. Students may learn misconceptions as if they are correct and they could miss the following parts. In addition, the answers of the questions should not be given in the provided texts. Students should note the answers after investigating them. However, it is nice to give the students some texts to get them ready for the classes and they may arouse their interest towards ecology topics.

Interviewer: What were the main problems that occurred when conducting the new instruction?

Teacher 1: Student came to the class without reading the texts [conceptual change texts]. The instruction was held on at the end of the semester. Students took all examinations until then, and they knew whether they passed or failed from the biology course. The experimental group was unwilling to participate in the new instruction, students have just brought the conceptual change texts to the class, and they utilized from the textbook less. While we use questioning method in the control group, the discussion method was used in the experimental group. This *instruction is time consuming. The instruction time should be 3 hours per week and one of these hours should be allocated for either small group work or laboratory experiments.*

Although the class size was ideal compared to other high schools [25 students in a class], it was hard to manage and control the class in this method since some students prefer to think aloud, and the students in the groups did not listen to each other enough. In my opinion, this method is effective for high achievers because:

- *the topics were not understood well,*
- *the groups did not listen to each other [in the whole class discussion],*
- *there were noisy students,*
- *most students did not read the predetermined conceptual change texts,*
- *students were bored of the long texts [conceptual change texts],*
- *the level of students were low and they had lack of interest in the lessons,*
- *students' prior knowledge was low according to their pre-test results [their TEC results],*
- *there was lack of communication among the group students,*
- *they were unwilling to be involved in group work.*

Teacher 2: The problems were:

- *time was not sufficient,*
- *the ecology topics were instructed at the end of the semester,*
- *the teachers and the students encountered this method for the first time,*
- *texts were too long. They could have less explanations and they should attract students attention more,*
- *students were not ready for group work and discussion environment,*
- *students were coming to class unprepared.*

Interviewer: How should the conceptual change texts be designed for your instruction?

Teacher 1: This method was not interesting enough for the students. Worksheets should contain color pictures [instead of black and white]. Water cycle should be itemized instead of full paragraph texts. I itemize everything and draw figures.

Teacher 2: Texts were uninteresting for the students and they can be shortened. It is good to give the prepared texts in the previous lesson to the students.

Interviewer: Were the texts sufficiently informative?

Teacher 1: Yes, they were.

Teacher 2: Yes, there was enough information, but it would be better to present more interesting information, puzzles, and more pictorial explanations.

Interviewer: Were the materials used for the demonstrations enough?

Teacher 1: It was good and enough. It was helpful for students' learning. Materials [Demonstration materials] attracted students' attention. The more the material there are the better it is. Also if needed, some materials could be hanged on the wall beforehand.

Teacher 2: The teaching materials [demonstration materials] used in this method were interesting for the students, and these materials made students to be interested in the subject. When the students found the materials interesting, they asked some questions related to them even in the breaks and I believe that students gained some knowledge with the given responses. In this method, visual tools attract students' attention a lot when they were used in the experimental classes.

The teachers did not like to give misconceptions at the beginning of the texts. They believed that students would be confused and they were afraid of not being able to change these misconceptions. They suggested that it is better not to give misconceptions at all. They liked the visual tools used in the experimental classes. However, they found the conceptual change texts were too long, and they stressed that they should be shortened and enriched with pictures and puzzles etc. Both teachers had some difficulties to teach ecology with this method because it was a new experience for them and their students. Students were noisy and class management was rather difficult during the discussions in small groups.

5.2.2 Interviews with the Students

In this study, the students were interviewed to take their opinions about the conceptual change oriented instruction after the treatment. The interviews were conducted as group interviews regarding an interview question. The question was: "*What are the opinions of the students about the instruction used in the experimental group?"* Students' responses to the question in these interview sessions were not presented individually, and they were summarized briefly as follows:

Interviewer: What do you think about learning the ecology with the new method?

The students found this method interesting. They felt free to talk and discuss the ecology topics with their classmates during the discussions in small groups. Expressing what they thought as a group was not something they experienced before. Seeing an energy pyramid model and other demonstration materials in their classrooms made them think about the ecology concepts. Several students expressed that they wished the other classes also had used this method.

Interviewer: Which parts of the new method did you like and dislike?

Some students mentioned that they liked group work. However, few students stated that they did not like this method at all and they stressed that they preferred the lecture method. Most students also complained about the length of the conceptual change texts and the time needed to complete the activities in the worksheets. Although they liked the activities in the worksheets, they said that the number of activities in the worksheets was too much and they were getting bored. They expressed that they also found the worksheets long. Additionally, most students mentioned that they like to response the questions in the worksheets during the whole class discussion. Otherwise, only some certain students responded to teachers' questions asked in other biology lessons during the lecture teaching.

Interviewer: What problems you have experienced in learning ecology with this method?

Most students indicated that there was too much noise during the activities in the worksheets and then, it was hard to concentrate on the topic. In general, students liked this new method. Although the majority of students liked the demonstration materials and activities in the worksheets, it was hard to focus on the long conceptual change texts and the long activities in the worksheets for them.

5.3 Descriptive Statistics

Descriptive statistics related to the students' ecology concepts pre-test scores, ecology concepts post-test scores, biology attitudes pre-test scores, biology attitudes post-test scores, environmental attitudes pre-test scores, environmental attitudes post-test scores, and test of logical thinking in the control and the experimental groups were performed. The results were shown in Table 5.1.

Table 5.1 Basic Descriptive Statistics Related to the Test of Ecological Concepts (TEC), the Attitude Scale towards Biology (ASB), the Attitude Scale towards Environment (ASE), and the Test of Logical Thinking (TOLT)

GROUP		DESCRIPTIVE STATISTICS							
		No	Range	Min	Max	Mean	Std.Dev.	Skewness	Kurtosis
EG	pre-TEC	45	18	4	22	13.59	4.19	-.224	-.203
	post-TEC	45	25	7	32	22.02	5.19	-.614	.596
	pre-ASB	45	48	27	75	56.54	10.35	-.573	.326
	post-ASB	45	47	28	75	57.21	10.00	-.488	.603
	pre-ASE	45	59	46	105	89.66	10.26	-1.744	6.290
	post-ASE	45	53	57	110	90.42	10.90	-.505	.676
	TOLT	45	4	0	4	.70	.94	1.694	3.038
CG	pre-TEC	37	22	1	23	15.06	4.43	-.579	1.390
	post-TEC	37	29	4	33	19.51	6.34	-.127	-.292
	pre-ASB	37	42	30	72	58.40	10.52	-1.170	1.292
	post-ASB	37	36	39	75	58.50	10.31	-.287	-.799
	pre-ASE	37	50	53	103	85.58	10.19	-.805	1.627
	post-ASE	37	40	66	106	88.51	10.60	-.351	-.773
	TOLT	37	7	0	7	.70	1.29	3.562	15.943

Students' test of ecological concepts scores range from 0 to 51. The higher scores mean the greater success in ecology. In Table 5.1, the mean of the pre-TEC is 13.59 and the post-TEC is 22.02 in the experimental group. On the other hand, the mean of the pre-TEC is 15.06 and the post-TEC is 19.51 in the control group. In that case, the experimental group showed a mean score increase of 8.43 and the control group performed a mean score increase of 4.45 on the TEC. It can be seen that the mean score increase in the experimental group was higher than in the control group. The experimental group' students have achieved higher ecology success than the control group' students.

Students' attitudes scale towards biology scores range from 0 to 75. Greater scores mean more positive attitudes towards to biology. As seen in Table 5.1, the mean of the Biology Attitude Pre-test is 56.54 and the Biology Attitude Post-test is 57.21 in the experimental group. There could be seen that there is a slight mean score increase (0.67) regarding experimental group' students attitudes towards biology. The mean of the Biology Attitude Pre-test is 58.40 and the Biology Attitude Post-test is 58.50 in the control group. There is a slight increase in mean scores (0.10) in control group' attitude towards biology.

Students' attitudes scale towards environment scores range from 0 to 110 with higher scores mean more positive attitudes towards environment. As seen in the Table 5.1, the mean of the Environmental Attitude Pre-test is 89.66 and the Environmental Attitude Post-test is 90.42 in the experimental group with a change of mean scores of 0.76. In the control group, the mean of the Environmental Attitude Pre-test is 85.58 and the Environmental Attitude Post-test is 88.51 with a change of mean scores of 2.93.

Students' test of logical thinking scores range from 0 to 10 and higher scores represent better logical thinking. As shown in Table 5.1, the mean of TOLT is .7 in the experimental and the control groups.

The Table 5.1 also shows some other basic descriptive statistics like range, minimum, maximum, standard deviation, skewness, and kurtosis values. The skewness of the pre-TEC was -.22 and the post-TEC was -.61 in the experimental group. The skewness of the pre-TEC was -.58 and the post-TEC was -.13 in the control group. The skewness of the pre-ASB was -.57 and changed to -.49 in the experimental group. The value of pre-ASB was –1.17 and changed to -.29 in control group. On the other hand, in the experimental group, the value of the pre-ASE was –1.74 and changed to -.51. For control group, the value of skewness of the pre-ASE was -.81 and changed to -.35. The kurtosis values are also displayed in Table 5.1. The skewness and kurtosis values in this study can be accepted as approximately normal.

Three histograms with normal curves related to the post-TEC, post-ASB, and post-ASE in the experimental and control groups are given in Figure 5.1, Figure 5.2, and Figure 5.3.These are also evidence for the normal distribution of these six variables.

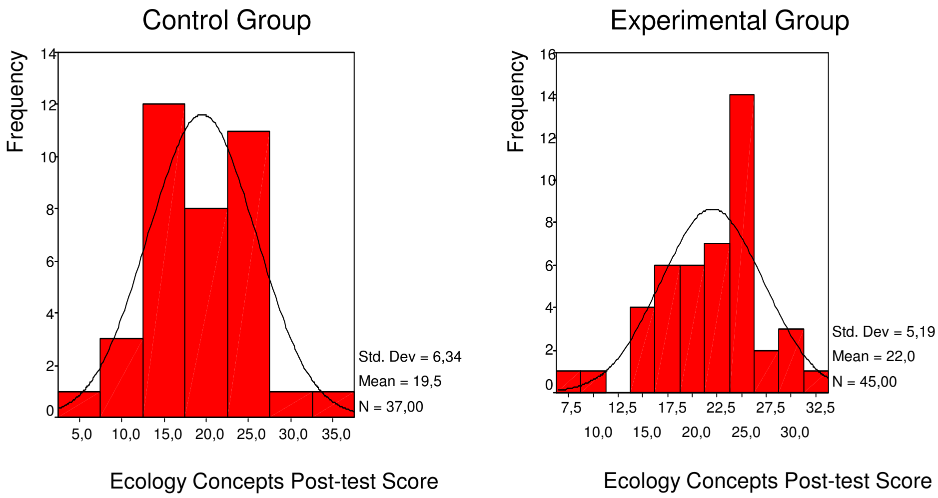


Figure 5.1. Histograms with Normal Curves Related to the post-TEC in the Experimental and the Control Groups

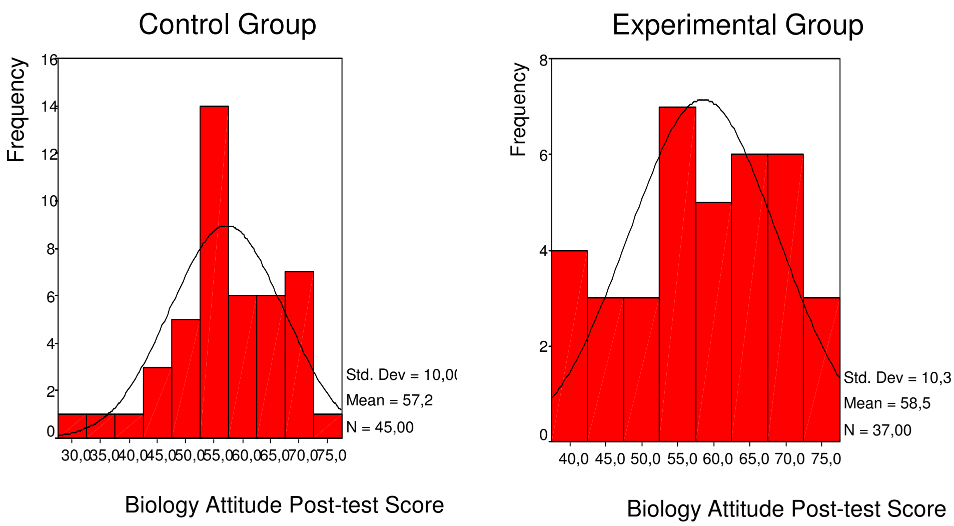


Figure 5.2. Histograms with Normal Curves Related to the post-ASB in the Experimental and the Control Groups

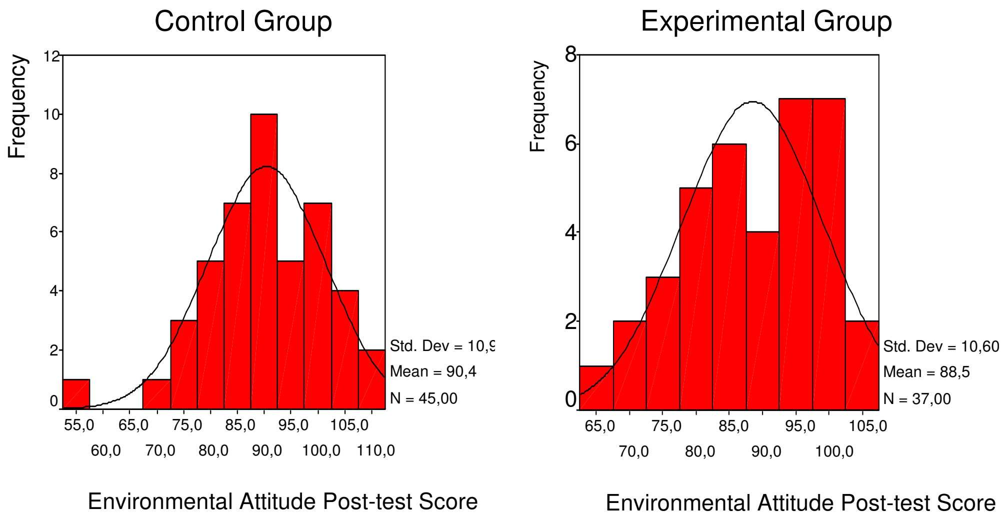


Figure 5.3. Histograms with Normal Curves Related to the post-ASE in the Experimental and the Control Groups

Figure 5.1 shows that the students' post-TEC mean score in the control group was 19.5, while the students' post-TEC mean score in the experimental group was 22.0. As it is seen from this histogram, students' post-TEC mean scores were higher, in favor of the experimental group. Students' post-ASB mean score in the control group was 57.2, while the students' post-ASB mean score in the experimental group is 58.2. As seen in the Figure 5.2, students' post-ASB mean scores were nearly similar in the control and experimental groups. Students' post-ASE mean score in the control group was 90.4, while the students' post-ASE mean score in the experimental group was 88.5. The Figure 5.3 shows that students' post-ASE mean scores were higher, in favor of the control group.

5.4 Inferential Statistics

This part included the following sections: determination of the covariates, assumptions of the Multivariate Analysis of Covariance (MANCOVA), the statistical model of MANCOVA, the analyses of the hypotheses, and the follow-up analysis.

5.4.1 Determination of Covariates

There were three dependent variables; the post-ecological concepts test, post-attitude scale towards biology, and post-attitude scale towards environment scores in this study. In order to statistically equalize the differences between the experimental and the control groups, five variables of the study; the students' average grades of two biology midterm exams, test of logical thinking ability, pre-ecological concepts test, pre-attitude towards biology, and pre-attitude towards environment scores were pre-determined as potential covariates.

In order to designate a variable as a covariate, that variable should demonstrate a significant correlation with at least one of the dependent variables. Table 5.2 presents the results of these correlations and their levels of significance. As seen from Table 5.2, the values of correlation coefficients of five pre-determined variables showed significant correlations with at least one of the dependent variables of the post-TEC, post-ASB, and post-ASE. The students' SAB, TOLT, pre-TEC, pre-ASB, and pre-ASE were assumed as covariates for analyzing data in the MANCOVA.

Table 5.2 Significance Test of Correlations between the Dependent and Independent Variables

Variables	post-TEC	post-ASB	post-ASE
SAB	.628*	.418*	.271*
TOLT	.128	.189	.230*
pre-TEC	.413*	.125	.113
pre-ASB	.335*	.676*	.465*
pre-ASE	.286*	.521*	.596*

*Correlation is significant at the .05 level (2-tailed).

Moreover, these covariates should also show no significant correlation among them. Table 5.3 displays correlations among covariates. This table shows that the correlations among covariates were not higher than .80. It can be said that there was no multicollinearity among those covariates. Hence, SAB, TOLT, pre-TEC, pre-ASB, and pre-ASE were determined as covariates in this study.

Table 5.3 Significance Test of Correlations among Covariates

Variables	SAB	TOLT	pre-TEC	pre-ASB	pre-ASE
SAB		.076	.349	.328	.207
TOLT			-.006	.091	.149
pre-TEC				.062	.065
pre-ASB					.507
pre-ASE					

5.4.2 Assumptions of Multivariate Analysis of Covariance (MANCOVA)

Before starting data analyses in the MANCOVA, all the variables were tested for five assumptions of MANCOVA; normality, homogeneity of regression, equality of variances, multicollinearity, and independency of observations.

For the normality assumption, skewness and kurtosis values calculated using descriptive statistics. The skewness and kurtosis values of post-TEC, post-ASB, and post-ASE were given in the Table 5.1. The skewness and kurtosis values of TEC and ASB, and ASE were approximetely in an acceptable range for a normal distribution.

Homogeneity of regression assumption means that the slope of regression of a dependent variable on covariates must be constant over different values of group membership. Table 5.4 indicates the results of Multiple Regression Correlation (MRC) for homogeneity of regression.

For the MRC analysis, fifteen new interaction terms were also formed. They were obtained by multiplying group memberships with the covariates separately. In other words, these interaction terms were prepared by multiplying the group memberships (treatment and gender) with covariates of SAB, TOLT, pre-TEC, pre-ASB, and pre-ASE. In this table, Block A included covariates, Block B included group memberships, and Block C contained interaction terms. The MRC analysis was run in order to test the significance of R^2 change for three dependent variables of the post-TEC, post-ASB, and post-ASE using enter method. In Table 5.4, the contribution of Block C was not found significant for post-TEC (F(15, 59) = 1.840, p= .052). Also, the contribution of Block C was not found significant for post-ASB (F(15, 59)=.568, p=.888). Similarly, for post-ASE, the contribution of Block C is not also significant (F(15, 59)=1.034, p=.435).

As a result, no significant interaction between the covariates and group memberships for dependent variables in Block Cs was found. In other words, homogeneity of regression was validated for the MANCOVA model.

Table 5.4 Results of the Multiple Regression Analysis of Homogeneity of Regression

Model	Change Statistics				
post-TEC	R Square Change	F Change	df1	df2	Sig. F Change
Block A	.474	13.722	5	76	.000
Block B	.063	5.011	2	74	.009
Block C	.148	1.840	15	59	.052
post-ASB					
Block A	.548	18.457	5	76	.000
Block B	.006	.488	2	74	.616
Block C	.056	.568	15	59	.888
post-ASE					
Block A	.422	11.081	5	76	.000
Block B	.005	.331	2	74	.719
Block C	.119	1.034	15	59	.435

Table 5.5 displays the Box's Test of Equality of Covariance Matrices. In this table, it was clearly seen that the observed covariance matrices of the dependent variables were equal across groups since p=.507 >.05.

Table 5.5 Box's Test of Equality of Covariance Matrices

Box's M	19,163
F	.958
Df1	18
Df2	3523
Sig.	.507

Table 5.6 shows the Levene's Test of Equality of Error Variances. The error variances of the selected dependent variables across groups were equal in Table 5.6. The significant levels of post-TEC, post-ASB, and post-ASE were .205, .205, and .559, respectively. Since these p values were higher than .05, the equality of variance assumption was validated for this model.

Table 5.6 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Post-TEC	1.563	3	78	.205
post-ASB	1.565	3	78	.205
post-ASE	.693	3	78	.559

Additionally, there were significant correlations among covariates (SAB, pre-TEC, pre-ASB, and pre-ASE), but the correlation values were smaller than .80. Hence, the assumption of multicollinearity was also provided according to Table 5.3.

Lastly, the assumption of independency of observations was provided for this model. This assumption was met with the observations of the control and experimental groups by the researcher. According to the findings of the observations, all students completed their tests themselves.

5.4.3 Multivariate Analysis of Covariance (MANCOVA) Model

According to the results of the validation of the MANCOVA assumptions, it was determined that post-TEC, post-ASB, and post-ASE are dependent variables. TRE and Gender are independent variables of the study. The SAB, TOLT, pre-TEC, pre-ASB, and pre-ASE are covariates of the study. Table 5.7 displays the results of MANCOVA. As Table 5.7 indicates, TRE explained 15 % variance of model for the collective dependent variables of post-TEC, post-ASB, and post-ASE. From the table, it can be also seen that covariates of the SAB, pre-TEC, and pre-ASB, and pre-ASE showed significant effect on the dependent variables of the post-TEC, post-ASB, and post-ASE. However, the TOLT did not show any significant effect on the dependent variables. While the treatment had significant effect on the model, gender did not show any significant effect on dependent variables. TRE*GENDER (interaction between the treatment and gender) also did not show any significant effect on the model.

Table 5.7 Multivariate Analysis of Covariance Test Results#

Effect	Value	F	Hypothesis df	Error df	P Sig.	Eta Squared	Observed Power
Intercept	.833	4.756	3	71	.004	.167	.884
SAB	.702	10.034	3	71	.000	.298	.997
TOLT	.954	1.132	3	71	.342	.046	.293
pre-TEC	.876	3.340	3	71	.024	.124	.736
pre-ASB	.750	7.892	3	71	.000	.250	.987
pre-ASE	.803	5.793	3	71	.001	.197	.941
TRE	.864	3.716	3	71	.015	.136	.785
GENDER	.979	.517	3	71	.672	.021	.151
TRE* GENDER	.980	.494	3	71	.688	.020	.145

#All values in the MANCOVA above were given according to Wilks' Lambda.

5.4.4 Results of Null Hypotheses Testing

In this study, 12 null hypotheses mentioned in the Chapter 3 were analyzed by the MANCOVA and 12 hypotheses were tested at a significance level of .05.

5.4.4.1 Null Hypothesis 1

The first hypothesis was; "there was no significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

The MANCOVA was conducted to determine the effect of the treatment on the collective dependent variables of the post-TEC, post-ASB, and post-ASE. As Table 5.7 indicates, the first null hypothesis was rejected (λ=.864, p=.015). Significant differences were found between the conceptual change text oriented instruction and the traditional instruction on the collective dependent variables of the post-TEC, post-ASB, and post-ASE.

In order to test the effect of the treatment on each dependent variable, an analysis of covariance (ANCOVA) was performed as follow-up tests to the MANCOVA. Table 5.8 presents the results of the ANCOVA.

Table 5.8 Follow-up Univariate Analysis of Covariance Test Results

Source	DV	Type III Sum of Squares	df	Mean Square	F	P Sig.	Eta Squared	Observed Power
Corrected Model	post-TEC	1500.283	8	187.535	10.885	.000	544	000
	post-ASB	4609.155	8	576.144	1.505	.000	558	.000
	post-ASE	3996.570	8	499.571	6.820	.000	428	000
Intercept	post-TEC	8.161		8.161	.474	.493	006	.104
	post-ASB	35.245		35.245	704	.404	.010	131
	post-ASE	1050.351		1050.351	14.340	.000	.164	.962
SAB	post-TEC	449.604		449.604	26.096	.000	263	.999
	post-ASB	318.199		318.199	6.354	014	.080	701
	post-ASE	43.974		43.974	.600	.441	.008	.119
TOLT	post-TEC	15.941		15.941	.925	.339	.013	.158
	post-ASB	66.522		66.522	.328	253	.018	.206
	post-ASE	196.488		196.488	2.682	106	.035	.366

Table 5.8 (continued)

Source	DV	Type III Sum of Squares	df	Mean Square	F	P Sig.	Eta Squared	Observed Power
pre-TEC	post-TEC	173.259		173.259	10.056	.002	121	879
	post-ASB	1.347		347	027	.870	.000	.053
	Post-ASE	17.576		17.576	.240	.626	.003	.077
pre-ASB	Post-TEC	49.883		49.883	2.895	.093	038	.390
	Post-ASB	1142.215		1142.215	22.810	000	.238	997
	post-ASE	243.600		243.600	3.326	.072	.044	.436
pre-ASE	post-TEC	.702		.702	.041	.841	.001	.055
	post-ASB	317.895		317.895	6.348	.014	.080	.701
	post-ASE	193.188		1193.188	16.290	000	.182	.978
TRE	post-TEC	188.011		188.011	10.912	.001	.130	903
	post-ASB	8.480		8.480	169	.682	002	.069
	post-ASE	5.848		5.848	080	778	001	.059

Table 5.8 (continued)

Source	DV	Type III Sum of Squares	df	Mean Square	F	P Sig.	Eta Squared	Observed Power
GENDER	post-TEC	3.554	1	3.554	.206	.651	.003	.073
	post-ASB	22.569	1	22.569	.451	.504	.006	.102
	post-ASE	28.411	1	28.411	.388	.535	.005	.094
TRE*	post-TEC	18.852	1	18.852	1.094	.299	.015	.178
GENDER	post-ASB	28.324	1	28.324	.566	.454	.008	.115
	post-ASE	8.982	1	8.982	.123	.727	.002	.064
Error	post-TEC	1257.730	73	17.229				
	post-ASB	3655.562	73	50.076				
	post-ASE	5347.105	73	73.248				

5.4.4.2 Null Hypothesis 2

The second hypothesis was; “there was no significant effect of gender (males and females) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students’ average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled”.

The MANCOVA was conducted to determine the effect of gender on the collective dependent variables of the post-TEC, post-ASB, and post-ASE. As Table 5.7 indicates, the second null hypothesis was not rejected (λ=.979, p=.672). Significant differences were not found between males and females on the collective dependent variables of the post-TEC, post-ASB, and post-ASE.

5.4.4.3 Null Hypothesis 3

The third hypothesis was; “there was no significant effect of interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the collective dependent variables of ecological concepts post-test scores, biology attitude post-test scores, and environmental attitude post-test scores when the effects of students’ average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled”.

The MANCOVA was conducted to determine the effect of interaction between the treatment and gender on the collective dependent variables of the post-TEC, post-ASB, and post-ASE. According to Table 5.7, the third null hypothesis was not rejected (λ=.980, p=.688), there was no significant effect of interaction between the treatment and gender on the collective dependent variables of the post-TEC, post-ASB, and post-ASE.

5.4.4.4 Null Hypothesis 4

The fourth hypothesis was; "there was no significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

As it can be seen from Table 5.8, the fourth null hypothesis was rejected ($F(1, 73)=10.912$, $p=.001$). That is; the conceptual change text oriented instruction was more effective in improving students' post-TEC scores than the traditional instruction. Students were taught using the conceptual change oriented instruction had higher ecology achievement scores than the students were taught using the traditional instruction.

5.4.4.5 Null Hypothesis 5

The fifth hypothesis was; "there was no significant effect of gender (males and females) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

According to Table 5.8, the fifth null hypothesis was not rejected (F(1, 73)=.206, p=.651). That is; there was no significant difference in the means of the post-TEC between males and females when the effects of the covariates have been controlled. Gender difference was not effective in improving students' post-TEC scores.

5.4.4.6 Null Hypothesis 6

The sixth hypothesis was; "there was no significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

As seen in Table 5.8, the sixth null hypothesis is not rejected (F(1, 73)=.169, p=.682). This statistics did not provide support for this null hypothesis. That is; there is no significant difference in the means of the post-ASB between the experimental and control groups when the effects of the covariates have been controlled. The conceptual change oriented instruction was not effective in increasing positive attitude towards biology more than the traditional instruction.

5.4.4.7 Null Hypothesis 7

The seventh hypothesis was; "there was no significant effect of gender (males and females) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

As seen in Table 5.8, the seventh null hypothesis is not rejected (F(1, 73=.451, p=.504). That is; there is no significant difference in the means of the post-ASB between males and females when the effects of the covariates have been controlled. Gender difference was not effective in increasing positive attitudes towards biology.

5.4.4.8 Null Hypothesis 8

The eighth hypothesis was; "there was no significant effect of the treatment (conceptual change approach versus traditional approach) on the population means of the environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

As seen in Table 5.8, the eighth null hypothesis was not rejected (F(1,73)=.080, p=.778). That is, the conceptual change approach was not effective in improving positive attitude towards environment more than the traditional approach.

5.4.4.9 Null Hypothesis 9

The ninth hypothesis was; "there was no significant effect of gender (males and females) on the population means of the environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

According to Table 5.8, the ninth null hypothesis was not rejected ($F(1,73)=.388$, $p=.535$). This statistics did not provide support for this null hypothesis. Therefore, gender difference was not effective in increasing positive attitude towards environment.

5.4.4.10 Null Hypothesis 10

The tenth hypothesis was; "there was no significant effect of interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the ecological concepts post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

As it can be seen from Table 5.8, the tenth null hypothesis was not rejected ($F(1, 73)=1.094$, $p=.299$). The p value was higher than .05. The interaction between the treatment and gender was not effective in improving students' post-TEC. This statistics therefore did not provide support for this null hypothesis and the tenth null hypothesis was not rejected.

5.4.4.11 Null Hypothesis 11

The tenth hypothesis was; "there was no significant effect of interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the biology attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

The MANCOVA was conducted to determine whether there was no significant difference of interaction between the treatment and gender on the population means of the post-ASB. As it can be seen from Table 5.8, the eleventh null hypothesis was not rejected ($F(1, 73)= .566$, $p=.454$). The p value was higher than .05. The interaction between the treatment and gender was not effective in improving students' post-ASB scores. This statistics therefore did not provide support for this null hypothesis and the eleventh null hypothesis was not rejected.

5.4.4.12 Null Hypothesis 12

The twelfth hypothesis was; "there was no significant effect of interaction between the treatment (conceptual change approach versus traditional approach) and gender (males and females) on the population means of the environmental attitude post-test scores when the effects of students' average grades of two biology midterm exams, test of logical thinking scores, ecological concepts pre-test scores, biology attitude pre-test scores, and environmental attitude pre-test scores were controlled".

As it can be seen from Table 5.8, the eleventh null hypothesis was not rejected ($F(1, 73)=.123$, $p=.727$). The p value was higher than .05. Therefore, the interaction between the treatment and gender was not effective in improving students' post-ASE scores.

Furthermore, adjusted means of the control and experimental groups for dependent variables were obtained in the MANCOVA. Table 5.9 shows adjusted means of the experimental and the control groups for the dependent variables of the post-TEC, post-ASB, and post-ASE and independent variables of the TRE. When the adjusted means were compared with the prior means, it was seen that controlling the effects of covariates on post-TEC scores results in a change of mean differences in favor of experimental group.

Table 5.9 Means and Adjusted Means of the Control and the Experimental Groups

Dependent Variable	Treatment	Mean	Adjusted Mean
post-TEC	Control Group	19.51	18.73
	Experimental Group	22.02	22.35

5.4.5 Students' Levels of Understanding of Ecological Concepts

The thirteenth research question investigated was:

"What types of responses emerged from students' alternative ideas that reflect the students' levels of understanding of ecological concepts before and after the treatment?"

To determine students' levels of understanding of ecological concepts, the students' responses were closely examined on each of the 17 questions in the Test of Ecological Concepts as pre- and post-test. The test had two parts: multiple-choice part with its reasoning, and open-ended part. The content analysis of students' emerging ideas from the Test of Ecological Concepts was performed and coded related to the students' responses in the reasoning and the open-ended parts. According to the content analysis of students' responses in the TEC, the students had several degrees of understanding of ecological concepts asked in the TEC. The students' responses were classified under six categories: five levels of understanding of ecology and no response categories. Five levels of students' understanding of ecological concepts were sound understanding, partial understanding, partial understanding which includes misunderstanding, misunderstanding, and no understanding. The category of "No understanding" included two sub-categories: nonsense and rewrite. The category of "No response" contained the 'I do not know' or zero response to the questions in the TEC. The category of misunderstanding for the multiple-choice questions in the TEC was divided into two subcategories: misunderstanding despite choice of the correct response for only multiple-choice questions and misunderstanding despite choice of the incorrect response for only multiple-choice questions. However, there were no subcategories for misunderstanding in the open-ended questions.

5.4.5.1 Students' Levels of Overall Understanding of Ecology

The Figure 5.4 shows the whole results of students' levels of understanding in the experimental and the control groups considering the Test of Ecological Concepts.

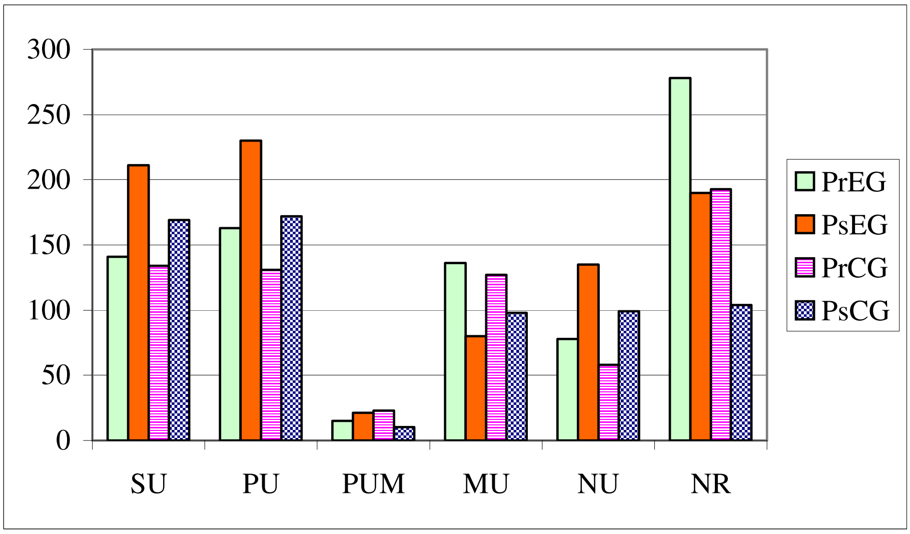


Figure 5.4 The Whole Picture of Students' Levels of Understanding of Ecological Concepts in the Experimental and the Control Groups

The Figure 5.4 shows that students' sound understanding increased in the experimental and the control groups after the treatment. There was a noticeable increase in students' partial understanding in the experimental and the control groups after the treatment. There was a slight increase in the experimental group students' partial understanding which includes misunderstanding, but a slight decrease in the control group after the treatment. Students' misunderstanding decreased in the experimental and the control groups after the treatment, but this decrease was more for the students in the experimental group than in the control group. The students' no-understanding increased in the experimental and the control groups after the treatment. The number of non-responding students decreased in the experimental and the control groups after the treatment.

The questions in the TEC were re-organized according to five key concept areas of ecology. These key concept areas were; biotic and abiotic factors, food chain, biological organization, cycles of materials, and environmental pollution. The changes in students' misunderstanding after the treatment in these key concept areas have been presented in the Figure 5.5 below.

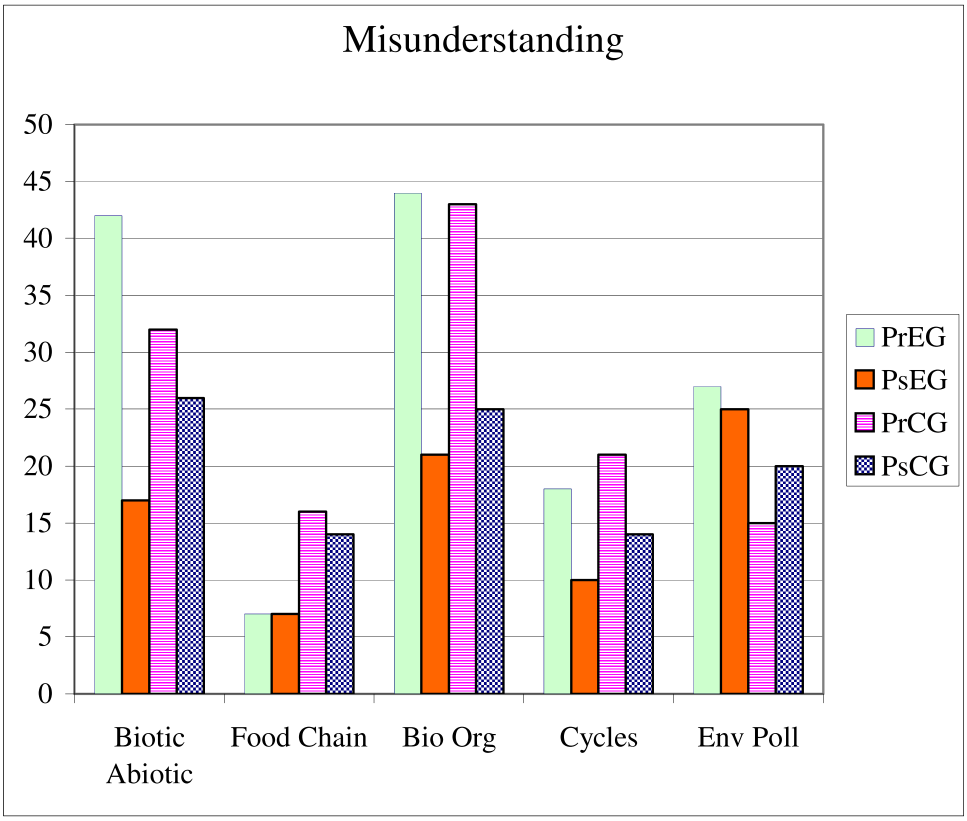


Figure 5.5 Students' Misunderstandings on Five Concept Areas of Ecology in the Experimental and the Control Groups

The results from the Figure 5.5 shows that there was a decrease in the students' level of misunderstanding in the control and the experimental groups regarding the key concept areas of biotic and abiotic factors, biological organization, and cycles of materials after the treatment. While there was no change in the experimental group regarding the key concept area of food chain, there was a slight decrease in the control group after the treatment. However, there was a slight decrease in the students' level of misunderstanding in the experimental groups regarding the key concept areas of environmental pollution, there was an increase in the control group.

In the following sections, five figures and five tables were prepared to show the students' levels of understanding of each key concept area in the TEC in the experimental and the control groups. Each figure displays the students' understanding levels related to each key concept area in the experimental and the control groups. Each table shows the students' levels of understanding and the number of their responses to a question representing each key concept area. These tables display the students' ideas related to the representing question only when students gave a correct response. Students' explanations for the correct response were further categorized as SU, PU, PUM, NU, and NR for either the multiple-choice question or the open-ended question. Moreover, when the student made a correct choice for the multiple-choice question, and the provided explanation was wrong it has been assumed as misunderstanding (MU). They were classified as sub-sections of misunderstanding despite the choice of the correct response for only multiple-choice questions, and again misunderstanding for the choice of the incorrect response for multiple-choice questions. When the student made an alternative for the open-ended question, it has been assumed as misunderstanding if the provided explanation was wrong.

5.4.5.2 Students' Levels of Understanding of Biotic and Abiotic Factors

Four questions (1, 2, 3 and 4) in the Test of Ecological Concepts were on the key concept area of biotic and abiotic factors. This key concept area included the key concepts of the biotic abiotic factors and symbiotic relationships. The Figure 5.6 displays the students' levels of understanding indicated by their responses to the key concept area of biotic and abiotic factors.

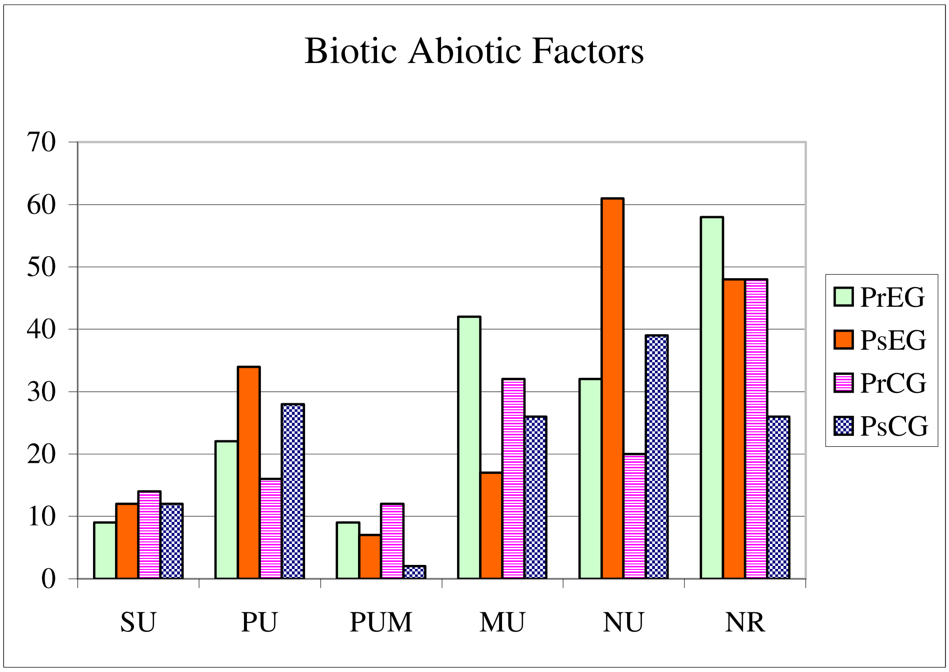


Figure 5.6 Students' Levels of Understanding of Biotic and Abiotic Factors in the Experimental and the Control Groups

The results from the Figure 5.6 shows that there was a slight increase in the students' sound understanding in the experimental group while there was a slight decrease in the control group after the treatment. Students' partial understanding increased in the experimental and the control groups after the treatment. Students' partial understanding which includes misunderstanding decreased in the experimental and the control groups after the treatment. This decrease was more for the control group students. Students' misunderstanding decreased in the experimental and the control groups' students after the treatment, but more decrease was observed in the experimental group. Students' no-understanding increased in the experimental and the control groups after the treatment. The number of non-responding students decreased in both groups after the treatment.

As an example, Question 1 in the TEC was given to find out students' ideas on the key concept area of the biotic and abiotic factors. This question covered the concepts of climate, light, water, heat, producer, consumer, and decomposer under the key concept of biotic abiotic factors.

Question 1.
There are two environmental factors that affect a living organism: biotic and abiotic factors.
Which one of the following items involves two biotic factors together?

A) Climate – Consumer
B) Light – Water
C) Heat – Producer
D) Producer – Decomposer

Explain briefly why you made that choice.

For this question, students were expected to choose the correct item "D" (Producer – Decomposer). An acceptable explanation of the question might include the following main idea:

- Producers and decomposers demonstrate the characteristics of the living things such as; developing, feeding, producing, dying, but the climate, light, water, and heat cannot demonstrate such characteristics.

Students gave various responses to the question, and those responses were categorized according to the their levels of understanding as shown in the following Table 5.10.

Table 5.10 Summary of Students' Levels of Understanding and their Types of Responses to "Biotic and Abiotic Factors" in the Experimental and the Control Groups during the Treatment

Types of Response	Number of Responses (n=45 for EG, n=37 for CG)			
	Pr EG	Pr CG	Ps EG	Ps CG
Sound Understanding	0	0	1	0
They have the characteristics of adapting to the environment: birth, growth, and death, etc.			1	
Partial Understanding	3	0	7	4
Producers are plants (tree is a producer), however decomposers are bacteria/fungi, and etc.	2		1	3
Producers are the living things producing their own food. Decomposers mix the cell of the dead organisms in the soil.	1			
Green plants are producers. Decomposers destroy them. They keep the balance in nature.			1	
Both of them live, show activity/for being able to move.			2	
Producers are plants or grasses, however decomposers are the living things in the soil.			1	1
Both are living things, but the others either they are non-living or one of them is living.			1	
Producers are the organisms that make their food themselves. They are autotrophic organisms.			1	
Partial Understanding Which Includes Misunderstanding	4	4	3	0
Producers are living organisms and decomposers are non-living organisms.	2			
While producers are plants/human/animal/environment, decomposers are bacteria/viruses.	1	2		
Producers take food materials directly and decomposers decay them.		1		
Producers produce food. Decomposer decays bacteria on the dead organisms.	1			
Producers produce and decay.		1		
Producers produce its own foods. Decomposers are human and, they decay what they eat.			1	
There is a producer for reproduction. Something cannot be decayed by itself; there must be a decomposer organism for decaying it.			1	
Living thing produces when it is eaten, whereas decomposer decays what it eats.			1	

Table 5.11 (continued)

Types of Response	Number of Responses (n=45 for EG, n=37 for CG)			
	Pr EG	Pr CG	Ps EG	Ps CG
Misunderstanding	14	9	4	4
Misunderstanding despite the choice of the correct response for the multiple-choice question	3	3	4	2
Both are human and, human is living organism/Human is producer/consumer/decomposer.	2	3	1	
There is a person or a living organism that produces or decomposes.	1			
Producers always produce. Decomposers determine the types of the producers.			1	
Producers are living organisms because they are the reproduction of somebody.			1	
Producers are green plants. Decomposers mix dead plants and animals in soil by decaying them.			1	
Other alternatives are non-living or abiotic organisms.				2
Misunderstanding for the choice of the incorrect response for the multiple-choice question	11	6	0	2
No Understanding	10	7	21	9
Non-sense	7	5	5	3
Rewrite	3	2	16	6
No Response	13	13	7	9

Additionally, students gave alternative responses to the question. They chose A, B, or C which were all incorrect. Although students' responses contained correct idea in corresponding alternatives, they were assumed to be 'misunderstanding'. For example, some students who chose "A" (Climate-Consumer) gave several responses such as; "Climate can always change and most consumers make use of this" and "If the climate is lend itself, fruits and vegetables grow and people consume them".

Also, some students who chose "B" (Light-Water) made several explanations like; "Plants make photosynthesis with light and water", "Light is needed to see something", "Light and water are needed for plants to sprout", "The whole environment is needed for living things to survive", "If there is no water and light, the organisms die", and "While light is non-living, water is living". Furthermore, some students chose "C" (Heat-Producer), and one of their alternative ideas was "While heat is non-living thing, producer is a living thing".

5.4.5.3 Students' Levels of Understanding of Food Chain

Questions 5, 6, and 14 in the Test of Ecological Concepts were on the key concept area of food chain. Food chain included the key concepts of food chain, food web, and energy pyramid. The Figure 5.7 displays the students' levels of understanding indicated by their responses to the key concept area of food chain.

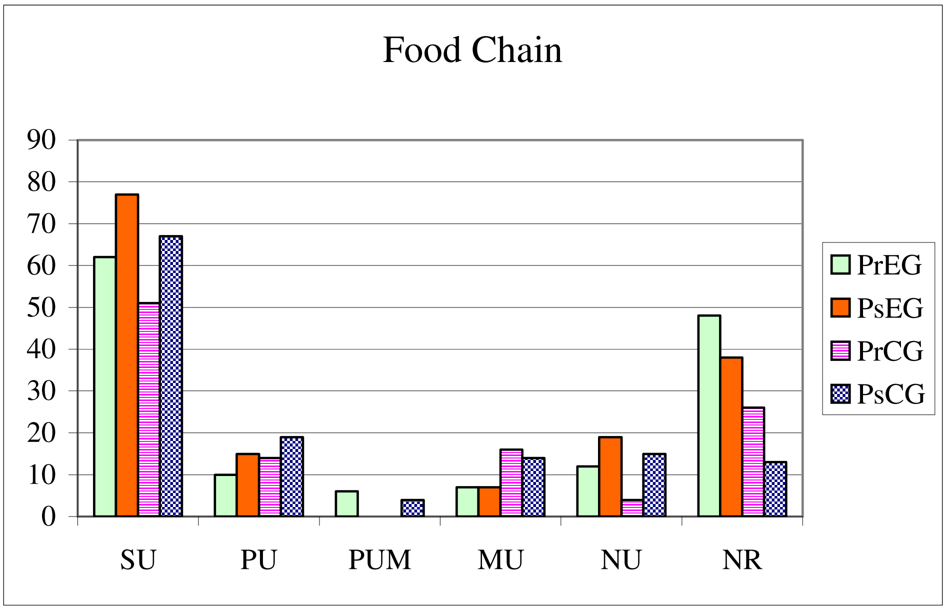
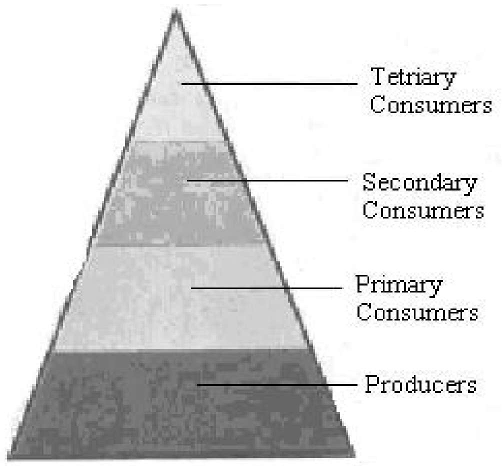


Figure 5.7 Students' Levels of Understanding of Food Chain in the Experimental and the Control Groups

The results from the Figure 5.7 shows that students' sound understanding and partial understanding increased in the experimental and the control groups after the treatment. Students' partial understanding which includes misunderstanding disappeared in the experimental group, while it showed a slight increase in the control group after the treatment. There was almost no change in the students' misunderstanding in the experimental group after the treatment, while there was a slight decrease in the control group. The students' no-understanding increased in the experimental and the control groups after the treatment. The number of non-responding students decreased in both groups after the treatment.

As an example, Question 5 in the TEC was given to show students' ideas on the key concept area of food chain. This question is related to the concepts of producer, primary consumer, secondary consumer, and tertiary consumer under the key concept of energy pyramid.

Question 5. The following figure shows an energy pyramid in an ecosystem.



According to this energy pyramid, which one of the followings is correct?

A) Secondary consumers feed on producers.

B) Tertiary consumers come first in the food chain.

C) Food produced by producers is first taken by tertiary consumers.

D) Tertiary consumers have the least energy among all consumers.

Explain briefly the reason for your choice.

For this question, students were expected to choose the correct item "D" (Tertiary consumers have the least energy among all consumers) and an acceptable explanation of the question might include this main idea:

- Availability of energy decreases as one progresses from producers to consumers.

Students gave various responses to the question, and these responses were categorized according to the their levels of understanding as shown in the following Table 5.11.

Table 5.11 Summary of Students' Levels of Understanding and their Types of Responses to "Energy Pyramid" in the Experimental and the Control Groups during the Treatment

Types of Response	Number of Responses (n=45 for EG, n=37 for CG)			
	Pre EG	Pre CG	Pst EG	Pst CG
Sound Understanding	0	0	2	3
The one who has the most energy are producers. Then, primary, secondary and tertiary consumers come.				1
When producers (plants) are making food, energy releases. The secondary consumers use whatever left from this energy and energy decreases. This energy reaches to the tertiary consumer at the least amount.			1	
When going to the upper steps, energy decreases, number of individuals decreases, and the size of the organisms gets bigger.			1	
When energy is being used from down to up, some of it spread out to the environment/Primary consumers feed on producer and they spend some of the energy that they took as heat. The secondary consumers feed on the first consumers and spend energy similarly. The tertiary consumers take the least energy because they feed on the secondary consumers.				2
Partial Understanding	5	6	8	8
They spent energy when they kill the secondary consumers.		1	5	2
The tertiary consumers get their food from secondary consumers.			1	
There is a producer. They have more food. Their foods decrease as going through the primary, secondary and tertiary consumers in this energy pyramid.		1		
The tertiary consumers get their foods from other organisms or eat leftovers from the nature or other animals.			2	
It is the farthest, very far, from producer/The tertiary consumers are the group take the least food made by producers.	1	1		
Producers produce food. The primary consumers eat the most, the secondary consumers eat more and the tertiary consumers eat the least.	2	1		2
Energy pyramid is getting smaller/The figure shows like that/It has the smallest place to cover/It is at the very low/Tertiary consumers are less/They are at the top of the energy pyramid.	2	2		3
They do not need to produce.				1
Partial Understanding Which Includes Misunderstanding	1	0	0	2
The tertiary consumers are the last group that feed on the secondary consumers. Lion, leopard, cheetah, and big snakes are found in this group.				1
10 % of the energy is received from the soil and water.	1			
The consumers that have the most energy are producers. Food chain begins via producers.				1

Table 5.11 (continued)

Types of Response	Number of Responses (n=45 for EG, n=37 for CG)			
	Pre EG	Pre CG	Pst EG	Pst CG
Misunderstanding	3	6	0	6
Misunderstanding despite the choice of the correct response for the multiple-choice question	0	1	0	2
The tertiary consumer takes its food from producers.		1		
The primary and secondary consumers take food from producers as the tertiary consumers get food from consumers.				1
Secondary consumers feed on the tertiary consumers.				1
Misunderstanding for the choice of the incorrect response for the multiple-choice question	3	5	0	4
No Understanding	1	2	6	7
Non-sense			2	1
Rewrite	1	2	4	6
No Response	31	19	27	9

In addition, students gave alternative responses A and B in the question in the TEC, and they provided some explanations for their alternatives. Some students who chose the alternative "A" (Secondary consumers feed on producers) made several explanations such as; "Producers pass their food on primary consumers", "Consumers take the food made by producers", "Deer eat the green plants which are producers. Jaguars as secondary consumers eat the deer", and "Secondary consumers are the first chain for providing food. It is a chain in which they both consume and provide food resource". Furthermore, some students chose the alternative "B" (Tertiary consumers come first in the food chain) and one of their ideas for that alternative was: "I see tertiary consumers on the top (and they are carnivorous)".

5.4.5.4 Students' Levels of Understanding of Biological Organization

Questions 4, 10, 11 and 12 in the Test of Ecological Concepts were on the key concept area of biological organization. Biological organization included the key concepts of species, pollution, community, ecosystem, biosphere, mutualism, commensalisms, and parasitism. The Figure 5.8 shows the students' levels of understanding indicated by their responses to the key concept area of biological organization.

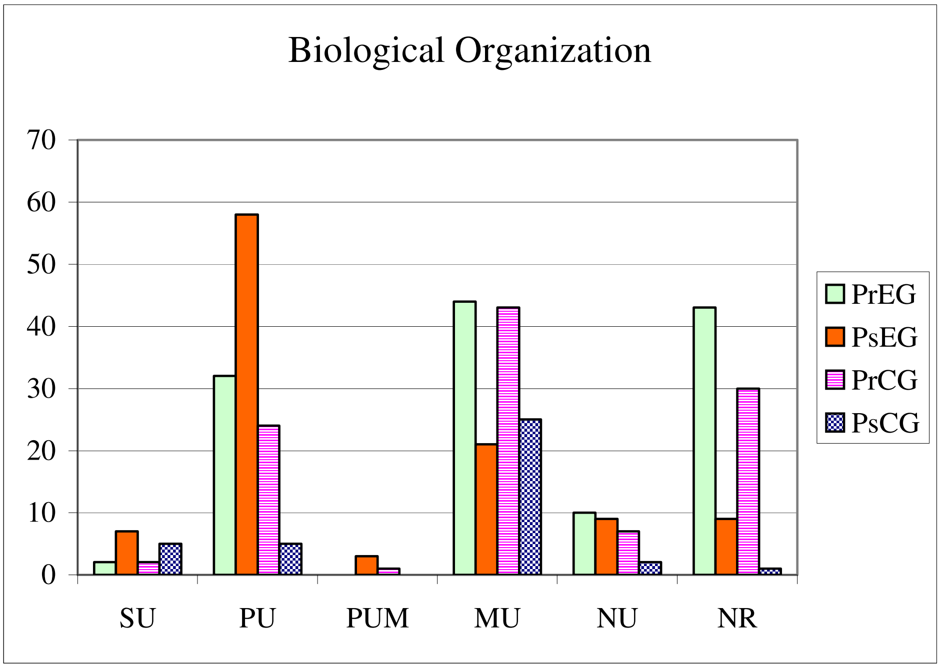


Figure 5.8 Students' Levels of Understanding of Biological Organization in the Experimental and the Control Groups

The results from the Figure 5.8 show that there was an increase in the students' level of sound understanding in the experimental and the control groups after the treatment. There was an apparent increase in the experimental group students' partial understanding, but there was an obvious decrease in the control group students' partial understanding after the treatment. Students' partial understanding which includes misunderstanding increased slightly for the experimental group and small number of partial understanding which includes misunderstanding in the control group students disappeared after the treatment. Students' misunderstanding decreased in the experimental and the control groups after the treatment. Students' no-understanding decreased in the experimental and the control groups after the treatment. There was an obvious decrease in the number of non-responding students in both groups after the treatment.

Question 4.
Some living organisms always need other organisms in order to survive. While these organisms feed on other living organisms, actually they harm other organisms. This symbiotic relationship is an example of;

A) Commensalisms
B) Mutualism
C) Parasitism
D) None

Explain briefly the reasoning behind your choice.

As an example, Question 4 in the TEC was given to display students' ideas on the key concept area of biological organization. This question was about symbiotic relationship. For this question, the correct answer is "C" (Parasitism) and an acceptable explanation of the question might be:

- Parasite organisms lack an enzyme system for digestion system, they feed on other organisms to survive, and they give harm to other organisms.

Students gave various responses to this question, and these responses were categorized according to the their levels of understanding as shown in the following Table 5.12.

Table 5.12 Summary of Levels of Students' Understanding and their Types of Responses to "Symbiotic Relationships" in the Experimental and the Control Groups during the Treatment

Types of Response	Number of Responses (n=45 for EG, n=37 for CG)			
	Pre EG	Pre CG	Pst EG	Pst CG
Sound Understanding	9	14	10	12
Two species of the groups living together feed on intestine or outside. This group is called parasitism/parasites. They injure other organisms when living on them.	8	8	8	9
Parasites take their foods as ready from people and living things, while they are living on other organisms/Parasites live on organisms and feed on them and multiply.	1	4	1	1
Parasitic animals are small, they either feed on an animal by sticking or feeding on belly/head of humans/Parasites like louse and flea cause damage since they live by sucking our blood/Louse lives as parasite on the skin of animal tissues/Organisms such as louse, flea, and tick take their required food from the organism that they live on as ready in order to survive.		2		2
There are some dangerous bacteria in human body. When these bacteria are taking their foods, they harm human beings.			1	
Partial Understanding	2	0	5	0
It is parasite/It lives as parasitic/They are parasitic bacteria.	2		4	
I remember from pinworm.			1	
Partial Understanding Which Includes Misunderstanding	3	3	0	2
Parasitism is a consumer animal.	0	3		1
Some parasites eat food that is taken by human and cause disease by entering human body. On the other hand, some of them are useful.	1			
Parasitic organisms have no digestive enzymes, they injure digestion system of the organisms on which they live.	1			
Digestion enzymes of parasitic organisms are not well developed. They use the enzymes of host organisms and cause damage to them.				1
Parasites usually live on human and animals, they cause damage to them and they live by sucking their blood.	1			

Table 5.12 (continued)

Types of Response	Number of Responses (n=45 for EG, n=37 for CG)			
	Pre EG	Pre CG	Pst EG	Pst CG
Misunderstanding	3	2	3	4
Misunderstanding despite choice of the correct response for the multiple-choice question	0	0	1	2
Organisms help each other in parasitism/They cause damage to each other.				2
These animals attack another animal and eat it in order to survive. For example, they live as parasites e.g. flycatcher.			1	
Misunderstanding for the choice of the incorrect response for the multiple-choice question	3	2	2	2
No Understanding	2	1	15	11
Non-sense	1	1	1	4
Rewrite	1		14	7
No Response	23	17	15	5

Moreover, students gave some alternatives to the question and they chose the alternatives A, B, or D. They provided some explanations for their incorrect choices. Some examples of the students' responses for the alternative "A" (Commensalisms) were: "Commensalisms; to destroy" and "Nature is in balance. If snakes do not eat mice, mice multiply. Therefore, snakes have to eat mice". On the other hand, students who chose the alternative "B" (Mutualism) stated "They live eating the leftovers of other organisms". Also, some students chose the alternative "D" (None), and one of the examples of their reasoning was: "In order to survive, they kill".

5.4.5.5 Students' Understanding Levels of Cycles of Materials

Questions 7, 8, and 9 in the Test of Ecological Concepts were on the key concept area of cycles of materials. The cycles of materials contained the key concepts of oxygen, carbon, nitrogen, and phosphorus cycles. The Figure 5.9 shows the students' levels of understanding indicated by their responses to the key concept area of cycles of materials.

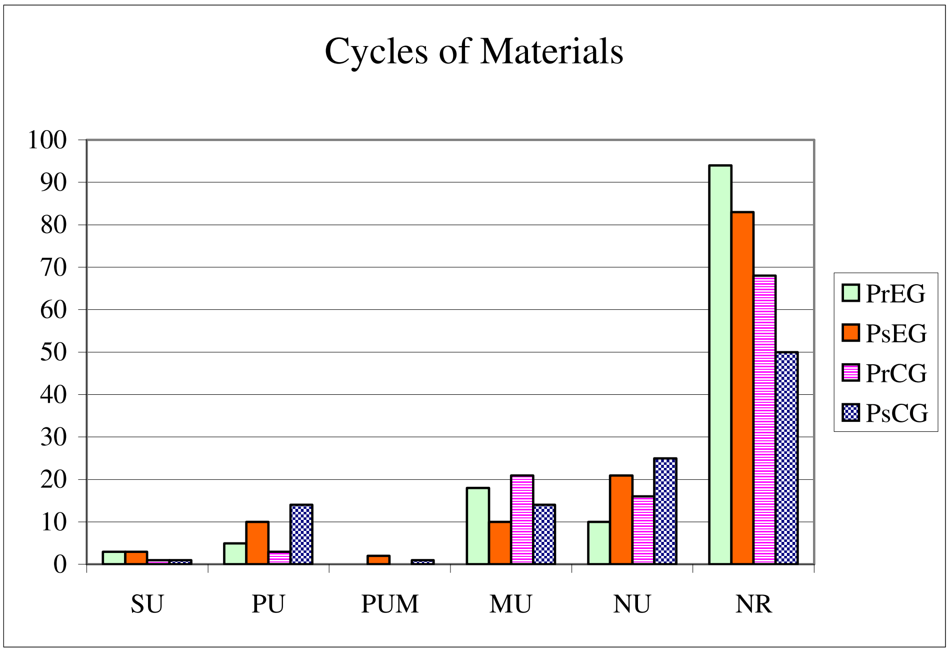


Figure 5.9 Students' Levels of Understanding of Cycles of Materials in the Experimental and the Control Groups

The results from the Figure 5.9 shows that students' sound understanding were low and stayed the same in the experimental and the control groups after the treatment. There was an increase in the experimental and the control group students' partial understanding after the treatment. Students' partial understanding which includes misunderstanding was not observed in the experimental and the control groups before the treatment. However, there was a slight increase in students' partial understanding which includes misunderstanding in the experimental and the control group after the treatment. There was a decrease in students' misunderstanding in the experimental and the control groups after the treatment. Students' no-understanding increased in the experimental and the control groups after the treatment. Students' non-response decreased in the experimental and the control groups after the treatment.

As an example of the key concept area of cycles of materials, Question 9 in the TEC was given. This question was about the key concept of phosphorus cycle.

Question 9.

Related to the phosphorus cycle, which one of the followings is correct?

A) The source of phosphorus cycle is phosphorus found in the atmosphere.
B) Phosphorus is first taken from the soil by animals and then, the phosphorus cycle starts.
C) Phosphorus cycle starts when rocks included phosphorus erode and pass the phosphorus through the water.
D) Phosphorus cycle starts with fishes in the sea.

Explain briefly why you made that choice.

For this question, students were expected to choose the correct answer "C" (Phosphorus cycle starts when rocks that included phosphorus erode and pass the phosphorus to the water). An acceptable explanation of the question might be:

- The source of phosphorus cycle is rocks. Phosphorus occurs by the erosion of the rocks then, it passes from soil to sea in time, e.g. through rain.

The types of students' responses are displayed below in Table 5.13 according to various students' levels of understanding of phosphorus cycle.

Table 5.13 Summary of Students' Levels of Understanding and their Types of Responses to "Phosphorus Cycle" in the Experimental and the Control Groups during the Treatment

Types of Response	Number of Responses (n=45 for EG, n=37 for CG)			
	Pre EG	Pre CG	Pst EG	Pst CG
Sound Understanding	0	0	0	0
Partial Understanding	0	0	3	2
As phosphorus is formed in rocks, water erodes the rocks and it starts. Living organisms in water take this phosphorus. Animals eat fish and phosphorus cycle continue like that.			1	
The source of phosphorus cycle is rocks/Rocks include phosphorus.			1	1
Water plants take phosphorus and animals eat these plants.				1
Phosphorus cycle occurs from land to the sea.			1	
Partial Understanding Which Includes Misunderstanding	0	0	0	0
Misunderstanding	3	3	2	3
Misunderstanding despite choice of the correct response for the multiple-choice question	1	0	1	0
Phosphorus pass to the water, then it evaporate and goes to the clouds, and comes back again to the water.	1			
Phosphorus cycle continues with fishes in sea.			1	
Misunderstanding for the choice of the incorrect response for the multiple-choice question	2	3	1	3
No Understanding	4	7	9	12
Non-sense		1	1	2
Rewrite	4	6	8	10
No Response	35	27	29	19

Some students also gave alternative responses (A, B, or D) to the question. One of the examples of the students' responses for the alternative "A" (The source of phosphorus cycle is phosphorus found in the atmosphere) was: "Phosphorus is substance that is found less in atmosphere layers". Some of the students who chose the alternative "B" (Phosphorus is first taken from the soil by animals and then, the phosphorus cycle starts) stated "Phosphorus cycle starts with animals in land first, and it starts with animals in sea" and "After animals take phosphorus, they leave phosphorus as dung to nature and plants use it. Then, animals eat plants again".

Furthermore, some students made the wrong choice "D" (Phosphorus cycle starts with fishes in the sea). One of their ideas for that alternative was: "Phosphorus is found in different kinds of animals. They transform inorganic phosphorus into organic phosphorus. While human beings eat these fishes, phosphorus passes through to them".

5.4.5.6 Students' Levels of Understanding of Environmental Pollution

Questions 13, 14, 15, 16, and 17 in the TEC were on the key concept area of environmental pollution. Environmental pollution contained the key concepts of water and soil cycle, radiation, and erosion. The Figure 5.10 displays the students' levels of understanding indicated by their responses to the key concept area of environmental pollution.

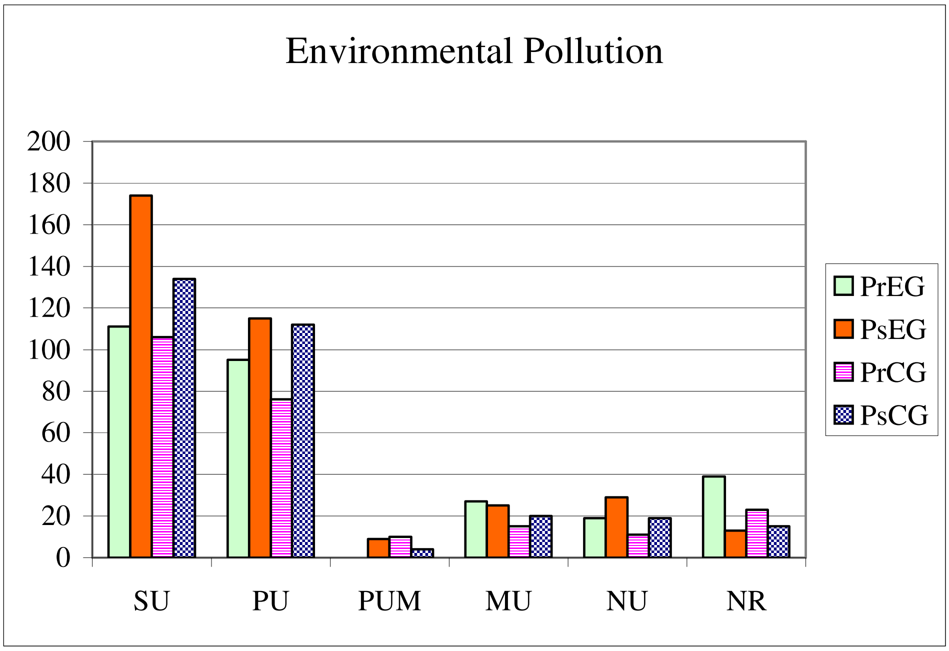


Figure 5.10 Students' Levels of Understanding on Environmental Pollution in the Experimental and the Control Groups

The results from the Figure 5.10 shows that students' sound and partial understanding increased in the experimental and the control groups after the treatment. While students' partial understanding which includes misunderstanding stayed almost same in the experimental group after the treatment, it decreased slightly in the control group after the treatment. Students' misunderstanding slightly decreased in the experimental group after the treatment, but increased in the control group. There was a slight increase in students' no-understanding in the experimental and the control groups after the treatment. However, students' non-response decreased in both groups after the treatment.

As an example, question 13 in the TEC was give to show the students' levels of understanding of the key concept area of environmental pollution. This question was about the key concept of water pollution.

Question 13. In some rivers and lakes the color of water looks turbid and sometimes bad smell spreads out to the environment. Explain why.

For this question, an acceptable explanation might include this main idea:

- Algae accumulation can cause to turbidity. Increasing number of bacteria and their decomposition process can be a reason for bad smell.

Students gave several responses to the question, and these responses were categorized according to the their levels of understanding of water cycle as shown in the following Table 5.14.

Table 5.14 Summary of Students' Levels of Understanding and their Types of Responses to "Water Pollution" in the Experimental and the Control Groups during the Treatment

Types of Response	Number of Responses (n=45 for EG, n=37 for CG)			
	Pre EG	Pre CG	Pst EG	Pst CG
Sound Understanding	26	38	61	49
Algae in water and thickness of algae layer.	2	2	2	2
There are bacteria or viruses.		1		
Dirty poisonous factory (industrial) leftovers.	3	4	20	10
Throwing (harmful) dirt or garbage.	13	12	21	20
Sewage.	1	15	4	12
(Poisonous or dirty) Wastes/Environmental wastes/Chemical wastes.	7	4	14	5
Partial Understanding	13	9	15	11
Water pollution.	4	1	8	5
Environmental pollution.	2	4	4	3
There is no flow in the lakes.	5	1	1	1
No water recycling itself.			1	
As organisms that live and die in water.	1	1		1
People.	1	2		
Air pollution/Air pollution, water pollution, and soil pollution.			1	1
Partial Understanding Which Includes Misunderstanding				
Misunderstanding	5	3	2	2
Water looks like turbid since lakes are muddy.		1		1
As turbid sand flow into water.	1	1		
Water is seen as the bottom of the lake/Reflection of shadow of the trees near the lakes.	1		1	
There are animals living in the streams or swamp under lakes. They made turbid in lakes and then bad smell spreads.	1	1		
Erosion.				1
Fossil fuel.			1	
Algae occur by feces of frogs.	1			
As decomposers decrease.	1			
No Understanding	2	1	2	1
Non-sense	2	1	2	1
Rewrite	0	0	0	0
No Response	7	2	0	1

5.5 Power Analysis

In this study, there were 82 ninth graders and ten variables: two independent variables (treatment and gender): three dependent variables (post-TEC, post-ASB, and post-ASE), and five covariates (pre-TEC, pre-ASB, pre-ASE, SABG, and TOLT). According to the MANCOVA results, the treatment showed statistically significant value with only post-TEC in this study. Gender did not show any statistically significant value with post-TEC, post-ASB, and post-ASE. Furthermore, the interaction of the treatment and gender did not show any statistically significant value with post-TEC, post-ASB, and post-ASE (See Table 5.7).

In order to calculate power of the post-TEC, effect size of the post-TEC should be calculated. The probability of rejecting true null hypothesis was set to .05. At the beginning of the study, effect size was set as medium size effect (.15). The observed value of effect size was again calculated using formula $f^2 = R^2 / (1-R^2)$ for the post-TEC at the end of the study. R^2 was found as .109 for the post-TEC in the MANCOVA as seen in the Table 5.7. The value of f^2 was found to be .13. We might say that there is a slight decrease in the second value and the practical significance of this study (.13) is lower than the expected one (.15). However, this study could be applied for the Test of Ecological Concepts practically.

Then, the power of post-TEC for the sample of 82 students and medium effect size was calculated. The value of power was set to .05 before null hypotheses testing. For power calculation, the formula used was $n= L / f^2 + K+1$.

The values used were n=82, f^2 =.15 and K=21 (3 dependents * 7 independents including covariates and grouping variables).

At the beginning of the study, pre-calculated power of this study was found as 9. This value corresponds to 78 % power using Cohen and Cohen's Table (Cohen and Cohen, 1983). At the end of this study, power was found as 84.2 % for the post-TEC from Table 5.7. The value of power increased after the treatment.

5.6 Summary of the Results of the Study

All students in four classes were administered the pre-TEC, pre-ASB, pre-ASE, and TOLT as pre-tests at the beginning of the treatment, and they were administered the post-TEC, post-ASB, and post-ASE at the end of the treatment. The data were analyzed by the MANCOVA.

In the light of the findings obtained by the statistical analyses, the following results could be summarized as follows:

1. The dependent and the independent variables of this study showed the following correlations; there were positive significant correlations between the SAB and the post-TEC, between the SAB and the pre-ASB, between the SAB and the post-ASB, and between the SAB and the post-ASE. However, no significant correlation was found between the SAB and the pre-ASE. There was also no significant correlation between the SAB and the TOLT. The TOLT showed a positive significant correlation with only the post-ASE. Moreover, a positive significant correlation between the SAB and the pre-TEC was found.

2. There was a positive significant correlation between pre-TEC and the post-TEC. There was a positive significant correlation between pre-ASB and the post-ASB. A positive significant correlation was found between the pre-ASE and post-ASE.

3. There was no significant correlation between the pre-TEC and the post-ASB, similarly, between the pre-TEC and the post-ASE, and also a positive significant correlation was found between the pre-ASB and the post-TEC. Similarly, there was a positive significant correlation between the pre-ASB and the post-ASE.

4. Statistical results showed that there was a significant correlation between the pre-ASE and the post-TEC. Similarly, a positive significant correlation between the pre-ASE and the post-ASB was found.

5. While there were positive significant correlations among the independent dependents of the SAB, the pre-TEC, the pre-ASB, and the pre-ASE, the independent variable of the TOLT did not show any correlation with them. As a result, the SAB, the pre-TEC, the pre-ASB, and the pre-ASE were determined as possible covariates.

6. In Multiple Regression Analysis, the independent variable of the pre-ASB, the SAB, the pre-TEC, and the pre-ASE did show significant values. Then, they were determined as covariates of the study.

7. The conceptual change text oriented instruction in the experimental group was more effective in improving the students' ecology

achievement and to remediate their misconceptions about ecology than did the traditional instruction in the control group. A statistically significant difference between the experimental and the control groups' ecology achievement was found. Additionally, the CCTI increased the students' ecology achievement and decreased the students' misconceptions about ecology more than did the traditional method.

8. There was there was a slight difference between the mean of the ASB scores of the experimental and the control groups from pre-test to post-test.. According to the MANCOVA, the results of the pre-ASB and post-ASB indicated that there was no statistically significant difference between the experimental and the control groups' attitudes towards biology. That is, the CCTI did not increase the students' attitudes towards biology more than did the traditional methods. Furthermore, using the CCTI did not cause a more significant increase in the students' attitudes towards biology and environment.

9. Similarly, there was a slight difference between the mean of the ASE scores of the experimental and the control groups from pre-test to post-test. There was no significant difference found between the experimental and the control groups' attitudes towards environment. The CCTI did not increase the students' attitudes towards environment more than the traditional method.

10. There was no statistically significant difference between males' and females' post-TEC, post-ASB, and post-ASE scores. Gender was not

effective in improving students' post-TEC, post-ASB, and post-ASE scores.

11. The interaction between the treatment and gender did not cause a significant difference on the population means of the post-TEC, the post-ASB, and the post-ASE scores as the p value of interaction between the treatment and gender was higher than .05. Thus, it can be stated that the interaction between the treatment and gender was not effective in improving students' post-TEC, post-ASB, and post-ASE scores.

12. The results of the content analysis related to the Test of Ecological Concepts showed that students had five levels of understanding: sound understanding, partial understanding, partial understanding which includes misunderstanding, misunderstanding, and no understanding. The category of "No understanding" also included two sub-categories: nonsense and rewrite. Furthermore, the treatment caused some positive differences in students' five levels of understanding when examining overall results of the Ecology Concepts Test. The overall results showed that the students' sound understanding increased in the experimental and the control groups after the treatment. There was an increase in the students' partial understanding in the experimental and the control groups after the treatment. There was a slight increase in the experimental group students' partial understanding which includes misunderstanding, and a slight decrease in the control group students after the treatment. The students' misunderstanding decreased in the

experimental and the control groups after the treatment, but the decrease was more in the students in the experimental group. The students' no-understanding increased in the experimental and the control groups after the treatment. The number of non-responding students decreased in the experimental and the control groups after the treatment.

13. In the ecological concepts related to "Biotic and Abiotic Factors", the students' misunderstanding decreased in the experimental and the control groups after the treatment. The decrease was more in the experimental group. In the concepts related to "Food Chain", the students' misunderstanding stayed the same in the experimental group, but there was a slight decrease in the control group. In the concepts related to "Biological Organization" there was a remarkable decrease in the experimental group than the decrease in the control group in the students' misunderstanding after the treatment. In "Cycles of Materials" concepts, there was a decrease in the students' misunderstanding in the experimental and the control groups after the treatment. In "Environmental Pollution" concepts, there was a decrease in students' misunderstanding in the experimental group, but an increase in the control group after the treatment.

CHAPTER 6

CONCLUSION, DISCUSSION, AND IMPLICATIONS

The purpose of this study was to investigate the influences of conceptual change texts oriented instruction accompanied by demonstrations within small groups on ninth grade students' understanding, achievement, attitudes towards biology, and attitudes towards environment about ecological concepts. This chapter includes five sections: conclusions, discussion of the results, internal and external validity of the study, implications of the study, and recommendations for further studies.

6.1 Conclusion

In this study, convenience sampling was used, and the sample was chosen from the accessible population as mentioned previously in Chapter 4. Thus, there is a limitation about generalization of the findings of the study. The results can only be generalized to the accessible population and to similar populations in Turkey. That is, the conclusions drawn from the results of the study below can be applied to a broader population of similar public high school students in Balıkesir.

The following conclusions can be drawn from the results of the study:

- The conceptual change texts oriented instruction accompanied by demonstrations in small groups was an effective tool in eliminating students' common misconceptions, and in improving the students' understanding of ecology and achievement. In contrast to the traditional instruction, the students' ecology achievement increased more with the conceptual change texts oriented instruction accompanied by demonstrations in small groups. However, it was not effective in increasing the experimental and the control group students' attitudes towards biology and environment. Therefore, it did not improve both group students' attitudes towards biology and environment more than the traditional instruction.
- Students' gender difference did not cause any significant increase in the experimental and the control group students' ecology achievement, and attitudes towards biology and attitudes towards environment. That is, it did not improve both group students' ecology achievement, and attitudes towards biology and environment.
- The interaction between the treatment and gender difference did not cause any significant increase in the experimental and the control group students' ecology achievement, and attitudes towards biology and environment. Hence, it did not improve both group students' ecology achievement, and attitudes towards biology and environment.
- The overall results of content analysis of the Test of Ecological Concepts showed that the students' sound understanding and the

partial understanding increased in the experimental and the control groups after the treatment. There was a slight increase in the experimental group students' partial understanding which includes misunderstanding, and a slight decrease in the control group after the treatment. Students' misunderstanding decreased in the experimental and the control groups after the treatment, but the decrease was more in the students in the experimental group. While the students' no-understanding increased in the experimental and the control groups after the treatment, the number of non-responding students decreased in the experimental and the control groups after the treatment.

6.2 Discussion of the Results

As can be seen from the results of the study, this study supports the findings of some previous studies particularly in the area of science achievement. In other words, the results of the study present that there were significant differences of ecology understanding and achievement between the CCTI and the traditional method, in favor of the students in the experimental group. However, both gender, and the interaction between the treatment and gender did not cause any statistically significant increase in students' ecology understanding and achievement, and attitudes towards biology and environment. The results of content analysis of the Test of Ecological Concepts showed that students' levels of understanding had changed similarly in each five level in the experimental and the control groups after the treatment except for the students' partial understanding which includes misunderstanding. In the students' partial understandings, there was an increase in the experimental group and a decrease in the control group after the treatment. Students' misunderstandings decreased more in the experimental group students after the treatment.

The findings of this study also supported the claim that conceptual change approach is one of the most effective strategies improving students' understanding in science. Although attitude have potential to affect science achievement, the findings of this study did not show attitude as a significant factor on students' ecology achievement.

The findings of this current study are in agreement with those of Chambers and Andre (1997), Özkan (2001), Sungur (2000), Eryılmaz (2002), Yeşilyurt (2002), and Graham (2003). Chambers and Andre (1997) demonstrated that the conceptual change text led to better conceptual understanding of electrical concepts than the traditional didactic text. Özkan (2001) found that students who were taught using the conceptual change texts oriented instruction had significantly higher scores of ecology achievement than those students who were instructed by traditional method. Also, she reported that there were no significant differences in students' attitudes towards environment between the experimental and the control groups. Sungur et al. (2001) showed that the conceptual change texts accompanied by concept mapping instruction produced a positive effect on tenth grade students' understanding of the human circulatory system. The mean scores of the experimental group performed better than the control group with respect to the human circulatory system. While the experimental group performed 59.8 %, the traditional group performed 51.6 % after the treatment.

Eryılmaz (2002) showed that the conceptual change discussion was an effective means of reducing the number of misconceptions students held about force and motion. The conceptual change discussion was found significantly effective in improving students' achievement in force and motion. All those results mentioned above were similar to our findings. This current study demonstrated that the conceptual change based instruction was effective than the conventional instruction. However, there was not any significant mean difference among the treatment, and attitude towards biology and environment.

Yeşilyurt (2002) found that the conceptual change text oriented instruction on overcoming students' misconceptions on fluid force at seventh grade level showed better scientific conceptions and elimination of misconceptions than the traditional methods based instruction. Furthermore, Graham (2003) demonstrated that the student-centered instruction with conceptual support had a significant effect on the students' misconceptions and achievement, but it was not effective on the students' attitudes towards science.

There are some other studies that used refutational texts as conceptual instructional tools. These studies displayed similar results like conceptual change texts. Palmer (2003) investigated the relationship between the refutational text and the conceptual change text and indicated that both texts were able to stimulate accommodation in a large quantity of the students about the concept of ecological role in nature. Sönmez (2002) found that the students who were instructed by the refutational text supported with discussion web had better scientific conceptions related to electric current and elimination of misconceptions than did the students who were taught using traditional methods.

Furthermore, the results of this current research are parallel to the findings of some other recent studies in science education. For example, Hardal (2003) used quasi-experimental design in her research. She found that hands-on activity based instruction was significantly effective to improve ninth grade students' achievement of physics (simple electric circuits), but, there was no significant mean difference of students' physics attitudes between the students in the experimental and the control groups. Aşcı (2003) used quasi-experimental design in her study too. She revealed that the multiple intelligences based instruction was significantly effective in the students' ecology achievement and their multiple intelligences, whereas the instruction was not significantly effective in the students' attitudes towards ecology.

Çakır (2002) also found that there was a significant difference between case-based instruction on students' performance skills and academic knowledge. The case-based instruction did not improve students' attitudes towards biology and higher order thinking skills. Students' learning styles and gender difference was also not effective in students' performance skills, attitudes towards biology, higher order thinking skills, and academic knowledge.

However, there are some studies showing conceptual change based instruction was effective in students' attitudes towards science (Sinclair, 1994; Greenfield, 1996). They are not concurrent with our findings. Sinclair (1994) supported the prediction activities were effective in learning genetic concepts in high school biology, and attitudes towards science. Greenfield (1996) indicated that students in grades 3-12 in the USA showed the most positive attitudes towards science and the most positive perceptions of their own science ability and achievement.

Logical thinking abilities can also affect students' science achievement. In literature, there are some studies like those of Yeşilyurt (2002) and Sönmez (2002) with their results supporting this view. Yeşilyurt (2002) indicated that students' logical thinking abilities were significant predictors in the understanding of fluid force concepts. Sönmez (2002) reported that conceptual change texts based instruction and students' logical thinking abilities increased students' achievement in chemistry. Those results are not concurrent with our findings showing there was no statistically significant difference of students' logical thinking abilities on students' ecology achievement, and attitudes towards biology and environment.

Additionally, gender difference can be one of the key factors affecting science achievement. Students' gender difference in science achievement generates much attention and debate. Gentry et al. (2002) reported that the elementary school students were more interested in classroom activities than the middle school students. The girls were also more interested in classroom activities and they enjoyed more than the boys. However, the data from this current study showed that gender, and the interaction between the treatment and gender, were not effective in the students' ecology achievement, and attitudes towards biology and environment. This is consistent with the works of Çakır et al. (2002) and Sungur and Tekkaya (2003).

Çakır et al. (2002) found that the concept mapping based instruction and the conceptual change texts based instruction caused significantly better acquisitions of scientific conceptions related to acid and base concepts than the traditional instruction. However, no significant gender difference was found on understanding of acid and base concepts between the experimental group and the control groups. Sungur and Tekkaya (2003) found that there was a statistically significant mean difference between the concrete and formal students in the students' achievement on the human circulatory system, and attitudes towards biology. There was no statistically significant mean difference between boys and girls in the students' achievement on the human circulatory system, and attitudes towards biology.

In this study, the conceptual change oriented instruction was performed in small groups, and it was effective in improving the students' understanding of ecology and achievement. Our findings have been consistent with previous studies, which reported improved science achievement. For instance, Jensen and Finley (1995) used historical materials in conjunction with a conceptual change strategy involving lecture and small group activities. According to the findings of the study, there was an overall increase in the students' understanding of evolution in Darwinian terms after the treatment.

Rueter and Perrin (1999) found that using the simulation software in the non-biology majors, especially in grade C was significantly effective on the open-ended essay question. Also, the group discussions probably enhanced students' learning as much as technology. Chang and Mao (1999a) also found that the students in the inquiry-group had significantly higher achievement scores and attitude scores about earth science than the students in the control group. The results of the study supported that cooperative learning promoted higher achievement than competitive and individualistic structures. They recommended that students should learn science through direct observation, hands-on activities, and collaborative participation.

The conceptual change oriented instruction explicitly dealt with students' misconceptions, while the traditional instruction did not in this current study. Also, CCTI is an alternative methodology for improving students' ecology achievement. In this study, the conceptual change texts and worksheets included daily life examples and experiences. Everyday examples and experiences are helpful for students to imagine easily the ecological contexts. Students may find easy to grasp some ecological concepts in the school context, and those concepts can become concrete and meaningful for the students.

As a result of the TEC, the students' ideas were analyzed in five levels of understanding categories: sound understanding, partial understanding, partial understanding which includes misunderstanding, misunderstanding, and no understanding. Jensen and Finley (1995) also used the same analyses in their study about evolution. They defined four categories: best understanding, functional misconception, correct/incomplete, and worst understanding. According to their pre-and post-test trace analyses, students showed 98 % increase in the best understanding.

In this current study, the whole results of students' levels of understanding in the experimental and the control groups showed that the students' sound understanding and partial understanding increased in both groups after the treatment. There was a slight increase in the experimental group students' partial understanding which includes misunderstanding, and a slight decrease in the control group students after the treatment. There was a decrease in students' level of misunderstanding in the experimental and the control groups. The students' no-understanding increased in both groups after the treatment. However, these results showed that students' non-response decreased in both groups after the treatment.

According to the results of the students' misunderstanding on five concept areas of ecology in the experimental and control groups, a decrease was found in the students' level of misunderstanding of the key concept areas of biotic-abiotic factors, biological organization, and cycles of materials. While a slight decrease was found in the control group students' level of misunderstanding of the key concept area of food chain, there was no change in the experimental group students' level of misunderstanding of the key concept area of food chain after the treatment. Furthermore, a slight decrease was found in the experimental group students' level of misunderstanding of the key concept area of environmental pollution, an increase was found in the control group students' level of misunderstanding of the key concept area of environmental pollution after the treatment.

Çetin (1998) also reported similar conclusions in her study. She studied English and Turkish eighth grade students' understanding of some selected ecological concepts. Many students from both countries had similar misconceptions and difficulties about the concepts of food chain, food web, food pyramid, and decomposition.

To reveal the reasons behind the conceptual difficulties and misconceptions about ecological concepts, core interview sessions were performed with two teachers, who conducted the treatment in this study. One teacher believed that their students would respond to the TEC questions properly, but if they could not respond to these questions, the reasons might be either the lack of students' knowledge about the ecological concepts related to the questions, or teacher's inappropriate teaching style of ecology. Also, she indicated that most students only wished to graduate from the high school and they did not plan to go to university and therefore, did not paid attention to science courses at that high school. These explanations can also bring reasoning to why students' attitude towards biology did not increase by the CCTI.

On the other hand, the CCTI did not improve students' attitudes towards biology and environment. According to the findings of the MANCOVA, there were no significant difference between the CCTI and the TI on students' attitudes towards biology and environment. As the teachers mentioned in the interviews above, most students do not have the intention to continue with their school life, and as a result their general attitudes towards science courses are not high. In short, the results of the teacher interviews provide a proof for the MANCOVA.

First of all, the first attitude to consider is the attitude towards biology. The CCTI did not show any significant difference of attitudes towards biology. The students in the control and the experimental groups had medium level of attitudes towards biology before and after the treatment according to the descriptive data analyses in this study. Students' average mean of attitude towards biology changed from 58.40 to 58.50 in the control group, while it changed from 56.54 to57.21 in the experimental group, which proves our initial statement about the results of study "There were no significant difference of students' attitudes towards biology between the CCTI and the TI according to the MANCOVA".

It is a commonly accepted notion that the time between pre-tests and post-tests should be three weeks at least, it is a fact that a period of at least three weeks is needed in order to observe a change in students' attitudes towards a subject. Therefore, the reason why there is no difference can be attributed to the inadequate treatment duration. It was observed that even the treatment period of five weeks was not probably sufficient time period to observe a difference in the students' attitudes towards biology. It can be concluded that to cause any change in students' attitudes towards science, longer time may be needed.

The study of Hardal (2003) supports our findings about the relationship between the treatment duration and attitude change. Hardal (2003) found there was no significant difference of students' attitudes towards physics between the hands-on activity based instruction and the conventional instruction. She gave some possible causes about the results of attitude in her study. She mentioned that a three week treatment time period was not enough to show the values of one teaching method over another. Additionally, the treatment was conducted in the last three weeks of the semester. Thus, causing boredom and a decrease in students' attitudes towards simple electric circuits.

Similarly, after five weeks' study duration no change in students' attitudes towards environment was observed as was observed in the study related to attitude towards biology. Then, it became obvious that inadequate treatment problem is valid for this study, and more time is needed for better results. Another reason behind this fact might be the treatment time (end of the semester). Thus, at that time students felt exhausted and they might not performed well.

Moreover, students find some biology and ecological concepts abstract. In addition, they have some difficulties in understanding and learning biology concepts because biology contains many terms originated from Latin language. To conceptualize those terms is not easy for them.

The second attitude to take up is the attitude towards environment. The students in the control and the experimental groups already had a higher mean average of attitude towards environment before the treatment. It changed from 85.58 to 88.51 in the control group, while it changed from 89.66 to 90.42 in the experimental group. There was not significant difference between the CCTI and the TI for the students' attitudes towards environment. They already had some ideas about the ecological phenomena around them which were acquired either from their own experiences, or observations as well as from formal sources. Hence, they are highly aware of the environmental problems around them.

Another reason for the results about students' attitudes toward biology and environment might be the sample size of the study (82 students). If this study were conducted in a bigger sample, the results of the attitude towards biology and environment might have been higher. The conclusion we can derive out of the study is that it is better to replicate this study with a bigger sample. Sinclair (1994) also supports our view by stating that if those kinds of studies were conducted in bigger samples, similar results as well as a positively changing attitude towards science might be reached.

Similarly, gender difference, and the interaction between the treatment and gender were not effective in students' ecology achievement, and attitudes towards biology and environment. If gender difference, and the interaction between the treatment and gender were investigated in a bigger sample, the results of the study would differ. In this study, the students' logical thinking abilities did not contribute to students' ecology achievement, and attitudes toward biology and environment. Again, if this study replicated with a bigger and different school students, the results of the logical thinking ability of students might be different.

Finally, it can be said that though there is a limitation about generalization of the results of this current study to other populations. The conclusion drawn from the results of the study can be applied to a bigger population of similar public high school students.

As described at the end of Chapter 4, medium size treatment effect was expected in our study (.15). At the end of the study, the effect size for post-TEC was found as .13. Pre-calculated power of this study was found as 9.45 for the post-TEC. This value indicates 78 % power using Cohen and Cohen's Table (Cohen and Cohen, 1983). The power was calculated at the end of this study again and it was pound as 84.2 % for the post-TEC. Then, the first value of power increased at the end of the treatment. It can be said that the TEC could be applied to further studies practically as well.

6.3 Internal Validity of the Study

Possible threads of internal validity and the methods were discussed in this section. Those following possible internal threads were considered and desired to control during this study: the subject characteristics, data collector, data collector bias, history, location, mortality, and implementation effect so on.

In this study, a convenience sampling was used to choose the high school and the classes to conduct the treatment. Each student in the classes has different subject characteristics such as gender, previous biology course grades, ecology concepts pre-test scores, biology attitude pre-test scores, environmental attitude pre-test scores, logical thinking abilities, and so on. They might affect students' ecology concepts post-test scores, biology attitude post-test scores, environmental attitude post-test scores, and logical thinking abilities. Hence, the variables of the SAB, pre-TEC, pre-ASB, pre-ASE, and TOLT were considered as covariates in this study (Table 5.2).

To administer the pre- and post-test to all groups approximately at the same time provide to control history and location threats. Student classes were similar characteristics such as same size, same setting, etc. Therefore, exam conditions for both groups were similar. To control the mortality thread in the study, missing data analysis was done. Since there were six of 88 missing students in the post-tests: one of the six students left the school and five of them were absent on the date of post-test, six students were excluded from the study completely. However, 4 of 82 students were not present on the date of the pre-tests. Thus, there were missing data for the independent variables of students' ecology concepts pre-test scores (pre-TEC), students' attitudes towards biology test scores (pre-ASB), students' attitudes towards environment test scores (pre-ASE), and students' test of logical thinking scores (TOLT). The percentage of missing data of pre-tests (4.8%) was less than 5 % of whole data. The missing data were directly replaced with the series mean of the entire subjects (SMEAN).

There were two data collectors; two teachers, and they conducted the treatment. Data collector characteristics and data collector bias were expected to control. Therefore, they were trained about the study aims, conceptual change texts, misconceptions, small group work, using conceptual change texts and demonstration materials during the instruction in the experimental and the control groups. They were also explained when and how the tests administered to the students. In short, the main aim of the training of the teachers was to ensure that data would be collected under standard conditions in teachers' classrooms. Additionally, the researcher made some observations during the instructions in the experimental and the control groups to see the conditions and the treatment applications in the classrooms as intended. However, the pre-tests application might affect the students' achievement in the post-tests after the treatment, it is supposed that effect could be ignored because as all groups would be affected from the pre-tests equally. Moreover, it is expected that the time between a pre- and a post-test should be at least three weeks. In this study, the treatment duration was five weeks. It seems that this time period was enough for pre-TEC and post-TEC, but five weeks might not be enough time for changing the students' attitudes towards biology and environment.

The other internal thread is the confidentiality thread. In this study, it would be not a problem because students were informed about their names would only be used in the statistical analyses. Finally, another internal thread in this study might be Hawthorne effect. It is too difficult to control this thread. To prevent it, researcher paid attention to the suggested rules of conducting an interview as much as possible (Fraenkel, and Wallen, 1996).

6.4 External Validity of the Study

An external validity of a study can contain population generalizibility and ecological generalizibility. The population generalizability is related to which degree the sample of a study represents its population (Fraenkel and Wallen, 1996). In this study, the accessible population was all ninth grade students at a public high school in Balıkesir and the sample of the study was 82 ninth grade students of two biology teachers from the same public high school. The subjects were not randomly chosen from the accessible population and the subjects were selected using non-random sample of convenience. Thus, it limited the generalizability of this study' results. As mentioned in Chapter 4, the students enrolled to this public high school were mostly from middle class socio-economic status living in urban or in the center of Balıkesir. However, the conclusions drawn in the study might be generalized to a broader population of similar public high school students in Balıkesir and Turkey.

The ecological generalizability refers to which degree the findings of the study could be extended to the other settings (Fraenkel and Wallen, 1996). In this study, testing procedures in the experimental and the control groups were conducted in their ordinary classrooms during the regular class time. While the control group was instructed in their ordinary classrooms during the regular class time, the experimental group was given the treatment in their biology laboratory during the regular class time. Therefore, the findings might be generalized to similar settings or conditions at similar public high schools in Turkey.

6.5 Implications of the Study

In the light of the findings of the study and related previous work about ecology and conceptual change approach in the literature, the following implications could be offered:

1. There is no methodology that can be used for all topics in science. However, well-designed conceptual change approach based instruction in science represents an alternative instruction approach to encourage students to modify misconceptions in science. Hence, conceptual change approach based instruction is a powerful methodology for science classes. Science educators, teachers and curriculum developers should take into consideration the student' misconceptions or alternative ideas about science topics. They are faced with the challenge of changing students' alternative ideas to scientifically accurate understandings. They can consider the students' existing conceptions or misconceptions in biology/science in order to select and organize students' intended learning outcomes in biology/science. Therefore, they can design biology/science instruction or biology/science teaching curricula regarding students' common misconceptions and conceptual change strategies in biology/science. If students' alternative ideas are known beforehand, the content of a curriculum might be designed according to the findings or the teacher can prepare a teaching scheme to remove those kinds of

misconceptions with his/her class (Griffiths and Grant, 1985; Adeniyi, 1985; O-Saki and Samiroden, 1990; BouJaoude, 1992).

2. According to the results of post-TEC, the CCTI explicitly dealt with the students' ecology misconceptions, while the traditional method did not. Student' misconceptions or alternative ideas on ecological concepts found in this study can be taken into consideration by science and biology teachers. The remediation techniques for ecological concepts can be re-designed according to the some factors such as class size, class level, and availability of teaching materials. The teachers and the students should be informed about importance and usage of conceptual change texts in science/biology classes. Then, the teachers could plan their instructional activities accordingly.

3. Teachers and curriculum developers can also consider the use of the CCTI as a regular part of biology/science instruction for the remediation of the students' misconceptions.

4. This research supported to use the conceptual change text oriented instruction at ninth grade students' achievement of ecology, though it did not provide any significant evidence in increasing the students' attitudes towards biology. Therefore, teachers can use safely the CCTI on ecology to improve the students' understanding ecological concepts at ninth grade at high school.

5. However, teachers should consider some factors such as class size, teaching materials, and students' pre-knowledge, and grade level can

affect ecology teaching before applying the CCTI to ecology topics. If necessary, the teacher should revise the CCTI, for example the conceptual change texts can be shortened or different teaching materials can be used in ecology instruction.

6. Conceptual change approach is a powerful methodology for science classrooms. This methodology can be applied to some other science/biology concepts at different grade levels in order to improve students' understanding of ecology. Teachers and researchers can also apply the CCTI used in this research to other sciences like chemistry, physics, and mathematics at different grade levels.

7. In this study, the CCTI was designed for small size classes. Therefore, it is advised to use in small size classrooms by teachers and it can be included in the curriculum as a teaching methodology for small size classes. However, the conceptual change texts oriented instruction accompanied by demonstrations among small groups can also be applied in big size classes. In that case, the conceptual change texts should be revised and worksheets should be arranged regarding whole class discussion guided by the teacher.

8. In their classrooms, the teachers can identify students' misconceptions and preconceptions with some measurement techniques such as; quiz involving some questions about misconceptions, misconception diagnosis test, and interview before and after instruction. Teacher should focus mainly higher order thinking skills in teaching and asking questions avoiding knowledge level questions.

9. Teachers in a school need time to plan and collaborate with one another to develop materials, and to try new instructional methods. Later, they need to meet to reflect upon their teaching processes. Teachers can develop and apply the conceptual change approach in their classes. While teachers can apply conceptual change approach requiring demonstrations in small groups in their class, they should find some misconceptions about ecology. Then, they should think carefully how to improve students' learning of ecology with this new method. Additionally, teachers should know or learn how to teach ecology students in small groups.

10. The developed conceptual change texts have several pages and they should be photocopied to hand the students. Sometimes, to find or prepare demonstration materials for biology laboratory class can be too costly. Hence, the teachers should cooperate with their administers in the school to take their support and encouragement in order to perform conceptual change approach requiring demonstrations in small groups. On the other hand, administrators of schools should also explore the possibilities of using the conceptual change approach requiring demonstrations in small groups and they need to support this kind of new methods to improve both teachers and students.

11. In order to facilitate student learning of biology/science at high school, teachers need to learn different biology/science teaching methods, to learn how to use different methods, and develop different activities for their classes. For this reason, some arrangements such as workshops or

in-service education courses in effective teaching methods in biology/science could be designed and presented for primary and secondary school teachers. Thus, they can plan more carefully their instructional activities accordingly. As one of the most effective teaching methods is conceptual change approach, teachers should be also informed about importance and usage of conceptual change texts. The conceptual change texts provide students to realize students' common misconceptions on ecology and the correction of these misconceptions. Since the conceptual change texts including worksheets used in this current study were clear and easy to follow by the teachers and the students, they can also be used for science and biology classrooms.

12. The CCTI can be combined with other teaching methods such as traditional methods, field study, or project work according to the appropriateness of the science topics and teachers can apply it to science classrooms at several levels. Therefore, the mixed methodology would be more powerful methodology for science classrooms.

13. All implications related to ecology at high school mentioned above can also be applied to ecology classes at elementary level. The CCTI present some hints for the graduate levels ecology teaching and it can be also conducted in ecology topics at university level. Thus, it will help to the biology instructors for designing an instruction of ecology as students' previous ecology learning at higher education. In other

words, the conceptual change approach requiring demonstrations in small groups can be performed on ecology topics regarding the students' levels.

6.6 Recommendations for Further Research

Based on the results of the study, related literature review about ecology and conceptual change, and consideration some problems encountered during the testing, and the treatment processes, the following recommendations can be offered for future studies:

1. Further research can be carried out in increasing the reliability of this study.
2. The sample size of this study was 82, and the sample size can be increased to obtain more valid and reliable results. Therefore, future research can replicate this current study in a big sample of population, and the results of the study can be generalized to a big population. In addition, this study showed that there were found that both the CCTI and gender difference were not effective in improving students' attitudes towards biology and environment. If future research can replicate this study in a big sample of population, it can give different results.
3. Future research can replicate this current study for a longer time period, since longer time might affect the students' attitude towards biology and students' attitude towards environment positively.

4. There is no methodology or techniques that can be used for all topics in science however, conceptual change approach is known as an effective methodology for science classrooms. Future research can investigate the effects of the conceptual change approach requiring demonstrations in small groups in improving students' achievement, and attitudes towards different biology topics, different science concepts, and different grade levels.

5. Researchers could make a longitudinal study of ecology from elementary to university level to comprehend development of students about ecological concepts.

6. The effect of different variables such as students' science process skills, motivation, learning styles, and cognitive styles with the CCTI on students' performance in any science topic can be investigated. For instance, students' cognitive styles can affect students' performance in any topic. It is no methodology suits every student in the class. Therefore, by preparing the instructional materials according to students' cognitive styles, teachers can minimize the effect of cognitive style on students' performance in a topic (Bahar, 2003b).

7. In this current study, two teachers carried out the treatment in the experimental and the control groups. However, the researcher, two teachers, and students have not experienced conceptual change approach earlier. On the other hand, using this methodology in small groups was also a little bit time consuming. Therefore, it would be better that further studies can make a trial study of the conceptual

change approach in one of the previous units of the ecology unit. It would give an experience to the researcher, the teacher, and the students. For instance, it would help to the researcher to plan and conduct more carefully the CCTI on ecology unit. If the teacher and students were provided a trial study about the CCTI on a science unit, they would be accustomed to use the CCTI in small groups.

8. If the researcher, teacher, and students have not experienced beforehand the methodology to be used in a biology/science research, it is better that the researcher make a trial study before conducting it in this biology/science topic.

9. Future research can shorten the conceptual change texts and worksheets used in this current. In this current study, two teachers and the students taught that the conceptual change texts and worksheets were too long and time consuming for the instruction, small group discussions, and whole class discussions. On the other hand, ecology unit duration in the Turkish biology curriculum should be made longer in effective instruction of ecology.

10. Further research could use the conceptual change approach with other instructional methods such as traditional methods, hands-on activities, and field study in the remediation of students' misconceptions and increasing students' understanding of ecology. For example, if there is an opportunity to teach ecology lessons outside, the researcher could plan a mixed instruction to teach ecology. This can be an advantage to students' for examining most of the ecology topics in nature and it will

help to students' understanding the abstract ecological concepts such as food web and population.

11. Future research could use another assessment techniques in the conceptual change approach to identify students' common misconceptions and to measure students' levels of understanding such as performance assessment, worksheets assessment, peer assessment, field study, project work, portfolios, semi-structured interviews, and systematic observation checklists to collect data.

REFERENCES

Adeniyi, E.O. (1985). Misconceptions of selected ecological concepts held by some Nigerian students. Journal of Biological Education, 19(4), 311-316.

Alexopoulou, E., & Driver, R. (1996). Small-group discussion in physics: Peer interaction modes in pairs and fours. Journal of Research in Science Teaching, 33(10), 1099-1114.

Anderson, B., & Wallin, A. (2000). Students' understanding of the greenhouse effect, the societal consequences of reducing CO_2 emissions and the problem of ozone layer depletion. Journal of Research in Science Teaching, 37, 1096-1111.

Anderson, D.L., Fisher, K.M., & Norman, G.J. (2002). Development and evaluation of the conceptual inventory of natural selection. Journal of Research in Science Teaching, 39, 952-978.

Appleton, K. (1999). Using theory to guide practice: Teaching science from a constructivist perspective. School Science and Mathematics, 93(5), 269-275.

Aşcı, Z. (2003). The effects of multiple intelligences based instruction on ninth graders' ecology achievement, attitudes toward ecology and multiple intelligences. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Bahar, M. (2003a). Misconceptions in biology education and conceptual change strategies. Kuram ve Uygulamada Eğitim Bilimleri, 3(1), 55-64.

Bahar, M. (2003b). The effect of instructional methods on the performance of the students having different cognitive styles. Hacettepe Üniversitesi, Eğitim Fakültesi Dergisi, 24, 26-32.

Bahar, M., & Hansell, M.H. (2000). The relationship between some psychological factors and their effect on the performance of grid questions and word association tests. Educational Psychology, 20(3),249-364.

Bahar, M., Johnstone, A.H., & Hansell, M. (1999a). Revisiting learning difficulties in biology. Journal of Biological Education, 33(2), 84-86.

Bahar, M., Johnstone, A.H., & Sutcliffe, R.G. (1999b). Investigation of students' cognitive structure in elementary genetics through word association tests. Journal of Biological Education, 33(3), 134-142.

Banister, F., & Ryan, C. (2001). Developing science concepts through story-telling. School Science Review, 83(302), 75-83.

Barman, C.R. Griffiths, A.K., & Okebukola, P.A.O. (1995). High school students' concepts regarding food chains and food webs: A multinational study. International Journal of Science Education, 17(6), 775-782.

Barnett, M., & Morran, J. (2002). Addressing children's alternative frameworks of the moon's phases and eclipses. International Journal of Science Education, 24(8), 859.

Basili, P. A., & Sanford, J. P. (1991). Conceptual change strategies and cooperative group work in chemistry. Journal of Research in Science Teaching, 28, 293-304.

Beeth, M.E. (1998). Teaching for conceptual change: Using status as a metacognitive tool. Science. Education, 82, 343-356.

Berberoğlu, G., Özgür, Ç., Özdemir, Ö., Uysal, E., & Yayan, B. (2003). Factors effecting achievement level of Turkish students in the third international mathematics and science study (TIMSS). Eğitim Bilimleri ve Uygulama Dergisi. 2(3), 1-14.

Binzat, O. (2000). The effects of concept mapping and some other variables on learning of human excretory system. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Börü, S., Öztürk, E., & Cavak, Ş. (2000). Lise biyoloji 1. İstanbul: Milli Eğitim Basımevi.

BouJaoude, S.B. (1992). The relationship between students' strategies and the change in their misunderstandings during a high school chemistry course. Journal of Research in Science Teaching, 29(7), 687-699.

Bowen, C.W., & Phelps, A.J. (1997). Demonstration-based cooperative testing in general chemistry: A broader assessment-of-learning Technique. Journal of Chemical Education, 74(6), 715-720.

Carlsson, B. (2002a). Ecological understanding 2: Transformation-- a key to ecological understanding. International Journal of Science Education, 24(7), 701-715.

Carlsson, B. (2002b). Ecological understanding 1: Ways of experiencing photosynthesis. International Journal of Science Education, 24(7), 681-699.

Chambers, S.K., & Andre, T. (1997). Gender, prior knowledge, interest, and experience in electricity and conceptual change text manipulations in learning about direct current. Journal of Research in Science Teaching, 34, 107-123.

Chan, D.W. (2003). Multiple intelligences and perceived self-efficacy among chinese secondary school teachers in Hong Kong. Educational Psychology, 23(5), 521-534.

Chang, C.Y., & Mao, S.L. (1999a). Comparisons of Taiwan science students' outcomes with inquiry-group versus traditional instruction. The Journal of Educational Research. 92(6), 340-347.

Chang, C.Y., & Mao, S.L. (1999b). The effects on students' cognitive achievement when using the cooperative learning methods in earth science classrooms. School Science and Mathematics, 99(7), 374-379.

Christianson, R.G., & Fisher, K.M. (1999). Comparison of student learning about diffusion and osmosis in constructivist and traditional classrooms. International Journal of Science Education, 21(6), 687– 698.

Cohen, J., & Cohen, P. (1983). Applied multiple regression/correlation analysis for the behavioral sciences. (2nd ed.). Hills, NJ: Lawrence Erlbaum.

Cooper, J.L., Robinson, P. & McKinney, M. (1994). Cooperative learning in the classroom. In D.F. Halpern and Associates. (Eds.) Changing College Classrooms (pp. 74-92). San Francisco: Jossey Bass.

Çakır, Ö. S., Uzuntiryaki, E., & Geban, Ö. (2002). Contribution of conceptual change texts and concept mapping to students' understanding of acids and bases. Paper presented at The Annual Meeting of the National Association for Research in Science Teaching, New Orleans, LA.

Çakır, Ö.S. (2002). The development, implementation and evaluation of a case-based method in science education. Unpublished Doctoral Thesis, The Middle East Technical University, Ankara.

Çakır, Ö.S., Yürük, N., & Geban, Ö. (2001). Effectiveness of conceptual change text oriented instruction on students' understanding of cellular respiration concepts, Paper presented at The Annual Meeting of the National Association for Research in Science Teaching, St. Louis, Minnesota.

Çakıroğlu, J., & Boone, W. (2002). Preservice elementary teachers' self-efficacy beliefs and their conceptions of photosynthesis and inheritance. Journal of Elementary Science Education, 14(1), 1-14.

Çapa, Y. (2000). An analysis of ninth grade students' misconceptions concerning photosynthesis and respiration in plants. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Çetin, G. (1998). A comparison of some English and Turkish students' understanding of selected ecological concepts. Unpublished Master Thesis, University of Leeds, Leeds.

Dahindsa, H.S., & Chung, G. (2003). Attitudes and achievement of Bruneian science students. Journal of Research in Science Teaching, 25(8), 907-922.

Driver, R. (1981). Pupils' alternative frameworks in science. European Journal of Science Education, 3(1), 93-101.

Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). Making sense of secondary science: Research into students' ideas. London, U.K.: Routledge.

Duit, R. (1991). Bibliography: Research on students' alternative frameworks in science-topics, theoretical frameworks, consequences for science teaching. Kiel, Germany, IPN.

Duschl, R.A., & Gitomer, D.H. (1991). Epistemological perspective on conceptual change: Implications for educational practice. Journal of Research in Science Teaching, 28(9), 839-858.

Ertepınar, H., & Geban, Ö. (1996). Effect of instruction supplied with the investigative-oriented laboratory approach on achievement in a science course. Educational Research, 38(3), 333-340.

Eryılmaz, A. (2002). Effects of conceptual assignments and conceptual change discussions on students' misconceptions and achievement regarding force and motion. Journal of Research in Science Teaching, 39(10), 1001-15.

Eyster, L.S., & Tashiro, J.S. (1997). Using manipulatives to teach quantitative concepts in ecology. American Biology Teacher, 59(6), 360-64.

Fernández-Manzanal, R., Rodríguez-Barreiro, L.M., & Casal, M. (1999). Relationship between ecology fieldwork and student attitudes toward environmental protection. Journal of Research in Science Teaching, 36, 431-453.

Finley, F. N., Stewart, J., & Yarroch, W. L. (1982). Teachers' perceptions of important and difficult science content. Science Education, 66(4), 531-538.

Fisher, K. M.(1985). A misconception in biology: Amino acids and translation. Journal of Research in Science Teaching, 22(1), 53-62.

Fraenkel, J. R., & Wallen, N. E. (1996). How to design and evaluate research in education (3rd ed.). New York: McGraw-Hill.

Furnham, A., Reeves, E., & Budhani, S. (2002). Parents think their sons are brighter than their daughters: Sex differences in parental self-examinations and estimations of their children's multiple intelligences. Journal of Genetic Psychology, 163(1), 24-40.

Gallegos, L., Jerezano, M. E., & Flores, F. (1994). Preconceptions and relations used by students in the construction of food chains. Journal of Research in Science Teaching, 31, 259-272.

Galley, M. (2001). Middle School Science Texts Full of Errors, Review Finds. Education Week, 20(19), 6.

Gauld, C. (1997). It must be true—it's in the textbook! Australian Science Teachers Journal, 43(2), 21-27.

Gayford, C. (1993). Discussion-based group work related to environmental issues in science classes with 15-year-old pupils in England. International Journal of Science Education, 15(5), 521-529.

Geban, Ö., Aşkar, P., & Özkan, İ. (1992). Effects of computer simulated experiment and problem solving approaches on students learning outcomes at the high school level. Journal of Educational Research, 86(1), 5-10.

Geban, Ö., Ertepınar, H., Yılmaz, G., Altın, A., & Şahbaz, F. (1994). Bilgisayar destekli eğitimin öğrencilerin fen bilgisi başarılarına ve fen Bilgisi ilgilerine etkisi [The effect of computer aided instruction to students' achievements and attitudes towards science]. I. Ulusal Fen Bilimleri Eğitimi Sempozyumu, Bildiri Özetleri Kitabı (pp.1-2). 9 Eylül Üniversitesi, İzmir.

Gedik, E. (2001). The effect of demonstration method based on conceptual change approach on students' understanding of electrochemistry concept. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Gentry, M., Gable, R.K., & Rizza, M.G. (2002). Students' perceptions of classroom activities: Are there grade-level and gender differences? Journal of Educational Psychology, 94(3), 539-544.

George, R. (2000). Measuring change in students' attitudes toward science over time: an application of latent variable growth modeling. Journal of Science Education and Technology, 9(3), 213-225.

Germann, P.J., & Aram, R.J. (1996). Students' performances on the science processes of recording data, analyzing data, drawing conclusions, and providing evidence. Journal of Research in Science Teaching, 33(7), 773-798.

Gilbert, J.K., & Watts, D.M. (1983). Concepts, misconceptions and alternative conceptions: changing perspectives in science education. Studies in Science Education, 10, 61-98.

Gilbert, J.K., Osborne, R.J., & Fensham, P.J. (1982). Students' science and its consequences for teaching. Science Education, 66(4), 623-633.

Gil-Perez, D., & Carrascosa, J. (1990). What to do about science "misconceptions". Science Education, 74(5), 531-540.

Glynn, S.M., & Takahashi, T. (1998). Learning from analogy-enhanced science text. Journal of Research in Science Teaching, 35(10), 1129-1149.

Graham, G.R. (2003). The effect of students-centred instruction with and without conceptual advocacy on biology students' misconceptions, achievement, attitudes towards science, and cognitive retention. Retrieved May 24, 2003, http://wwwlib.umi.com/dissertations/fullcit/3067506.

Greenfield, T.A. (1996). Gender, ethnicity, science achievement, and attitudes. Journal of Research in Science Teaching, 33, 901-933.

Griffiths, A.K., & Grant, B.A.C. (1985). High school students' understanding of food webs: Identification of a learning hierarchy and related misconceptions. Journal of Research in Science Teaching, 22(5), 421-436.

Han, S. (2002). Using deductive reasoning to promote the change of students' conceptions about force and motion. Journal of Research in Science Teaching. 24(6), 593-610.

Hanley, S. (1994). On constructivism. Retrieved July 11, 2003, from http://www.towson.edu/csme/mctp/Essays/Constructivism.txt.

Hardal, Ö. (2003). The effects of hands-on activities on ninth grade students' achievement and attitudes towards physics, Unpublished Master Thesis, The Middle East Technical University, Ankara.

Hellden, G. (1992a). Pupils' understanding of ecological process. (The LISMA group learning in science and mathematics Report No. 3). Kristianstad University College, Sweden.

Hellden, G. (1992b). Pupils' understanding of ecological process. (The LISMA group learning in science and mathematics Report No. 2). Kristianstad University College, Sweden.

Hewson, M.G., & Hewson, P.W. (1983). Effects of instruction using students' prior knowledge and conceptual change strategies on science learning. Journal of Research in Science Teaching, 20(8), 731-743.

Hewson, P.W., & Thorley, N.R. (1989). The conditions of conceptual change in the classroom. Journal of Research in Science Teaching, 1, 541-553.

Hogan, K., & Fisherkeller, J. (1996). Representing students' thinking about nutrient cycling in ecosystems: biodimential coding of a complex topic. Journal of Research in Science Teaching, 33(9), 941-970.

Hynd, C.R., Mcwhorter, J.Y., Phares, V.L., & Suttles, C.W. (1994). The role of instructional variables in conceptual change in high school physics topics. Journal of Research in Science Teaching, 31(9), 933-946.

Ignatiuk, G.T. (1978). Influence of the amount of time spent in field trip Activities on student attitude toward science and the environment. S.S.T.A. Research Centre Report No. 49, Saskatchewan School Trustees Association, Regina. (ERIC Document Reproduction Service No. ED180758)

Jaus, H. (1982). The effect of environmental education instruction on children's attitudes in elementary school students. Science Education, 66(5), 690-692.

Jegede, O. J., Alaiyemola, F. F., & Okebukola, P. A. O. (1990). The effect of concept mapping on students' anxiety and achievement in biology. Journal of Research in Science Teaching, 27(10), 951-960.

Jensen, M., & Finley, F. (1995). Teaching evolution using historical arguments in a conceptual change strategy. Science Education 79, 147-166.

Jofili, Z., Geraldo, A., & Watts, D.M. (1999). A course for critical constructivism through action research: a case study. Journal for Research in Science and Technology Education, 17(1), 5-17.

Jones, M.G., Howe, A., & Rua, M.J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. Science Education, 84, 180-192.

Keng, G.K. (1997). Students' understanding of photosynthesis, learning approaches and attitudes towards science across grade levels. Unpublished Ph.D. thesis, Leeds University, Leeds.

Kesamang, M.E.E., & Taiwo, A.A. (2002). The correlates of the socio-cultural background of Botswana junior secondary school students with their attitude towards and achievements in science. International Journal of Science Education, 24(9), 919–940.

Khalid, T. (1999). Pre-service teachers' alternative conceptions regarding three ecological issues. Paper presented at the annual meeting of the national association for research in science teaching, Boston, Massachusetts.

Khatete, D.W. (1995). Students' understanding of decomposition and its importance in nature among some Kenyan Students. Unpublished Doctoral Thesis, University of Leeds, Leeds.

Koulaides, V., & Christidou, V. (1999). Models of students' thinking concerning the greenhouse effect and teaching implications. Science Education, 83(5), 559-576.

Lazarowitz, R., Hertz-Lazarowitz, R., & Baird, J. H. (1994). Learning science in a cooperative setting: Academic achievement and affective outcomes. Journal of Research in Science Teaching, 31, 1121-1131.

Leach, J. (1995). Progression in understanding of some ecological concepts, students aged 5 to 16. Unpublished Doctoral Thesis, University of Leeds, Leeds.

Lehman, J.D., Carter, C., & Butler, J.K. (1985) Concept mapping and achievement. Journal of Research in Science Teaching, 22(7), 663-673.

Lewicki, K. (2002). Satisfying Multiple Intelligences and Diverse Talents through Musical Theater. Middle School Journal. 34(2), 39-44.

Lonning, R.A. (1993). Effect of cooperative learning strategies on student verbal interactions and achievement during conceptual change instruction in 10th grade science. Journal of Research in Science Teaching, 30, 1087-1101.

Lord, T. (1994). Using constructivism to enhance student learning in college biology. Journal of College Science Teaching, 23(6), 346-48.

Manzanal, R.F., Rodriguez Barreiro, L.M., & Casal Jimenez M. (1999). Relationship between ecology fieldwork and student attitudes toward environmental protection. International Journal of Science Education, 36(4), 431–454.

McClure, J.R., Sonak, B., & Suen, H.K. (1999). Concept map assessment of classroom learning: reliability, validity, and logistical practicality. Journal of Research in Science Teaching, 36(4), 475-492.

McComas, W. F. (2002). The ideal environmental science curriculum: I. History, rationales, misconceptions and standards. American Biology Teacher, 64(9), 665-672.

McCormick, B., MacKinnon, C., & Jones, E.R.L. (1999). Evaluation of attitude, achievement, and classroom environment in a learner-centered introductory biology class. Presented to the National Association of Research in Science Teaching Annual Meeting in Boston, MA.

Mirjamaija, M. (2001). Improving conceptual change concerning photosynthesis through text design. Learning and Instruction, 11, 241-257.

Mullet, E. (2002). High school students' understanding of resistance in simple series electric circuits. International Journal of Science Education, 24(6), 551-564.

Niaz, M. (2002). Facilitating conceptual change in students' understanding of electrochemistry. Journal of Research in Science Teaching, 24(4), 425-530.

Nolen, J.L. (2003). Multiple intelligences in the classroom. Education, 124(1), 120.

Norman, R. (2003). Gender and physics. International Journal of Science Education, 25(4), 509-536.

Novak, J.D. (1990). Concept mapping: A useful tool for science education. Journal of Research in Science Teaching, 27(10), 937-949.

Nussbaum, E.M. (2002). How introverts versus extroverts approach small-group argumentative discussions. The Elementary School Journal, 102(3), 183-197.

Odom, A.L., & Barrow, L.H. (1995). Development and application of a two-tier diagnostic test measuring college biology students' understanding of diffusion and osmosis after a course of instruction. Journal of Research in Science Teaching, 32(1), 45-61.

Okebukola, P.A. (1990). Attaining meaningful learning of concepts in genetics and ecology: An examination of the potency of the concept-mapping technique, Journal of Research in Science Teaching, 27(5), 493-504.

Okeke, E.A.C., & Wood-Robinson, C. (1980). A study of Nigerian pupils' understanding of selected biological concepts. Journal of Biological Education, 14(4), 329-338.

O-saki, K.M., & Samiroden, W.D. (1990), Students' conceptions of 'Living' and 'Dead'. Journal of Biological Education, 24(3), 199-207.

Özkan, Ö. (2001). Remediation of seventh grade students' misconceptions related to ecological concepts through conceptual change approach. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Palmer, D.H. (1999). Exploring the link between students' scientific and nonscientific conceptions. Science Education, 83, 639-653.

Palmer, D.H. (2003). Investigating the relationship between refutational text and conceptual change. Science Education, 87, 663-684.

Papanastasiou, E.C., & Zembylas, M. (2002). The effect of attitudes on science achievement: A study conducted among high school pupils in Cyprus. International Review of Education, 48(6), 469-484.

Pearsall, N. R., Skipper, J., & Mintzes, J. (1997). Knowledge restructuring in the life sciences: A longitudinal study of conceptual change in biology. Science Education,81(2), 193-215.

Pell, T., & Jarvis, T. (2001). Developing attitude to science scales for use with students of ages from five to eleven years. International Journal of Science Education, 23(8), 1847–1862.

Posner, G.J., Strike, K.A., Hewson, P.W., & Gertzog, W.A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. Science Education, 66(2), 211-227.

Potts, A., Stanisstreet, M., & Boyes, E. (1996). Children's ideas about the ozone layer and opportunities for physics teaching. School Science Review, 78, 57-62.

Pyle, E.J., & Akins-Moffatt, J. (1999). The Effects of Visually-Enhanced Instructional Environments on Students' Conceptual Growth. East Lansing, MI: National Center for Research on Teacher Learning. (ERIC Document Reproduction Service No. EJ651157).

Rice, D., Ryan, J., & Samson, S. (1998). Using concept maps to assess student learning in the science classroom: Must different methods compete?" Journal of Research in Science Teaching, 35(10), 1103-1127.

Ronneau, C. (1990). Radioactivity: A natural Phenomenon. Journal of Chemical Education, 67(9), 736-37.

Rueter, J.G., & Perrin, N.A. (1999). Using a simulation to teach food web dynamics. The American Biology Teacher, 61(2), 116-123.

Schmidt, H.G., De Volder, M.L., De Grave, W.S., Moust, J.H.C., & Patel, V.L. (1989). Explanatory models in the processing of science text: The role of prior knowledge activation through small-group discussion. Journal of Educational Psychology, 81(4) 610-619.

Sharon, K., & Chambers, T.A. (1997). Gender, prior knowledge, interest, and experience in electricity and conceptual change text manipulations in learning about direct current. Journal of Research in Science Teaching. 34(2), 107-123.

Simpson, W.D., & Marek, E. (1988). Understanding and misconceptions of biology concepts held by students attending small high schools and students attending large high schools. Journal of Research in Science Teaching, 25(5), 361-374.

Sinclair, A. S. (1994). Prediction making as an instructional strategy: implications of teacher effects on learning, attitude toward science, and classroom participation. Journal of Research and Development in Education, 27(3), 153-61.

Smerdon, B.A., & Burkam, D.T. (1999). Access to constructivist and didactic teaching: Who gets it? Where is it practiced? Teacher College Record, 101(1), 1-23.

Songer, C.J., & Mintzes, J.J. (1994). Understanding cellular respiration: An analysis of conceptual change in cell biology. Journal of Research in Science Teaching, 31(6), 621-637.

Sönmez, G. (2002). The role of refutational text supported with discussion web in overcoming difficulties with electric current concepts of 6th grade students. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Stavy, R. (1991). Using analogy to overcome misconceptions about conservation of matter. Journal of Research in Science Teaching, 28(4), 305-313.

Stofflett, R.T. (1994). The accommodation of science pedagogical knowledge: The application of conceptual change constructs to teacher education. Journal of Research in Science Teaching, 31(8), 787-810.

Storey, R.D. (1989). Textbook errors and misconceptions in biology: Photosynthesis. American Biology Teacher, 51(5), 271-74.

Storey, R.D. (1992). Textbook Errors and Misconceptions in Biology: Cell Physiology. American Biology Teacher, 54(4), 200-203.

Stylianidou, F. (1997). Students' learning about energy and processes of change. School Science Review, 78(286), 91-97.

Sungur, S. (2000). The contribution of conceptual change texts accompanied by concept mapping to students' understanding of circulatory system. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Sungur, S., & Tekkaya, C. (2003). Students' achievements in human circulatory system unit: The effect of reasoning ability and gender. Journal of Science Education and Technology, 12(1), 59-64.

Sungur, S., Tekkaya, C., & Geban, Ö. (2001). The contribution of conceptual change text accompanied by concept mapping instruction on 10th grade students' understanding of the human circulatory system. School Science and Mathematics, 101(2), 91-102.

Tianyu, W., & Thomas, A. (1991). Conceptual change text versus traditional text and application questions versus no questions in learning about electricity. Contemporary Educational Psychology, 16(2), 103-16.

Tinklin, T. (2003). Gender differences and high attainment. British Educational Research Journal, 29(3), 307-326.

Tobin, K., & Capie, W. (1981). Development and validation of a group test of logical thinking. Educational and Psychological Measurement, 4l(2), 4l3-424.

Valdez, P.S. (November 2001). A monthly portfolio project improves student performance. The Science Teacher, 41-43.

Venville, G.J., & Treagust, D.F. (1998). Exploring conceptual change in genetics using a multidimentional interpretive framework. Journal of Research in Science Teaching, 35(9), 1031-1055.

Wallace, J. D., & Mintzes, J. J. (1990). The concept map as a research tool: Exploring conceptual change in biology. Journal of Research in Science Teaching, 27(10), 1033-1052.

Watson, J. (Dec-Jan 1991). Cooperative learning and computers: One way to address student differences. The Computing Teacher, 9-12

Weaver, G.C. (1998). Strategies in K-12 science instruction to promote conceptual change. Science Education. 82, 455-472.

Webb, P., & Boltt, G. (1990). The food chain to food web: A natural progression? Journal of Biological Education, 24(3), 187-197.

Westbrook, S.L., & Marek, E.A. (1991). A cross-age study of student understanding of the concept of diffusion. Journal of Research in Science Teaching, 28(8), 649-660.

Willson, V.L., Ackerman, C., & Malave, C. (2000). Cross-time attitudes, concept formation, and achievement in college freshman physics. Journal of Research in Science Teaching, 37(10), 1112-1120.

Wood-Robinson, C., Lewis, J., & Leach, J. (2000). Young people's understanding of the nature of genetic information in the cells of an organism. Journal of Biological Education. 35(1), 29-36.

Yager, R.E., & Luts, M.V. (1994). Integrated science: The importance of "how" versus "what". School Science and Mathematics, 94(7), 338-347.

Yeşilyurt, H. (2002). Effectiveness of conceptual change instruction on overcoming students' misconceptions of fluid force at seventh grade level. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Yürük, N., & Geban, Ö. (2001). Conceptual change text: A supplementary material to facilitate conceptual change in electrochemical cell concepts.

Paper presented at The Annual Meeting of the National Association for Research in Science Teaching. St. Louis, Minnesota.

Zhang, Y. (1999). Gender differences in mathematics and science achievement. Applied Research Branch Strategic Policy Human Resources Development Canada. (R-99-18E.a, ISBN: 0-662-28428-3. Cat. No.: MP32-29/99-18E. 1-41).

APPENDIX A

THE OBJECTIVE LIST OF ECOLOGY UNIT

EKOLOJİ ÜNİTESİ HEDEFLER LİSTESİ

HEDEF 1. Ekoloji bilgisi.

DAVRANIŞLAR

1. Organizmaların birbirleri ve çevreleriyle olan ilişkilerini inceleyen bilime ekoloji denildiğini söyleme / yazma.
2. Çevreyi etkileyen canlı ve cansız etmenleri söyleme / yazma.
3. Canlılar arasındaki simbiyotik ilişkileri; mutualizm, kommensalizm ve parazitizmin oluşturduğunu söyleme / yazma.
4. Doğadaki sürekliliğin madde döngüleri ile sağlandığını söyleme / yazma.
5. Madde döngülerinin; su, karbon, oksijen, azot ve fosfor döngüleri olduğunu söyleme / yazma.
6. Biyosferdeki yaşama birliklerinin populasyon, komünite ve ekosistem olduğunu söyleme / yazma.
7. Su, toprak, hava, ses ve radyasyon gibi kirliliklerin olduğunu söyleme / yazma.
8. Erozyona sebep olan etmenleri söyleme / yazma.

HEDEF 2. Ekolojiyi kavrayabilme.

DAVRANIŞLAR

1. Cansız etmenlerden ışık, sıcaklık, iklim, mineral, su ve pH'ın canlılar üzerindeki etkilerini açıklama.
2. Üretici, tüketici ve ayrıştırıcıların çevreye etkilerini açıklama.
3. Ayrıştırıcı bakterilerin ekolojik yönden önemini açıklama.
4. Doğada kirlenmeye neden olabilecek etmenleri açıklama.
5. Sera etkisi, asit yağmurları, ozon tabakasındaki incelme gibi etmenlerin biyosfer üzerindeki etkilerini açıklama.
6. Populasyonun büyümesini etkileyen etmenleri açıklama.
7. İnsanın çevre üzerindeki etkisini açıklama.
8. Populasyon, komünite ve ekosistem arasındaki ilişkiyi açıklama.
9. Madde döngülerinin özelliklerini açıklama.
10. Üretici, tüketici ve ayriştırıcılardan herhangi birinin yok olması halinde doğacak sonuçlarını açıklama.

HEDEF 3. Canlılar arasındaki ilişkileri kavrayabilme.

DAVRANIŞLAR

1. Simbiyotik ilişkileri örnek vererek açıklama.
2. Canlılar arasındaki beslenme ilişkilerinin farklılıklarını açıklama.
3. Ekosistemdeki enerji akışını açıklama.

HEDEF 4. Ekolojinin günlük hayattaki önemini kavrayabilme.

DAVRANIŞLAR

1. Belirlenen bir çevre kirliliğinin yol açabileceği olumsuzlukları söyleme / yazma.
2. Populasyon büyüklüğü ile çevrenin taşıma kapasitesi arasındaki ilişkiyi açıklama.

3. Çevre kirliliğini önlemek için alınabilecek önlemleri, örnek vererek açık-lama.

4. Erozyonun önlenmesi için alınabilecek önlemleri, örnek vererek açıklama.

5. Çevresel Etki Değerlendirmesi'nin (ÇED) amaçlarını açıklama.

HEDEF 5. Ekoloji ile ilgili bilgileri uygulayabilme.

DAVRANIŞLAR

1.Verilen canlı türlerinden besin zinciri oluşturma.

2.Doğadaki madde döngülerini şema halinde gösterme.

3.Verilen bir madde döngüsü şemasında boş bırakılan basamakları tamam-ama.

4.Canlı ve cansız etmenleri kullanarak bir ekosistem modeli oluşturma.

HEDEF 6. Doğal dengeyi korumanın canlılar için önemini takdir ediş.

DAVRANIŞLAR

1.Ülkemizde erozyonu önlemenin önemini belirten yazılar yazma.

2.Doğal dengenin korunması için yapılabilecek çalışmalara aktif olarak katılma.

3.Doğal dengeyi bozmayacak şekilde bilinçli bir üretici ve tüketici olmanın önemini belirten yazılar yazma.

4.Yaşadığı çevre ve doğal dengeyi koruyucu gelişmeleri izleme.

APPENDIX B

THE TEST OF ECOLOGICAL CONCEPTS

EKOLOJİ KAVRAMLARI TESTİ

Adı Soyadı:
Süre: 1 saat
Sınıfı:
Doğum Tarihi:

BÖLÜM 1

Bu bölümde 10 soru vardır. İlk 9 soru için dört seçenek verilmiştir. Her sorunun yalnız bir doğru cevabı vardır. Lütfen size doğru gelen cevabı seçip yanındaki A, B, C veya D harfini daire içine alın. Daha sonra ise, seçeneklerin altında verilmiş olan boşluğa neden bu seçeneği seçtiğinizi açıklayınız.

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1. Bir canlı organizmayı etkileyen çevresel faktörler, canlı (biyotik) ve cansız (abiyotik) faktörler olarak ikiye ayrılır.

Aşağıdaki seçeneklerden hangisinde, iki tane canlı faktör yazılmıştır?

A) İklim – Tüketici

B) Işık – Su

C) Sıcaklık – Üretici

D) Üretici – Ayrıştırıcı

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız.

2. Canlı ve cansızların bir arada bulunduğu ve birbirleriyle etkileşim halinde oldukları sisteme ekosistem denir. Örneğin, Balıkesir'de bulunan Değirmenboğazı Ağaçlandırma ve Piknik alanı bir ekosistemdir.

Aşağıdaki canlılardan hangisi bir ekosistemde kendi besinini üretir?

A) Su yılanı

B) Sinek

C) Çam ağacı

D) Serçe

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız

3. Sinekkapan gibi bazı bitkiler için böcekyiyen yada böcekçil bitki denmektedir. Bununla ilgili olarak aşağıdakilerden hangisi doğrudur?

A) Bu bitkiler ve böcekler birlikte yaşarlar

B) Bu bitkiler ve böceklerin her ikisi de tüketicidir.

C) Böcekler bu bitkilere parazit olarak yaşarlar.

D) Bu bitkiler, hem üretici hem tüketicidirler.

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız

4. Bazı canlılar yaşamlarını sürdürebilmek için sürekli başka canlılara gereksinim duyarlar. Bu canlılar, besinlerini diğer canlılardan sağlarken, aslında o canlılara da zarar vermiş olurlar. Bu durum hangi ortak yaşam şekline örnektir?

A) Kommensalizm

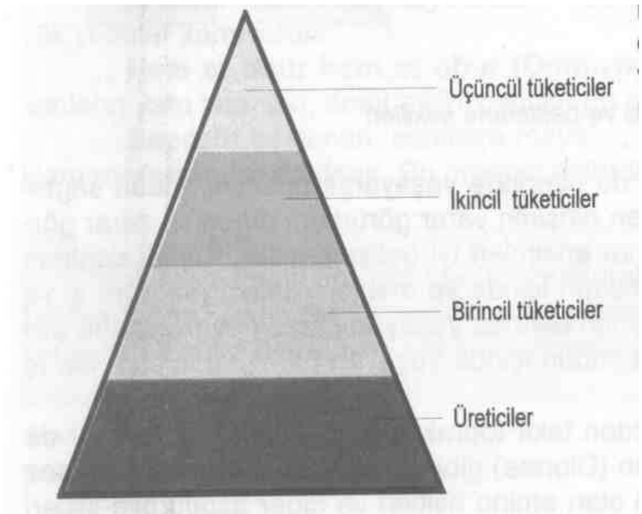
B) Mutualizm

C) Parazitizm

D) Hiçbiri

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız.

5. Aşağıdaki şekil bir ekosistemdeki enerji piramidini göstermektedir.



Bu enerji piramidine göre, aşağıdakilerden hangisi doğrudur?

A) İkincil tüketiciler, üreticilerden besin sağlar.

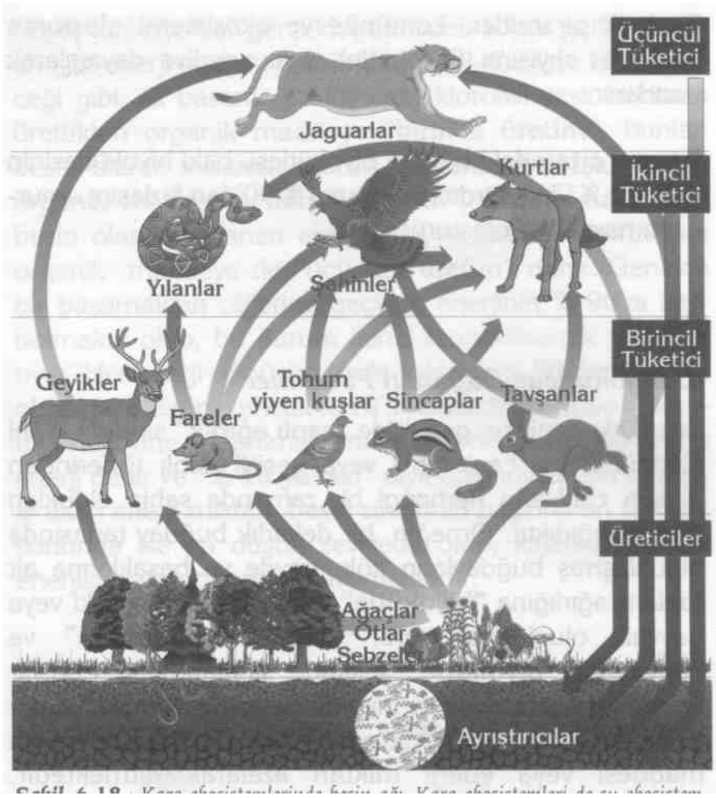
B) Üçüncül tüketiciler, besin zincirinde ilk halkayı oluştururlar.

C) Üreticiler tarafından oluşturulan besinler, ilk önce üçüncül tüketiciler tarafından alınır.

D) Üçüncül tüketiciler, tüketiciler arasında en az enerjiye sahip olan gruptur.

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız

6. Aşağıdaki şekil bir kara ekosistemindeki besin ağını göstermektedir.



Şekle göre, aşağıdakilerden hangisi yanlıştır?

A) Geyik, bitki ile beslenirler.

B) Yılan, sincapla beslenir.

C) Yılan ve şahin, fare ile beslenir.

D) Jaguar, geyik ve ikincil tüketicilerle beslenir.

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız

7. Oksijen ve karbon döngüsü ile ilgili olarak aşağıda verilen cümlelerden hangisi doğrudur?

A) Oksijen döngüsünde, oksijenin kaynağı fotosentez ile oluşan oksijendir.

B) Oksijen döngüsünde, solunumla hidrojen açığa çıkar.

C) Karbon döngüsünde, bitkilerin fotosentezi sonucunda, besin ve karbondioksit üretilir.

D) Karbon döngüsünde, bitkiler atmosferdeki karbondioksiti kullanırlar.

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız

8. Bezelye ve fasulye gibi bitkiler baklagiller denilen bitki grubundandır. Bitkiler, baklagiller ve azot döngüsü ile ilgili olarak aşağıdakilerden hangisi doğrudur?

A) Azot döngüsünde, baklagiller yer almaz.

B) Azot döngüsünde, bitkiler atmosferdeki azot gazını doğrudan almazlar.

C) Azot döngüsünde, mantarlar rol oynar.

D) Azot döngüsünde, herhangi bir bakteri türü rol oynayabilir.

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız

9. Fosfor döngüsü ile ilgili olarak aşağıdakilerden hangisi doğrudur?

A) Fosforun döngüsünün kaynağı atmosferdeki fosfordur.

B) Fosfor döngüsü, karalarda fosforun önce hayvanlar tarafından alınmasıyla başlar.

C) Fosfor döngüsü, fosfatlı kayaçların aşınmasıyla ve fosforun suya geçmesiyle başlar.

D) Fosfor döngüsü denizlerdeki balıklarla başlar.

Seçtiğiniz seçeneğin nedenini kısaca açıklayınız.

10. Aşağıda ekoloji ile ilgili beş kavram verilmiştir. Bunları küçükten büyüğe doğru sıralayınız.

Tür	Biyosfer	Komunite	Ekosistem	Populasyon

EN BÜYÜK

EN KÜÇÜK

BÖLÜM 2

Bu bölümde 7 kısa cevaplı soru bulunmaktadır. Lütfen soruları mümkün olduğunca cevaplamaya çalışınız.

11. Bazı Afrika ülkelerinde, örneğin Etiyopya'da insanlar açlık, hastalık ve ölümle mücadele etmektedir.
Burada yaşayan insan populasyonu dengede midir? Düşüncelerinizi açıklayınız?

12. Bir ormanlık alanda türlerin zaman içinde birbirlerinin yerini alarak ormanlık alana baskın olması söz konusudur.
Ormanlık alanlarda bulunan çimen, çalı ve ağaçtan hangisi baskın tür konumundadır? Neden? Açıklayınız.

13. Bazı dere ve göllerde suyun rengi bulanık görünür, ayrıca bazen buralardan kötü kokular da çevreye yayılır.
Bunlar neden kaynaklanmaktadır? Bu konuda ne düşünüyorsunuz?

14. Bazen TV haberlerinde, bir deniz, göl yada nehirdeki pek çok balığın ölmüş olarak karaya vurduğunu görmekteyiz. Ayrıca, yetkililer o yöredeki diğer balıkların neslinin de tehlikede olduğunu belirtmektedirler.
Bu durumun nedeni ne olabilir?

15. Güzel bir pazar günü pikniği dönüşünde, pek çok yerde oraya buraya atılmış gazete kağıtları, plastik şişeler, metal içecek kutuları veya meyva sebze artıkları görebiliriz.
Tüm bu artıklar doğada ne olur? Düşüncelerinizi belirtiniz.

16. II. Dünya savaşı sırasında atılan atom bombaları ve Çernobil kazası ile ortaya çıkan radyoaktif maddeler, insanlar ve çevre üzerinde olumsuz etkiler yapmaktadır.
Radyoaktif maddelerin insan ve çevreye olan olumsuz etkisi nasıl oluşur, kısaca açıklayınız.

17. Türkiye Erozyonla Mücadele Vakfı (TEMA)'nın söylemlerinden biri de 'Türkiye Çöl Olmasın' dır. Türkiye gerçekten çölleşmekte midir? Eğer çölleşmektedir diyorsanız bunun nedenleri ve sonuçları hakkında ne düşünüyor sunuz?

APPENDIX C

THE ATTITUDE SCALE TOWARDS BIOLOGY

BİYOLOJİ TUTUM ÖLÇEĞİ

Adı Soyadı :…………………………..
Numarası :…………………………..
Doğum Tarihi : ………………………….
Sınıfı :……………………….…….

Açıklama

Bu ölçekte Biyoloji dersine olan tutumu yansıtan cümleler verilmiştir. Her cümlenin karşısına tamamen katılıyorum, katılıyorum, kararsızım, katılmıyorum, hiç katılmıyorum olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

	Tamamen katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç katılmıyorum
1. Biyoloji çok sevdiğim bir alandır.	O	O	O	O	O
2. Biyoloji ile ilgili kitapları okumaktan hoşlanırım.	O	O	O	O	O
3. Biyolojinin günlük hayatta çok önemli yeri yoktur.	O	O	O	O	O
4. Biyoloji ile ilgili ders problemlerini çözmekten hoşlanırım.	O	O	O	O	O
5. Biyoloji konuları ile ilgili daha çok şey öğrenmek isterim.	O	O	O	O	O
6. Biyoloji dersine girerken sıkıntı duyarım.	O	O	O	O	O

7. Biyoloji derslerine zevkle girerim.	O	O	O	O	O
8. Biyoloji dersine ayrılan ders saatinin daha çok olmasını isterim.	O	O	O	O	O
9. Biyoloji dersine çalışırken canım sıkılır.	O	O	O	O	O
10. Biyoloji konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim.	O	O	O	O	O
11. Düşünce sistyemimizi geliştirmede biyoloji öğretimi önemlidir.	O	O	O	O	O
12. Biyoloji çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir.	O	O	O	O	O
13. Dersler içinde biyoloji dersi sevimsiz gelir.	O	O	O	O	O
14. Biyoloji konuları ile ilgili tartışmaya girmek bana cazip gelmez.	O	O	O	O	O
15. Çalışma zamanımın önemli bir kısmını biyoloji dersine ayırmak isterim.	O	O	O	O	O

APPENDIX D

THE ATTITUDE SCALE TOWARDS ENVIRONMENT

ÇEVRE TUTUM ÖLÇEĞİ

Bu ölçek sizlerin çevreye yönelik tutumlarınızı belirlemek üzere hazırlanmıştır. Bu amaçla sizlere çevre ile ilgili çeşitli ifadeler verilmiştir. Herbir ifadenin karşısında Tamamen Katılıyorum, Katılıyorum, Kararsızım, Katılmıyorum, ve Hiç Katılmıyorum seçenekleri bulunmaktadır. Verilen ifadeye ne derecede katıldığınızı, size uygun gelen seçeneğe "çarpı" (X) işareti koyarak belirtiniz. Doğru seçenek size en uygun seçenektir. Lütfen her cümleyi dikkatle okuyunuz, boş bırakmamaya özen gösteriniz.

Adı Soyadı :…………………………. Cinsiyeti : …………………………. Sınıfı :…………………………. Biyoloji Notu : ………………………….	Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1. Çevre konusunda birşeyler öğrenmek hoşuma gider.	O	O	O	O	O
2. Çevre ile ilgili sorunların çözümüne katkıda bulunmak isterim.	O	O	O	O	O
3. "Çevre korunması" sözünü duymaktan bıktım.	O	O	O	O	O
4. İnsanın çevre kirliliğinde en önemli faktör olduğuna inanıyorum.	O	O	O	O	O
5. Çevre konusunda yayımlanan yazıları okurum.	O	O	O	O	O
6. Çevreye zarar vermeyen ürünleri satın almayı tercih ederim.	O	O	O	O	O
7. Çevre sorunlarının, en önce çözümlenmesi gereken sorunlar olduğuna inanıyorum.	O	O	O	O	O
8. Plastik şişede satılan ürünleri kullanmayı tercih etmem.	O	O	O	O	O

9. Orman yangınları beni çok üzer.	O	O	O	O	O
10. “Ozon Tabakası” konusu beni ilgilendirmiyor.	O	O	O	O	O
11. İnsanların attığı çöplerin dünyaya zarar vermediğine inanıyorum.	O	O	O	O	O
12. Hava kirliliğinin çevreye zarar verdiğine inanıyorum.	O	O	O	O	O
13. Avcılığın yasaklanması gereken bir uğraş olduğuna inanıyorum.	O	O	O	O	O
14. Doğadaki en önemli sorunun, çevre kirliliği olduğuna inanıyorum.	O	O	O	O	O
15. Kullanılmış gazete ve kağıtları geri dönüşüm kutularına atmaya özen gösteririm.	O	O	O	O	O
16. Çevreye karşı daha bilinçli olmam için, okulda çevre ile ilgili derslerin daha fazla olmasını isterim.	O	O	O	O	O
17. Çevre ile ilgili projelerde gönüllü olarak çalışmak isterim.	O	O	O	O	O
18. Yaşadığım yerin yakınlarında bir nükleer santral bulunması beni rahatsız etmez.	O	O	O	O	O
19. Ormanların azalmasıyla bitkilerin yok edilmesinin sadece ağaç kesmek değil, orada yaşayan hayvanları ve tüm çevreyi yok etmek olduğuna inanırım.	O	O	O	O	O
20. Nüfus artışının bir çevre sorunu olduğuna inanırım.	O	O	O	O	O
21. Çevre kirliliğinin doğa için en önemli faktör olduğuna inanırım.	O	O	O	O	O
22. Biyoloji dersinin ekoloji ve çevre konuları çok ilgimi çeker.	O	O	O	O	O

APPENDIX E

THE TEST OF LOGICAL THINKING

MANTIKSAL DÜŞÜNME TESTİ

AÇIKLAMA: Bu test, çeşitli alanlarda, özellikle Fen ve Matematik dallarında karşılaşabileceğiniz problemlerde neden-sonuç ilişkisini görüp, problem çözme stratejilerini ne derece kullanabileceğinizi göstermesi açısından çok faydalıdır. Bu test içindeki sorular mantıksal ve bilimsel olarak düşünmeyi gösterecek cevapları içermektedir.

NOT: Soru Kitapçığı üzerinde herhangi bir işlem yapmayınız ve cevaplarınızı yalnızca cevap kağıdına yazınız. CEVAP KAĞIDINI doldururken dikkat edilecek hususlardan birisi, 1 den 8 e kadar olan sorularda her soru için cevap kağıdında iki kutu bulunmaktadır. Soldaki ilk kutuya sizce sorunun uygun cevap şıkkını yazınız, ikinci kutucuğa yani AÇIKLAMASI yazılı kutucuğa ise o soruyla ilgili soru kitapçığındaki Açıklaması kısmındaki şıkları okuyarak sizce en uygun olanını seçiniz. Örneğin 12'nci sorunun cevabı sizce b ise ve Açıklaması kısmındaki en uygun açıklama ikinci şık ise cevap kağıdını aşağıdaki gibi doldurun:

12. $\boxed{b}$ AÇIKLAMASI $\boxed{2}$

9 ve 10 uncu soruları ise soru kitapçığında bu sorularla ilgili kısımları okurken nasıl cevaplayacağınızı daha iyi anlayacaksınız.

SORU 1: Bir boyacı, aynı büyüklükteki altı odayı boyamak için dört kutu boya kullandığına göre sekiz kutu boya ile yine aynı büyüklükte kaç oda boyayabilir?

a. 7 oda

b. 8 oda

c. 9 oda

d. 10 oda

e. Hiçbiri

Açıklaması :

1. Oda sayısının boya kutusu sayısına oranı daima $\frac{3}{2}$ olacaktır.

2. Daha fazla boya kutusu ile fark azalabilir.

3. Oda sayısı ile boya kutusu sayısı arasındaki fark her zaman iki olacaktır.

4. Dört kutu boya ile fark iki olduğuna göre, altı kutu boya ile fark yine iki olacaktır.

5. Ne kadar çok boyaya ihtiyaç olduğunu tahmin etmek mümkün değildir.

SORU 2: On bir odayı boyamak için kaç kutu boya gerekir? (Birinci soruya bakınız)

a. 5 kutu

b. 7 kutu

c. 8 kutu

d. 9 kutu

e. Hiçbiri

Açıklaması

1. Boya kutusu sayısının oda sayısına oranı daima $\frac{2}{3}$ dür.

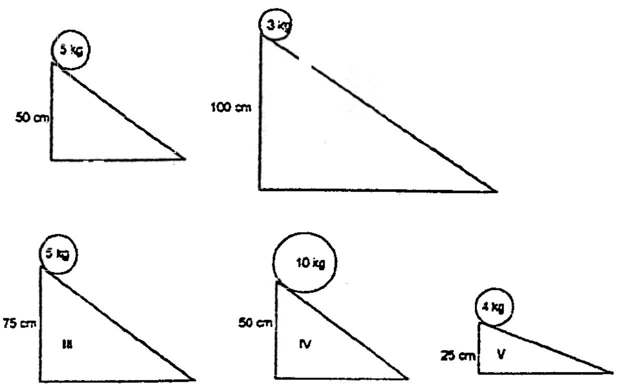
2. Eğer beş oda daha olsaydı, üç kutu boya daha gerekecekti

3. Oda sayısı ile boya kutusu arasındaki fark her zaman ikidir.

4. Boya kutusu sayısı oda sayısının yarısı olacaktır.

5. Boya miktarını tahmin etmek mümkün değildir.

SORU 3: Topun eğik bir düzlemden (rampa) aşağı yuvarlandıktan sonra kat ettiği mesafe ile eğik düzlemin yüksekliği arasındaki ilişkiyi bulmak için deney yapmak isterseniz, aşağıda gösterilen hangi eğik düzlem setlerini kullanırdınız?



a. I ve IV

b. II ve IV

c. I ve III

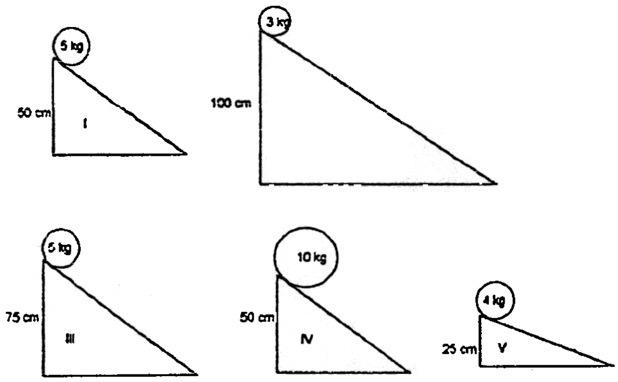
d. II ve V

e. hepsi

Açıklaması :

1. En yüksek eğik düzlemle (rampa) karşı en alçak olan karşılaştırılmalıdır.
2. Tüm eğik düzlem setleri birbiriyle karşılaştırılmalıdır.
3. Yükseklik arttıkça topun ağırlığı azalmalıdır.
4. Yükseklikler aynı fakat top ağırlıkları farklı olmalıdır.
5. Yükseklikler farklı fakat top ağırlıkları aynı olmalıdır.

SORU 4: Tepeden yuvarlanan bir topun eğik düzlemden (rampa) aşağı yuvarlandıktan sonra kat ettiği mesafenin topun ağırlığıyla olan ilişkisini bulmak için bir deney yapmak isterseniz, aşağıda verilen hangi eğik düzlem setlerini kullanırdınız?



a. I ve IV

b. II ve IV

c. I ve III

d. II ve V

e. hepsi

Açıklaması :

1. En ağır olan top en hafif olanla kıyaslanmalıdır.
2. Tüm eğik düzlem setleri birbiriyle karşılaştırılmalıdır.
3. Topun ağırlığı arttıkça, yükseklik azaltılmalıdır.
4. Ağırlıklar farklı fakat yükseklikler aynı olmalıdır.
5. Ağırlıklar aynı fakat yükseklikler farklı olmalıdır.

SORU 5: Bir Amerikalı turist Şark Expresi'nde altı kişinin bulunduğu bir kompartımana girer. Bu kişilerden üçü yalnızca İngilizce ve diğer üçü ise yalnızca Fransızca bilmektedir. Amerikalının kompartımana ilk girdiğinde İngilizce bilen biriyle konuşma olasılığı nedir?

a. 2 de 1

b. 3 de 1

c. 4 de 1

d. 6 da 1

e. 6 da 4

Açıklaması :

1. Ardarda üç Fransızca bilen kişi çıkabildiği için dört seçim yapılması gerekir.
2. Mevcut altı kişi arasından İngilizce bilen bir kişi seçilmelidir.
3. Toplam üç İngilizce bilen kişiden sadece birinin seçilmesi yeterlidir.
4. Kompartımandakilerin yarısı İngilizce konuşur.
5. Altı kişi arasından, bir İngilizce bilen kişinin yanısıra, üç tanede Fransızca bilen kişi seçilebilir.

SORU 6: Üç altın, dört gümüş ve beş bakır para bir torbaya konulduktan sonra, dört altın, iki gümüş ve üç bakır yüzük de aynı torbaya konur. İlk denemede torbadan altın bir nesne çekme olasılığı nedir?

a. 2 de 1

b. 3 de 1

c. 7 de 1

d. 21 de 1

e. Yukarıdakilerden hiçbiri

Açıklaması :

1. Altın, gümüş ve bakırdan yapılan nesneler arasından bir altın nesne seçilmelidir.
2. Paraların $\frac{1}{4}$ ü ve yüzüklerin $\frac{4}{9}$ u altından yapılmıştır.

3. Torbadan çekilen nesnenin para veya yüzük olması önemli olmadığı için, toplam 7 altın nesneden bir tanesinin seçilmesi yeterlidir.
4. Toplam yirmi bir nesneden bir altın nesne seçilmelidir.
5. Torbadaki 21 nesnenin 7 si altından yapılmıştır.

SORU 7: Altı yaşındaki Ahmet'in şeker almak için 50 lirası vardır. Bakkaldaki kapalı iki şeker kutusundan birinde 30 adet kırmızı ve 50 adet sarı renkte şeker bulunmaktadır. İkinci bir kutuda ise 20 adet kırmızı ve 30 adet sarı şeker vardır. Ahmet kırmızı şekerleri sevmektedir. Ahmet'in ikinci kutudan kırmızı şeker çekme olasılığı birinci kutuya göre daha fazla mıdır?

a. Evet
b. Hayır

Açıklaması :

1. Birinci kutuda 30, ikincisinde ise yalnızca 20 kırmızı şeker vardır.
2. Birinci kutuda 20 tane daha fazla sarı şeker, ikincisinde ise yalnıca 10 tane daha fazla sarı şeker vardır.
3. Birinci kutuda 50, ikincisinde ise yalnızca 30 sarı şeker vardır.
4. İkinci kutudaki kırmızı şekerlerin oranı daha fazladır.
5. Birinci kutuda daha fazla sayıda şeker vardır.

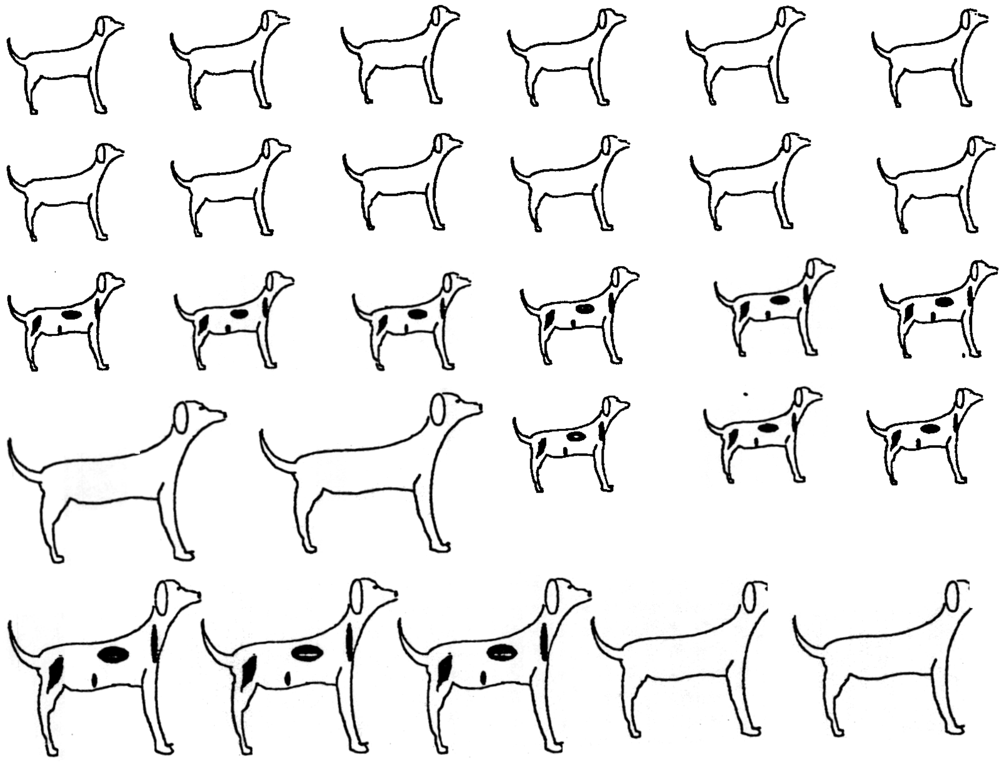
SORU 8: 7 büyük ve 21 tane küçük köpek şekli aşağıda verilmiştir. Bazı köpekler benekli bazıları ise beneksizdir. Büyük köpeklerin benekli olma olasılıkları küçük köpeklerden daha fazla mıdır?

a. Evet
b. Hayır

Açıklaması :

1. Bazı küçük köpeklerin ve bazı büyük köpeklerin benekleri vardır.
2. Dokuz tane küçük köpeğin ve yalnızca üç tane büyük köpeğin benekleri vardır.
3. 28 köpekten 12 tanesi benekli ve geriye kalan 16 tanesi beneksizdir.
4. Büyük köpeklerin $\frac{3}{7}$ si ve küçük köpeklerin $\frac{9}{21}$ i beneklidir.

5. Küçük köpeklerden 12 sinin, fakat büyük köpeklerden ise sadece 4 ünün beneği yoktur.



SORU 9: Bir pastanede üç çeşit ekmek, üç çeşit et ve üç çeşit sos kullanılarak sandviçler yapılmaktadır.

<u>Ekmek Çeşitleri</u>	<u>Et Çeşitleri</u>	<u>Sos Çeşitleri</u>
Buğday (B)	Salam (S)	Ketçap (K)
Çavdar (Ç)	Piliç (P)	Mayonez (M)
Yulaf (Y)	Hindi (H)	Tereyağı (T)

Her bir sandviç ekmek, et ve sos içermektedir. Yalnızca bir ekmek çeşidi, bir et çeşidi kullanılarak kaç çeşit sandviç hazırlanabilir?

Cevap kağıdı üzerinde bu soruyla ilgili bırakılan boşluklara bütün olası sandviç çeşitlerinin listesini çıkarın.
Cevap kağıdında gereksiniminizden fazla yer bırakılmıştır.

Listeyi hazırlarken ekmek, et ve sos çeşitlerinin yukarıda gösterilen kısaltılmış sembollerini kullanınız.

Örnek: BSK =Buğday, Salam, ve Ketçap dan yapılan sandviç

SORU 10: Bir otomobil yarışında Dodge (D), Chevrolet (C), Ford (F) ve Mercedes (M) marka dört araba yarışmaktadır. Seyircilerden biri arabaların yarışı bitiriş sırasının DCFM olacağını tahmin etmektedir. Arabaların diğer mümkün olan bütün yarışı bitirme sıralamalarını cevap kağıdında bu soruyla ilgili bırakılan boşluklara yazınız.

Cevap kağıdında gereksiniminizden fazla yer bırakılmıştır.

Bitirme sıralamalarını gösterirken, arabaların yukarıda gösterilen kısaltılmış sembollerini kullanınız.

Örnek: DCFM yarışı sırasıyla önce Dodge'nin, sonra Chevrolet'in, sonra Ford'un ve en sonra Mercedes'in bitirdiğini gösterir.

APPENDIX F

THE LIST OF MISUNDERSTANDINGS ABOUT ECOLOGICAL CONCEPTS USED IN THE CONCEPTUAL CHANGE TEXTS 1-3

KAVRAMSAL DEĞİŞİM METİNLERİ 1-3'TE KULLANILAN EKOLOJİ KAVRAMLARI İLE İLGİLİ YANLIŞ ANLAMALAR/KAVRAM YANILGILARI

BİOTİK ABİYOTİK FAKTÖRLER

Biyotik Abiyotik Faktörler:

- Işık ve su canlı faktördür, çünkü susuz yaşam olmaz; ışıksız bir ortamda yaşam olmaz; onlar maddenin gelişmesini sağlar; insanın yaşamı için ışık ve suyun olması gerekir veya ışıksız ortamda bitkiler büyüyemez, su içindeki maddeler canlıları etkiler,
- Işık cansız ama, su canlı faktördür,
- İklim ve tüketiciler, çevreyi etkileyen canlı faktördür,
- Üretici ve ayrıştırıcının her ikisi de insan olabilir,
- Üretici ve ayrıştırıcı faktörler bitki ve hayvan olduğundan canlıdır.

Tüketiciler:

Tüketiciler yok olunca;

- bir şey olmaz., ekosistem kendini devam ettirirdi,
- üreticiler üretme görevini yerine getiremezdi,
- tüm ağaçlar yok olduğundan besin üretilmeyecek/besin üretimi olmayacak böylece pek çok canlı yok olacak/çevredeki (stoktaki) besinler biter. Besin

üretimi durduğu için tüm canlılar ölür/canlıların beslenme şansı azalacaktı. Dünya çöl olabilirdi,

- böylece, pek çok canlı yok olacak, oksijen üretimi ve besin yapımı durur,
- üreticiler, üretecekleri gerekli maddeleri bulamazlardı,
- tüketiciler her şey daha fazla olur,
- iyi olmaz çünkü doğada bir hayvan ölse bunu tüketiciler yok eder,
- tüm canlılar ölür/yaşam olmazdı.

Ayrıştırıcılar:

- Ayrıştırıcılar yok olunca ölen canlılar ayrıştırılamaz ve ekosistemde zararlı bakteriler (mikroorganizmalar) çoğalırdı/ekosistem mikroplardan korunamaz ve çökerdi.
- Ayrıştırıcılar yok olunca,artıklar ve inorganik maddeler ayrıştırılamaz.
- Ekosistemde ayrıştırıcılar olarak ağaçlar yer alır. Bunlar olmasaydı canlılar yaşayamazdı,
- Ayrıştırma işleminden ayrıştırıcılar sorumludur çünkü, onlar besin üretirler
- Ayrıştırmadan toprak sorumludur. Çünkü, toprak doğal olan her şeyi ayrıştırır
- Ayrıştırmadan toprak sorumludur. Çünkü, toprak vitamin ve minerallerce zengindir.

Mutualizm:

Mutualizmde;

- Alg ve mantarı her ikisi de yarar görür çünkü; liken kommensal olarak yaşar; birisi yarar birisi zarar görür; biri fotosentez biri besin yapar; liken bir bitkidir oksijen ve besin üretir mantar tüketicidir karbondioksit ve su üretir,
- Alg mantara parazit yaşar çünkü, liken alg ve mantara parazir yaşar; alg mantarlara karşı hazır yiyen canlılardır; mantarlar ağaç ve yeşillik alanda yetiştiği için.

Böcekçil (Et yiyen) Bitkiler:

- Bu bitkiler ve böceklerin her ikisi de hem ot hem et yer çünkü her ikisi de kendi besinini üretemez, heterotroftur.
- Bu bitkiler ve böcekler birlikte yaşadıkları için birbirlerini yiyerek beslenirler.
- Böcekler, bitkiler üzerinde parazit olarak yaşarlar.
- Böcek, bitkinin üzerine parazit olarak yerleşmiştir. Bitki de böcekler gibi böceklerle beslenir.
- Bu bitkiler, hem ototrof hem heterotrofturlar bunlar hem böceklerle hem de başka bitkilerle beslenir yada besin yapmak için uygun şartlar olmadığında böceklerle beslenirler.

Besin Zinciri:

- Besin zincirindeki bitkiler topraktan besinlerini alır.
- Bitkilerin gelişmek için atmosferik gazlara ihtiyacı vardır.
- Besin zincirinin enerji kaynağı;
- Meşe ağacı yapraklarıdır,
- Topraktaki minerallerdir,
- Topraktaki sudur.

Besin Ağı:

Bu besin ağında; (Besin ağı ile ilgili bir soru ile ilgili olarak)

- ton balığı ringa balığı ile beslenmez,
- plankton küçük olduğu için mavi balina küçük plankton balığı ile beslenir ya da besinini çevreden alır,
- erkek balina hem ton balığı hem de ringa balığı ile beslenir,
- erkek balina otoburdur yani plankton da yiyebilir yada her çeşit canlıyla beslenebilir,
- erkek balina ton balığını yemez çünkü onlar aynı soydan gelir,
- kısa boyunlu martı, yılan balığı yanında karadan da beslenir,
- yılan balığı kısa boyunlu martı ile beslenir.

Enerji Piramidi:

- İkincil tüketiciler, hayvanlar ve insanlardır, bunlar besinlerini üreticilerden sağlarlar,
- Birincil ve ikincil tüketiciler, besin üretemezler ve besinlerini üreticilerden sağlarlar,
- İkincil tüketiciler, hem üreticilerden hem de birincil tüketicilerden besin sağlarlar.
- Piramidin en tepesinde bulunanlar piramidin ilk halkasını oluşturur,
- Piramitte az sayıda canlı çok sayıda madde ayrıştırabilir bunlar ayrıştırıcıdır,
- Üçüncül tüketiciler fazla olursa üreticiler azalır ve denge bozulur.

BİYOLOJİK ORGANİZASYON İLE İLGİLİ YANLIŞ ANLAMALAR/YANLIŞ KAVRAMLAR

Biyolojik Organizasyon:

- Biyosfer-Ekosistem-Populasyon-Komünite-Tür
- Biyosfer-Ekosistem-Tür-Komünite-Populasyon
- Biyosfer-Komünite-Populasyon-Ekosistem-Tür
- Biyosfer-Komünite-Populasyon--------------Tür
- Biyosfer-Tür-Populasyon-Komünite-Ekosistem
- Biyosfer-Ekosistem-Populasyon-Komünite-----
- Biyosfer-Komünite-Ekosistem-Populasyon-Tür
- Biyosfer-Populasyon-Komünite-Ekosistem-Tür
- Biyosferekosistem-Komünite-Tür-Populasyon
- Biyosfer-Populasyon-Komünite-Populasyon-Tür
- Biyosfer-Ekosistem-Tür-Populasyon-Komünite
- Biyosfer-Populasyon-Ekosistem-Komünite-Tür
- Biyosfer-Ekosistem-Populasyon-Biyosfer-Tür
- Ekosistem-Populasyon-Tür-Biyosfer-Komünite
- Biyosfer-Ekosistem-Populasyon-Tür-Komünite
- Biyosfer-Komünite-Tür-Populasyon-Ekosistem

- Biyosfer-Komünite-Tür-Ekosistem-Populasyon
- Biyosfer-Tür-Komünite-Ekosistem-Populasyon
- Biyosfer-Ekosistem-Ekosistem-Komünite-Tür
- Biyosfer-Tür-Ekosistem-Populasyon-Komünite

Baskın Tür:

- Ağaç veya çalı baskındır.
- Çalı baskındır çünkü; çalı çok yetişir; çalı, baskındır çünkü; çalı kendiliğinden çıkar. Ağacı ekersen çıkar. Ekmediğinde kendiliğinden çıkmasından emin değilim; çalı fazla ağaç dikilmediği için ve ağaçlandırma yapılmadığı için çimen üzerinde kendiliğinden oluşur; çalı baskındır çünkü, ormanda göze çarpan çalıdır. Ağaçlar, yetkililerin bakması sonucu meydana çıkar.
- Çalı baskındır çünkü, çalının oluşabilmesi için ağaç ve çimenin oluşması kadar su gerekmez.
- Çalı baskındır çünkü, tohumsuz ürediği için her sene kurusada çıkar.
- Çalı baskındır çünkü çalılar yetiştikçe ve orasını yeşertmeye başladıkça ağaç çeşidi artacak ve orman oluşumunda etkili olacaktır.
- Çimen baskındır çünkü, çalılar büyüyor ve ağaç oluyor.
- Çimen baskındır çünkü, önce yosun ve algler sonra çimen, çalı ve en son olarakta ağaçlar meydana gelir.
- Çimen çünkü ormanda en çok çimen bulunur. Çimen daha çok ve sıktır. Her ormanda çimen vardır; orman oluşturulduğu için ilk önce ağaçlar ve çalılar azdır yada küçüktür ve çimenler daha çok yer kaplar.
- Çimen baskındır çünkü, çimen çalılar ağaçların arasında yaygındır. Ağaçlar ise diğerlerine göre daha azdır. Çimen yetişmesi ağaç ve çalıya göre daha kolaydır (çimen çabuk ürer); çimen baskındır çünkü, bunlar daha küçük ve yaşamaları kolay oldudugu için her yerde yaşayabilirler. Doğal bir ortamda kendiliğinden üreyebilir; çimen miktar olarak fazladır. Az yer kaplar. Çimen en küçük yerde çakılı gibidir.

MADDE DÖNGÜSÜ İLE İLGİLİ YANLIŞ ANLAMALAR/YANLIŞ KAVRAMLAR

Karbon Döngüsü:

- Oksijen, fotosentezde kullanılırken, CO_2 solunumda kullanılır.
- Solunumda karbon kullanılır ve oksijen verilir/Solunumda oksijen ve karbondioksit kullanılır.
- Solunumda organik maddeler karbondioksitle parçalanırlar çünkü, enerji, fotosentez sonuncunda ortaya çıkar.

Oksijen Döngüsü:

- Oksijen, fotosentezde kullanılırken, karbondioksit solunumda kullanılır.
- Solunumda karbon kullanılır ve oksijen verilir/Solunumda oksijen ve karbondioksit kullanılır.
- Solunumda organik maddedeler karbondioksitle parçalanırlar çünkü, enerji, fotosentez sonuncunda ortaya çıkar.

Azot Döngüsü:

- Azot döngüsünde baklagiller yer almaz.
- Baklagiller azotu doğrudan kullnabilirler.
- Azot, bezelye, fasulye gibi baklagillerde yer alır.
- Nitrifikasyon bakterileri nitratı nitrite dönüştürürler.

Fosfor Döngüsü:

- Fosforun kaynağı atmosferdir.
- Fosfor döngüsü karalarda fosforun önce hayvanlar tarafından alınmasıyla başlar.
- Fosfor döngüsü denizlerde fosforun bitkiler tarafından alınmasıyla başlar.

ÇEVRESEL KİRLİLİK İLE İLGİLİ YANLIŞ ANLAMALAR/YANLIŞ KAVRAMLAR

Su Kirliliği:

- Balıkların ölmesinin nedeni deniz kirletilerek balıkların fotosentez olaylarının gerçekleşmemesidir.
- Hiç TV'de böyle bir şey görmedim. Görsemde inanmam.

Toprak Kirliliği:

- Doğa bunları yok eder; bunlar kendi kendilerine yok olabilirler.
- Hepsi ayrıştırıcılarla ayrıştırılırlar.
- Doğada yok olmaz öylece yüzyıllarca dururlar;
- Doğa bu artıkları parçalayamaz.
- Plastikler doğada yok olmaz çevre kirliliğine yol açarlar; Plastik şişeler, naylon poşetler veya metal kutular ayrıştırılmadan toprakta durular.
- Metal kutuların doğada kendiliğinden yok olması yüzyıllar sürer.
- Hepsi ayrıştırıcılarla ayrıştırılırlar.
- Meyve sebze artıkları (belki) doğada yok olabilir.
- Toprağın bunları yok etmesi uzun sürer.
- Meyve sebze artıkları kısa sürede toprağa karıştığından tehlikeli değildir.
- Plastikler metal kutular yok olmazlar bunlar geri dönüşümle değerlendirilebilirler.
- Plastik şişeler ve metal kutular doğaya tekrar geri dönmezler.
- Toprak tarafından ayrıştırılırlar.
- Toprak altına girer ve canlılara zarar verir.
- Çürür ve mikroplar kötü kokulara sebeb olur.
- Kağıtlar, gazeteler blli bir süre sonra yok olabilirler ama cam parçalar, metal kutular ve naylonlar yok olmazlar.

Erozyon:

- Orman yangınları, ozon tabakasının incelmesi ve etkisini sürdürememesinden kaynaklanmaktadır.

APPENDIX G

THE SAMPLES OF THE CONCEPTUAL CHANGE TEXT-1 AND WORKSHEETS 1-5

KAVRAMSAL DEĞİŞİM METNİ 1 VE ÇALIŞMA KAĞITLARI 1-5

YÖNERGE

Bilimsel araştırmalar, öğrencilerin kafasında okula gelmeden önce kavramlar hakkında bazı fikirlerin oluştuğunu göstermektedir. Bu kavramların bazıları doğru, bazıları ise yanlışlıklar içerebilmektedir. Öğrencilerin kendilerinin edindiği ve bilimsel gerçeklere uygunluk göstermeyen fikirleri yanlış kavramlara yol açar. Bunlara "kavram yanılgısı" denilmektedir. Öğrencilerde oluşan bu kavram yanılgılarının giderilmesi için önerilen yöntemlerden birisi de derslerde **"**Kavramsal Değişim Metinlerinin**"** kullanılmasıdır. Bu nedenle, Ekoloji "Dünya ve Çevre Ortamı" ünitesinin öğretimi sırasında, sizlerde de varolabilecek bazı kavram yanılgılarının giderilmesine yönelik olarak bu ünite ile ilgili üç kavramsal değişim metini hazırlanmıştır. Bunlar, 1. Canlılar ve çevre, 2. Madde döngüleri, populasyon ve biyosferdeki yaşama birlikleri ve 3. Çevre kirliliğidir. Her bir kavram değiştirme metninde; önce sizlere sorular yöneltilmiş, ardından varsa bazı öğrencilerin konu ile ilgili kavram yanılgıları verilmiş, daha sonra tartışma bölümlerine geçilmiş ve son olarak ta ilk başta verilen sorularla ilgili cevaplar verilmiştir. Kavramsal değişim metinlerinin amacına ulaşması için sizden beklenen, metinlerde verilen her bir sorunun cevabını düşündükten sonra, size verilen metindeki ilgili tüm açıklamaları okumanız ve tartışma bölümlerini uygulamanızdır. Daha sonra da, sorunun cevabını tekrar düşünrek bunu ilk cevabınızla karşılaştırarak doğru cevaba karar vermenizdir.

KAVRAMSAL DEĞİŞİM METNİ 1. CANLILAR VE ÇEVRE

Soru 1. Çevrenin canlı ve cansız etmenleri nelerdir?

Canlı ve cansızlar arasında kesin bir ayrım yapmak zordur. Varlıkları neye göre canlı ve cansız diye sınıflandırırız? Toprak üzerinde duran bir taş parçası ve bir böceğe bakıp biri hareket ediyor diğeri hareket etmiyor diye düşünüp, hareket eden böceğe canlı, hareket etmeyen taşa da cansız mı deriz? Canlı varlıklar, canlılarla olduğu kadar çevrelerindeki cansız varlıklarla da iletişim halindedirler.

TARTIŞMA: Canlı ve cansız konusunu daha iyi kavrayabilmek için Çalışma Yaprağı 1'i inceleyelim. Bakınız Çalışma Yaprağı 1. "Canlı ve Cansız Çevremiz".

Ekoloji, canlıların birbirleriyle ve cansız çevreleriyle olan ilişkisini inceleyen bilim dalıdır. Ekoloji, biyolojinin alt dallarından biridir. Doğada yaşam belirtileri gösteren, doğan, büyüyen, hareket eden, solunum yapan, tepki veren, beslenen, üreyen, iç dengesi (homeostasis) olan, ölen vb. faaliyetler gösteren varlıklara canlı, bu özellikleri göstermeyen varlıklara da cansız diyebiliriz. Bu canlı bireyin yaşamını sürdürdüğü dış ortama çevre diyebiliriz. Doğada canlılar ve onların etrafındaki cansızlar iletişim halindedir.

Soru 2. Bir canlı organizmayı etkileyen diğer canlı ve cansız faktörler nelerdir?

Bazı öğrenciler, çevrenin canlı ve cansız etmenleri sorulduğunda şu şekilde düşünmektedirler:

😐 ışık ve su canlı faktördür, çünkü susuz yaşam olmaz; ışıksız bir ortamda yaşam olmaz; onlar maddenin gelişmesini sağlar; insanın yaşamı için ışık ve suyun olması gerekir veya ışıksız ortamda bitkiler büyüyemez, su içindeki maddeler canlıları etkiler,

😐 ışık cansız ama, su canlı faktördür,

😐 iklim ve tüketiciler, çevreyi etkileyen canlı faktördür,

😐 üretici ve ayrıştırıcının her ikisi de insan olabilir,

😐 üretici ve ayrıştırıcı faktörler bitki ve hayvan olduğundan canlıdır.

Tüm bu öğrencilerin düşünceleri yanlıştır.

TARTIŞMA: Bu konuda açıklama yapmadan önce yine Çalışma Yaprağı 1'e bakalım. Bakınız Çalışma yaprağı 1. “Canlı ve Cansız Çevremiz”.

Şimdi yukarıda örnek verilen öğrencilere ait fikirlerdeki yanlış yerleri bulmaya çalışalım.

Canlı organizmalarla cansız etmenler bir arada bulunurlar. Bunların bir arada bulunduğu sisteme ekosistem denir. Bir ekosistemdeki canlı ve cansız etmenler arasında nasıl bir ilişki vardır? Canlı organizmalar, birbirleriyle ve aynı zamanda yaşadıkları ortamla etkileşim halindedirler. Her organizmanın kendine özgü bir yaşam çevresi vardır. Nasıl biz tuzlu su içemezsek, tatlı su balığının da tuzlu sularda yaşaması zordur. Çünkü tatlı su balığının ekosistemi tatlı suların bulunduğu göl ve nehirlerdir. Ancak, bazı organizmalar belirli çevre koşullarında daha iyi yaşama ve daha iyi uyum sağlama yeteneğine sahiptirler. Buna da, adaptasyon (ortama uyum yeteneği) denir. Bazı canlıların adaptasyon yeteneği yüksek, bazılarınınki de düşük olabilmektedir.

Canlıları, yaşadıkları ortamda etkileyen diğer canlılara çevrenin canlı (biyotik) faktörleri denir. Bunlar, üreticiler, tüketiciler ve ayrıştırıcılar olarak üçe ayrılır. Biz canlıları daha sonra canlıların beslenmesi ile ilgili kısımda detaylı olarak göreceğiz. Canlıları yaşadıkları çevrede etkileyen canlı olmayan varlıklara da çevrenin cansız (abiyotik) faktörleri denir. Cansız faktörleri biz altı grupta toplayabiliriz: ışık, sıcaklık, iklim, toprak ve mineral maddeler, su ve pH.

☺ Bazı öğrenciler iklim, ışık, ve su için canlı demektedirler ancak, bunlar görüleceği gibi cansız faktörlerdir. Ayrıca, üreticiler fotosentez yapar. Ancak, insan fotosentez yapamaz bu nedenle insan üretici değildir. Hayvanlar ve insanlar besinlerini dışardan hazır alırlar, yani tüketicidirler ve ayrıştırıcı değildirler. Ayrıştırıcılar, bazı bakteri ve mantarlardan oluşur. Bunlar, ölmüş bitki, hayvan ve insanları ayrıştırırlar.

Soru 3. Canlılarda besleme şekilleri nelerdir?

Öğrencilere bir ormanlık alandaki ekosistemde bulunan üretici, tüketici ve ayrıştırıcılarla ilgili bir soru sorulduğunda öğrencilerin üreticiler ile ilgili fazla yanlış kavramlara sahip olmadıkları gözlenmiştir. Ama, bunun yanında öğrencilerin tüketici ve ayrıştırıcı ile ilgili bazı kavram yanılgılarına sahip oldukları tespit edilmiştir.

Bazı öğrenciler, tüketicilerle ilgili olarak şunları söylemektedirler:
Tüketiciler yok olunca;

😐 bir şey olmaz., ekosistem kendini devam ettirirdi,

😐 üreticiler üretme görevini yerine getiremezdi,

😐 tüm ağaçlar yok olduğundan besin üretilmeyecek/besin üretimi olmayacak böylece pek çok canlı yok olacak/çevredeki (stoktaki) besinler biter. Besin üretimi durduğu için tüm canlılar ölür/canlıların beslenme şansı azalacaktı. Dünya çöl olabilirdi,

😐 böylece, pek çok canlı yok olacak, oksijen üretimi ve besin yapımı durur,

😐 üreticiler, üretecekleri gerekli maddeleri bulamazlardı,
tüketiciler her şey daha fazla olur,

😐 iyi olmaz çünkü doğada bir hayvan ölse bunu tüketiciler yok eder,

😐 tüm canlılar ölür/yaşam olmazdı.

Bazı öğrenciler de, ayrıştırıcılarla ilgili olarak şunları söylemektedirler:

😐 Ayrıştırıcılar yok olunca, ölen canlılar ayrıştırılamaz ve ekosistemde zararlı bakteriler (mikroorganizmalar) çoğalırdı/ekosistem mikroplardan korunamaz ve çökerdi.

😐 Ayrıştırıcılar yok olunca , artıklar ve inorganik maddeler ayrıştırılamaz.

😐 Ekosistemde ayrıştırıcılar olarak ağaçlar yer alır. Bunlar olmasaydı canlılar yaşayamazdı,

😐 Ayrıştırma işleminden ayrıştırıcılar sorumludur çünkü, onlar besin üretirler

😐 Ayrıştırmadan toprak sorumludur. Çünkü, toprak doğal olan her şeyi ayrıştırır

😐 Ayrıştırmadan toprak sorumludur. Çünkü, toprak vitamin ve minerallerce zengindir.

Tüm bu öğrencilerin tüketiciler ve ayrıştırıcılarla ilgili belirttikleri düşünceler yanlıştır. Peki yanlışlık nerededir?

TARTIŞMA: Önce bu konu ile ilgili bir çalışma yapalım. Bakınız <u>ÇalışmaYaprağı 2."Canlılarda Beslenme".</u>

Bir ekosistemde canlıların (üretici, tüketici ve ayrıştırıcılar) yanında onların içinde bulunduğu cansız çevreleri de vardır. Canlılar, yaşamlarını devam ettirebilmek, enerji ve yapı maddelerini sağlayabilmek için beslenmek zorundadırlar. Canlılar arasında bir beslenme ilişkisi vardır. Canlıları beslenme ilişkileri bakımından iki ana grupta toplayabiliriz: Üreticiler ve tüketiciler.

Üreticiler (ototroflar), kendi besinlerini fotosentez yoluyla kendileri üretirler. Örneğin, bitkiler üretici canlılardır. Üreticiler, ürettikleri besinin bir kısmını bitkinin hayatını devam ettirmesi için kullanılırken, bir kısmını da nişasta olarak depo ederler. Ototrof canlılar, fotosentetik ototrof ve kemosentetik ototrof olarak ikiye ayırabiliriz. Eğer ototrof bir canlı, güneş enerjisi kullanarak fotosentezle kendi besinlerini sentezlerse buna fotosentetik ototrof canlı denir. Bitkiler ve bazı bakteriler bu gruba girerler. Bazı canlılar da, kendi besinlerini güneş enerjisi yerine kimyasal enerji kullanarak sentezlerler. Buna, kemosentez denir. Bunu yapan canlılara, kemosentetik ototrof canlılar denir. Örneğin nitrit ve nitrat bakterileri kemosentez yaparlar.

Tüketiciler (heteretroflar) ise, kendi besinini yapamayan,. doğrudan ya da dolaylı yollardan besinini dışardan hazır alan canlılardır. Örneğin, protistalar, hayvanlar, insanlar ile mantarların ve bakterilerin bir kısmı besinlerini hazır alırlar. Heterotroflar, beslenmeleri açısından üç grupta toplanabilir: Holozoik beslenme, saprofit yaşam ve ortak yaşam (simbiyoz yaşam). Holozoik beslenen canlılar, besinlerini katı parçalar halinde alırlar. Holozoik beslenen hayvanlar üçe ayrılır: otçul hayvanlar, etçil hayvanlar, ve hem otçul hem etçil hayvanlar. Bazı hayvanlar, fotosentez yapan bitkilerle beslenirler. Kısaca, ot ile beslenen hayvanlara otçul (otobur, herbivor) hayvan denir. Örneğin koyun, keçi, inek, geyik, böcekler ve tavşan gibi. Etçiller (etoburlar; karnivorlar) ise, etle beslenen hayvanlardır. Bunlar otla beslenen ya da etle beslenen hayvanları avlayarak besinlerini sağlarlar. Örneğin aslan, kartal, tilki, baykuş, yılan ve timsah gibi. Bazı hayvanlar ise hem ot hem de etle beslenirler ve bunlara hem etçil hem otçul (hem otobur hem etobur; omnivor) hayvan denir. Bu tür beslenen canlılara insan, ayı ve balık örnek olarak verilebilir.

☺ Bazı öğrenciler, "Tüketiciler yok olunca bir şey olmaz., ekosistem kendini devam ettirirdi" demektedirler. Ancak, bu ifade yanlıştır. Aslında, tüketiciler yok olunca ekosistemin işleyişi de bozulacaktır. Yine, bazı öğrenciler "Tüketiciler yok olursa dünyanın dengesi bozulur, tüm canlılar ölür/yaşam olmazdı" demişlerdir. Burada dünyanın dengesi bozulur kısmı doğrudur. Ancak, tüketiciler olmadan üreticiler ve ayrıştırıcılar uzunca bir süre daha yaşamaya devam ederler. Çünkü, tüketicilerin yok olması ile canlıların beslenme şansı azalmayacaktır. Canlıları, üretici, tüketici ve ayrıştırıcı olarak sınıflandırmıştık. Tüketiciler yok olduğunda, bitkiler fotosentez yapmaya ve ayrıştırıcılar da ölen bitkileri ayrıştırmaya devam edecektir. İki canlı da uzunca bir süre ölmeyecektir. Ayrıca, tüketiciler bitkileri tüketmediğinden besin fazlalılığı olacak ve çölleşme olmayacaktır. Kısaca, üretilenler tüketilmeyecek ve dünyada aşırı besin artışı olacaktır. Üretimin fazla olmasıyla ayrıştırma işlemi bu hıza yetişemeyecek ve yeni bitkilerin büyümesi için yer problemi olacaktır. Sonunda ekosistemin, dünyanın dengesi giderek bozulacaktır.

☺ Yukarıdaki açıklamalar ışığı altında bazı öğrencilerin belirttiği "Tüketiciler yok olunca tüm ağaçlar yok olduğundan besin üretilmeyecek/besin üretimi olmayacak böylece pek çok canlı yok olacak/çevredeki (stoktaki) besinler biter. Besin üretimi durduğu için tüm canlılar ölür/canlıların beslenme şansı azalacaktı. Dünya çöl olabilirdi/böylece, pek çok canlı yok olacak, oksijen üretimi ve besin yapımı durur" ifadelerinin de yanlış olduğu görülmektedir. Bazı öğrenciler "Tüketiciler yok olduğunda, tüketiciler her şey daha fazla olur" demektedirler. Bu ifade yanlıştır. Tüketiciler yok olunca, tüketicilerin fazla olması söz konusu olamaz.

☺ Diğer taraftan, tüketiciler ayrıştırıcı olmadıkları için “Tüketiciler yok olunca iyi olmaz çünkü doğada bir hayvan ölse bunu tüketiciler yok eder” ve “Tüketiciler yok olduğunda, üreticiler üretecekleri gerekli maddeleri bulamazlardı” cümleleri de yanlıştır. Doğada ölen canlılar ayrıştırıcılar tarafından parçalanırlar, bunu tüketiciler yapamazlar. Ölü organizmaladaki inorganik maddele ayrıştırılınca inorganik madeler haline dönüşürler. Bunlar da yine başka bitlier tarafından kullanılırlar.

☺ Bunların dışında yukarıdaki öğrencilerin ayrıştırıcılar hakkında da kavram yanılgıları olduğunu belirtmiştik. Örneğin, bazı öğrenciler, ağaçların, ekosistemde ayrıştırıcı olduğunu söylemektedirler.Bu düşünce yanlıştır çünkü, ağaçlar üreticidirler. Bazı öğrenciler, ayrıştırma işleminden toprak sorumludur demektedirler. Bu yanlıştır çünkü, bundan ayrıştırıcı canlılar sorumludur. Bazı öğrenciler de “Ayrıştırma işleminden ayrıştırıcılar sorumludur çünkü, onlar besin üretirler” demektedirler. Bu ifade tam olarak doğru değildir. Ayrıştırma işlemi ayrıştırıcılar tarafından gerçekleştirilir ancak, ayrıştırıcılar besin üretmezler, bunu üreticiler yapar.

🕮 Aslında, ayrıştırıcılar beslenme bakımından kendi besinlerini yapamazlar ve dışardan hazır olarak alırlar yani bunlar tüketici organizmalardır. Ayrıştırıcılara, saprofitler veya çürükçül canlılar da denilmektedir. Ayrıştırıcılara örnek olarak bazı bakteriler, küf mantarları ve şapkalı mantarlar verilebilir. Saprofitler, azotlu ve karbonlu besin ihtiyaçlarını, ölen organizmalardan veya canlı artık ve salgılarından sağlarlar. Bazı öğrencilerin belirttiği ayrıştırıcılar yok olunca, artıklar ve inorganik maddelere ayrıştırılamaz cümlesi yanlıştır. Çünkü, ölü canlılardaki organik maddeler inorganik maddelere parçalanıp, ayrışarak toprağa karışır. Ayrıca, topraktaki madensel tuz oranı da artmış olur. Böylece ölü bitkilerdeki organik maddeler inorganik hale dönüşmüş olur. İnorganik maddeler de, tekrar başka bitkilerce kullanılabilirler. Böylece, bitkiler üretecekleri inorganik maddeleri bulurlar. İnorganik maddeler de, tekrar başka bitkilerce kullanılabilirler.

🕮 Ayrıştırma işleminde saprofitler, önce salgıladıkları enzimlerle besinleri sindirir, canlı artıklarını parçalarlar ve suda çözünen küçük molekülleri emerek beslenirler ve daha sonra ve vücutlarına bunları dahil ederler. Bu şekildeki beslenmeye saprofit (çürükçül) beslenme denir. Kısaca, çürükçül canlılar, ölü organizmaları doğadan temizleyerek aynı zamanda kendilerine besin elde ederler.

☺ Bazı öğrenciler, "Ayrıştırıcılar yok olunca, ölen canlılar ayrıştırılamaz ve ekosistemde zararlı bakteriler (mikroorganizmalar) çoğalırdı/ekosistem mikroplardan korunamaz ve çökerdi" demektedirler. Bu da doğru değildir. Çünkü, bazı mikroorganizmalar ayrıştırıcıdır, ayrıştırıcılar yok olunca da bu mikroorganizmalarda (mikroplarda) yok olacaktır. Bu nedenle, ekosistemde mikroplar çoğalmayacak, mikroplar yok olacaktır. Ancak, burada ekosistem çökerdi cümlesi doğrudur. Çünkü, ortamda sadece üretici ve tüketici kalacaktır. Üreticiler, besin üretince bunları tüketiciler tüketecek, ama ölü organizmalar ayrışmayacak ve bunlar ortamda birikecektir. Ayrışma olmayınca da bitkilerin büyümesi için gerekli inorganik maddeler ortamda olmayacak ve bitkiler yeterince gelişemeyecek. Bir süre sonra da ekosistem çökecektir.

Soru 4. Canlılarda ortak yaşam nasıl olmaktadır?
Öğrencilere mutualizm ilgili soru sorulduğunda bazı yanlış kavramlara sahip oldukları gözlenmiştir. Bunlardan bazıları şöyledir:
Bu yaşam şeklinde;

😐 Alg ve mantarı her ikisi de yarar görür çünkü; liken kommensal olarak yaşar; birisi yarar birisi zarar görür; biri fotosentez biri besin yapar; liken bir bitkidir oksijen ve besin üretir mantar tüketicidir karbondioksit ve su üretir,

😐 Alg mantara parazit yaşar çünkü, liken alg ve mantara parazir yaşar; alg mantarlara karşı hazır yiyen canlılardır; mantarlar ağaç ve yeşillik alanda yetiştiği için.

Tüm bu öğrencilerin düşünceleri yanlıştır. Yanlışlıkları bulmadan önce ortak yaşamla ilgili bir tartışma yapalım.

TARTIŞMA: Bakınız Çalışma yaprağı 3. "Ortak Yaşam".

Bazı canlılar yaşamak için bir diğer canlı organizmaya ihtiyaç duyabilirler. Yaşamak için iki canlı birlikteliğinde canlılar arasında pozitif veya negatif ilişkiler de bulunabilir. İki canlının birlikteliğine simbiyoz yaşam (ortak yaşam) denir. Bunlardan en yaygın olarak bilinenleri: mutualizm, kommensalizm ve parasitizmdir.

Mutualizmde, birlikte yaşayan canlıların her ikisi de bu ortaklıktan fayda sağlar (++). Ancak, bu iki canlıdan biri diğeri olmadan yaşayamaz. Örneğin likenler bu gruba girerler. Diğer bir oratk yaşam şekli kommansalizmdir. Beraber yaşayan iki canlıdan biri, bu birliktelikten fayda yada zarar görmez diğeri ise fayda görürse böyle beslenme ilişkisine kommensalizm (+0) denir. Örneğin, köpek balığının etrafından dolaşan ve onun artıklarıyla beslenen küçük balıklar kommensal olarak yaşarlar. Diğer taraftan, eğer bir canlı yaşamak için sürekli diğerini besin kaynağı olarak kullanıyor ve bundan fayda sağlıyorsa bu canlıya parazit canlı denir. Böyle bir beslenme ilişkisine de parazitizim (asalak yaşam) denir. Parazit olan canlının sindirim enzimleri iyi gelişmemiştir. Bu nedenle parazit canlı, diğer bir canlıdan beslenirken ona zarar vermş olur. Örneğin, hayvanlar ve insanda hastalık yapan bakteriler parazittir. Parazitler, vücut içinde ve vücut dışında yaşamalarına göre ikiye ayrılırlar: iç parazit (endoparazit) ve dış parazit (ektoparazit). Örneğin, bağırsak solucanı, tenya, kıl kurdu ve bazı bakteriler iç parazittken, sivrisinek, bit, pire, kene ve tahta kurusu ise dış parazittir. Bakınız Resim 1. Bakteri (İç parazit) ve Sivrisinek (Dış parazit). Bazı bitkiler de parazit olarak yaşar ve üzerinde yaşadıkları bitkilere de zarar verirler. Örneğin klorofili olmayan ökse otu, cin saçı, yılan yastığı gibi bitkiler, üzerinde yaşadıkları bitkilerin iletim demetlerine köksü yapılar uzatır ve buradan beslenirler.

Resim 1. Bakteri (İç parazit) ve Sivrisinek (Dış parazit)

☺ Öğrencilere ortak yaşamla ilgili bir liken sorusu sorulduğunda öğrencilerin yanlış ifadelerde bulunduğunu belirtmiştik. Bu soru mutualizm (karşılıklı yarar) ile ilgilidir. Bazı öğrenciler algler mantara parazit yaşar. Çünkü liken, alg ve mantara parazit yaşar demektedir. Ancak, likenler parazit yaşamazlar onlarda mutualizm görülür. Yine, bazı öğrenciler alg mantara parazit yaşar çünkü alg mantarlara karşı hazır yiyen canlılardır demektedirler. Bu da yanlış bir ifadedir. Çünkü, alg üreticidir besinini kendi yapar hazır yer cümlesi tüketiciler için kullanılabilir. Yine bazı öğrenciler algler mantara parazit yaşar çünkü mantarlar ağaç ve yeşillik alanda yetiştiği için demektedirler. Bu da yanlıştır zaten, liken mikroskobik yapıdaki alg ve mantarları içerir. Bunlardaki alg ve mantar gözle görülmez. Likenler, mutualizme örnektirler. Likenler, alg ve mantarlardan oluşan bir bitki grubudur. Alg ve mantar bir arada bulunur, bunların etrafı mantardan oluşan bir kabuk tabakasıyla sarılmıştır. Likenler, alg ve mantardan morfolojik, fiziksel ve kimyasal açıdan farklılık gösterirler. Liken birliğinde, mantarın klorofili yoktur ve fotosentez yapamaz. Mantar, algi yoğun güneş ışığı ve kurumadan korurlar ayrıca, alge gerekli su ve mineral maddeleri sağlarlar. Alg de, mantara fotosentezle oluşan besin sağlar.

☺ Bazı öğrenciler ise, liken yaşam birliğinde, alg ve mantarın her ikisinin de yarar gördüğünü söylemeleri doğrudur. Ancak, bu öğrencilerin açıklamaları yanlıştır. Örneğin, bununla ilgili açıklamalardan birinde likenin kommensal olarak yaşadığı belirtilmiştir, ancak, likenler mutualizme örnektir. Diğer bir açıklamada liken birliğinde, birisi yarar birisi zarar görür denilmektedir, ancak bu birliktelikte alg ve mantar da yarar görür. Başka bir açıklamada bazı öğrenciler, biri fotosentez biri besin yapar demektedirler. Ancak, fotosentez sonucunda besin üretilir ve bunu da alg yapar, mantar ondan besin alır. Yine bununla ilgili açıklamada, öğrencilerden bazıları liken bir bitkidir oksijen ve besin üretir mantar tüketicidir karbondioksit ve su üretir demektedirler. Burada algin rolü verilmemiştir. Belki de, öğrenciler liken ve mantarı birlikte ortak yaşayan canlılar olarak düşünmektedirler. Ancak, alg ve mantar ortak yaşayarak liken denilen canlıyı oluştururlar.

Öte yandan, öğrencilere bitkilerin böceklerle beslenmeleri hakkında bir soru sorulduğunda, onların bazı yanlış kavramalara sahip oldukları gözlenmiştir. Bunlardan bazıları şöyledir:

😐 Bitkiler ve böceklerin her ikisi de hem ot hem et yer çünkü her ikisi de kendi besinini üretemez, heterotroftur.

😐 Bu bitkiler ve böcekler birlikte yaşadıkları için birbirlerini yiyerek beslenirler.

😐 Böcekler, bitkiler üzerinde parazit olarak yaşarlar.

😐 Böcek, bitkinin üzerine parazit olarak yerleşmiştir. Bitki de böcekler gibi böceklerle beslenir.

😐 Bu bitkiler hem ototrof hem heterotrofturlar bunlar hem böceklerle hem de başka bitkilerle beslenir yada besin yapmak için uygun şartlar olmadığında böceklerle beslenirler demektedirler.

Bu düşüncelerin hepsi yanlıştır.

Doğada bazı canlılar vardır ki buları beslenme bakımından sınıflandırmak zordur. Bitki (üretici; ototrof) olup aynı zamanda böcekleri sindirebilen canlılar vardır (tüketici; heterotrof). Bunlara hem üretici hem tüketici canlılar denir. Bunlara böcek yiyen veya böcekçil bitkiler denir.

Gerçektende bir bitki böcek yer mi diyebilirsiniz? Bunlar arasında parazit yaşam yoktur veya bunlar birbirlerini yiyerek beslenmezler. Böcekler heterotrofturlar ancak, bu bitkiler yeşil yaprakları ile fotosentez yaptıklerı için hem üreticdirler (ototrofturlar) hem de böceklerle beslendiklerinden heterotrofturlar. Yani, azot bakımından fakir yerlerde yetiştikleri için bitki azot ihtiyacını karşılamak için böcek yer. İbrik otu ve Sinekkapan bu tip bitkilerdir. İbrik otu'nun yaprakları ibrik şeklinde ve Sinekkapan'ın yaprakları da kapan şeklindedir. Bu bitkiler renk ve kokularıyla böcekleri çeker. Bu yapraklara böcek değdiğinde yapraklar uyarılıp kapanır ve böcek içerde kalır. Bitkinin tuzağına düşen böcek, bitkinin salgıladığı enzimle ölür ve bitki hücresi içine alınmadan yaprakta sindirilir. Daha donra böcekten elde edilen amino asitler, bitki hücrelerine alınır ve kullanılır. Bakınız Resim 2. Sinekkapan bitkisi.

Resim 2. Sinekkapan bitkisi

Soru 5. Besin zinciri ve besin ağı nedir?

Öğrencilere, besin zincirindeki bitkiler neyle beslenir diye sorulduğunda pek çoğu bitkiler, topraktan besinlerini alır demişlerdir. Az sayıda öğrenci bitkilerin gelişmek için atmosferik gazlara ihtiyacı olduğunu belirtmiş, ancak hiç bir öğrenci bitki gelişmesi için bu gazların kaynak olarak rol oynadığını belirtmemiştir. Öğrencilere "Besin zincirinin kaynağı nedir?" diye sorulduğunda ise, bazı öğrencilerin şu yanlış kavramalara sahip olduğu gözlenmiştir:

Besin zincirinin enerji kaynağı;

😐 meşe ağacı yapraklarıdır,

😐 topraktaki minerallerdir,

😐 topraktaki sudur.

TARTIŞMA: Şimdi gelin bu konuyu daha iyi anlamak için bir besin zincirini tartışalım. Bakınız <u>Çalışma yaprağı .4 "Besin Zinciri".</u>

Yeryüzündeki canlılar arasında beslenme ilişkileri vardır. Canlılar arasındaki zincir şeklindeki besin ilişkisine besin zinciri denilebilir. Canlılar arasındaki bu ilişkiler, bir halkadan diğerine sürekli olarak devam eder. Besin zincirinin kaynağı güneştir. Bitkilerin fotosentezle besin maddelerinde depoladığı enerji besin zinciri ile diğer organizmalara aktarılır. Karada yaşayan üreticiler (bitkiler) güneş ışınlarıyla, havadaki karbondioksitle ve kökleriyle aldıkları suyla fotosentez yaparlar. Sonuçta organik maddeler (besin) ve oksijen açığa çıkar. Böylece, karalarda besin zinciri bitkilerle (çimen ve ağaç gibi) başlar. Yeşil bitkilerin üretmiş olduğu besin maddesi diğer canlılar tarafından yenir ve enerji diğer canlılara geçmiş olur. Karada bitkilerle yani üreticilerle başlayan bu besin zinciri, bu bitkilerle beslenen hayvanlarla yani birincil tüketicilerle devam eder. Daha sonra, etçil hayvanlar (ikincil tüketiciler) otla beslen hayvanları yer yani etçiller otçullarla beslenir. Üçüncül tüketiciler de, ikincil tüketicilerle beslenirler. Kısaca, bir besin zincirinde üreticiler, tüketiciler ve ayrıştırıcılar bulunur.

Üreticiler → Birincil tüketiciler→ İkincil tüketiciler → Üçüncül tüketiciler → Ayrıştırıcılar

☺ Diğer taraftan öğrencilere bir kara ekosistemindeki besin ağı sorulduğunda öğrencilerde bazı yanlış kavramalara rastlanmıştır. Çocuklardan bazıları besin ağındaki okların yönünü ters yorumlamıştır. Bu oklar, besin ağındaki canlıların beslenme yönlerini gösterir. Bu besin ağına göre, yılanlar farelerle beslenmektedir. Çocuklara “Bu besin ağındaki yılanlar azalırsa ne olacağını beklersiniz?” diye sorulduğunda, bazı çocuklar fare populasyonu düşer derken, bazıları fare populasyonu aynı kalır demişlerdir. Bu ifade yanlıştır. Çünkü yılanlar azalırsa fareler tüketilmeyeeğinden sayıca artar yani fare populasyonu artacaktır.

Daha önce, bir ekosistemdeki beslenme ilişkilerini anlamak için besin zincirini gördük. Besin zinciri bir yöndeki ilişkiler şeklinde gösterilir. Ancak, doğada ilişkiler karmaşıktır. Ekosistemde besin ilişkileri bir çok besin zincirinin bir araya gelmesiyle daha karmaşık olur. Birden fazla besin zincirinin bulunduğu beslenme ilişkilerine besin ağı denir.

Öğrencilere bir su ekosistemindeki besin ağı ile ilgili bir soru sorulduğunda, onlarda verilen besin ağı şeklini yorumlamada bazı problemler belirlenmiştir . Bunlardan bazıları şöyledir:

Bu besin ağında;

- ton balığı ringa balığı ile beslenmez,
- plankton küçük olduğu için mavi balina küçük plankton balığı ile beslenir ya da besinini çevreden alır,
- erkek balina hem ton balığı hem de ringa balığı ile beslenir,
- erkek balina otoburdur yani plankton da yiyebilir yada her çeşit canlıyla beslenebilir,
- erkek balina ton balığını yemez çünkü onlar aynı soydan gelir,
- kısa boyunlu martı, yılan balığı yanında karadan da beslenir,
- yılan balığı kısa boyunlu martı ile beslenir.

Tüm bu öğrencilerin düşünceleri yanlıştır.

TARTIŞMA: Şimdi bir kara ekosistemindeki besin ağı ile ilgili bir çalışma yapalım. Bakınız Çalışma yaprağı 5. “Besin Ağı ve Enerji Piramidi”.

Su ekosistemini ele alırsak, burada yaşayan mikroskobik alg ve hayvanlara plankton denir. Bitkisel olanlara, fitoplankton, hayvansal olanlara ise zooplankton denir. Sudaki besin zinciri, mikroskobik algler veya fotosentetik bakterilerle başlar. Bunları zooplanktonlar yer. Küçük balıklar planktonlarla beslenir. Büyük balıklarda küçük balıkları yer. Zincirde en son ayrıştırıcılar bulunur.

☺ Yukarıda bahsedilen soruya verilen ifadelerde, bazı öğrenciler verilen şekildeki canlıların beslenmesini gösteren okların yönlerini yanlış yorumlamışlardır. Çünkü, bu su ekosisteminde erkek balina ringa balığı ile beslenir. Ton balığı, ringa balığı ile beslenir. Ringa balığı da planktonla beslenir. Kısa boyunlu martı ise, yılan balığı ile beslenir. Mavi balina da, planktonla beslenir.

Soru 6. Enerji piramidi nedir?

Öğrencilere bir enerji piramidindeki canlılarla ile ilgili bir soru sorulmuş ve bazı öğrencilerin bu soru ile ilgili yanlış kavramaları olduğu belirlenmiştir. Bunlar şu şekildedir:

😐 ikincil tüketiciler hayvanlar ve insanlardır, bunlar besinlerini üreticilerden sağlarlar,

😐 birincil ve ikincil tüketiciler besin üretemezler ve besinlerini üreticilerden sağlarlar,

😐 ikincil tüketiciler hem üreticilerden hem de birincil tüketicilerden besin sağlarlar.

😐 piramidin en tepesinde bulunanlar piramidin ilk halkasını oluşturur,

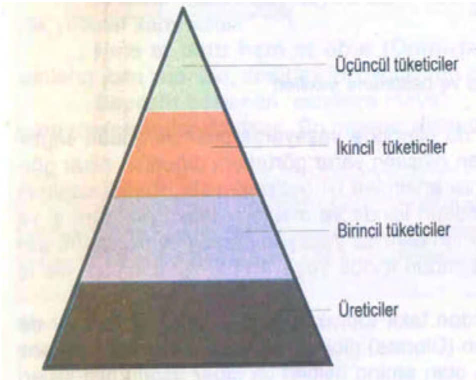
😐 piramitte az sayıda canlı çok sayıda madde ayrıştırabilir bunlar ayrıştırıcıdır,

😐 üçüncül tüketiciler fazla olursa üreticiler azalır ve denge bozulur.

Bu öğrencilerin hepsinin düşünceleri yanlıştır.

TARTIŞMA: Şimdi bu konu ile ilgili bir tartışma yapıp sonra konuya geçelim. "Besin Zinciri ve Enerji Piramidi" başlıklı Çalışma yaprağı 5'e yeniden bakalım.

🕮 Bir besin zincirinde hangi canlının neyle beslendiğini gösteren piramit şeklindeki yapıya energy piramidi denilebilir. Canlıların besin zincirinde beslendikleri canlıdan elde ettikleri enerjinin piramit şeklinde gösterilmesine enerji piramidi denilebilir. Bu bir besin zincirinde hangi canlının bir sonraki basamakta kime enerjisini aktardığını gösterir (aşağıdaki şekilde görüldüğü gibi).



Şekil 1. Bir kara ekosisteminde enerji piramidi

Besin zincirinde üretici, tüketici ve ayrıştırıcı bulunur. Enerji piramidinde de onlar bulunur. Pirmidin tabanında, en altta üreticiler, ondan sonra birincil tüketiciler (otçullar), onlardan sonra da, ikincil tüketiciler (etçiller), en sonra da üçüncül tüketiciler (burada etçiller veya hem otçul hem etçiller bulunbilir) bulunur. Ayrıştırıcılar, piramit kenarı boyunca yer alabilir.

Piramitte bitkiler en çok sayıya sahiptir. Piramidin ikinci basamağındaki otçulların sayısı bitkilerden daha azdır. Çünkü bitkilerden arta kalan enerjiyi alan otçulların sayısı bitkilerden az olur. Tüketici olan otçullar bitkileri yerler. Böylece bitkilerden gelen enerji otçullara geçmiş olur. Otçullar kazanmış oldukları bu enerjinin büyük kısmını kendileri kullanır. Artan enerji ise etçiller tarafından kullanıldığı için piramitte etçillerin sayısı en az olan grup olur. Enerji piramidi gittikçe daralır çünkü her basamakta enerji kaybı olur. Bu ısı enerjisine dönüşerek çevreye verilir. Piramitte yukarı doğru gidildikçe bireylerin kütlesi artarken, bireylerin sayısında azalma görülür.

Pirmitte enerji her basamakta %90 azalarak zincirin ilk halkasından son halkasına doğru çıkmaktadır. Örnek verecek olursak yeşil bitkilerden (piramidin ilk basamağı) sonra gelen basamakta, otla beslenen inek ve tavşan gibi canlılar bulunur. Bu otçul canlılar, birinci basamaktaki bitkileri yiyerek beslenirler. Otçul bir canlının bir bitkiyi yemesiyle, bitkideki enerji %90 oranında azalarak otçullara geçer. Daha sonraki basamaklarda ise enerji de giderek azalır.

☺ Öğrencilerin “İkincil tüketiciler hayvanlar ve insanlardır, bunlar besinlerini üreticilerden sağlarlar”, “Birincil ve ikincil tüketiciler besin üretemezler ve besinlerini üreticilerden sağlarlar” ve“İkincil tüketiciler hem üreticilerden hem de birincil tüketicilerden besin sağlarlar” ifadeleri yanlıştır. Çünkü, her canlı grubu bir alt basamaktaki canlılar ile beslenir. Piramidin en tepesinde bulunanlar piramidin ilk halkasını değil son halkasını oluştururlar. Piramitte az sayıda canlı çok sayıda madde ayrıştırabilir bunlar ayrıştırıcıdır ifadesi yanlıştır. Çünkü az sayıda olan canlılar üçüncül tüketicilerdir ve bunlar ayrıştırma yapamazlar. Ayrıştırıcılar da, ölü canlıları parçalarlar. Bazı öğrenciler üçüncül tüketiciler fazla olursa üreticiler azalır ve denge bozulur demektedirler bu doğru değildir çünkü üçüncül tüketiciler ikincil tüketicilerle beslenirler bunlar üretiileri etkilemezler.

ÇALIŞMA YAPRAĞI 1. CANLI VE CANSIZ ÇEVREMİZ

<table>
<tr><td colspan="2">Soru 1. Doğada pek çok canlı ve cansız varlık bulunmaktadır. Siz canlı ve cansız denilince ne anlıyorsunuz? Aşağıya yazınız.</td></tr>
<tr><td>1. Grubunuzun düşüncesi:
Canlı:

Cansız:</td><td>1. Sınıfın genel düşüncesi:
Canlı:

Cansız:</td></tr>
<tr><td colspan="2">Soru 2. Aşağıda verilen varlıkları canlı yada cansız olarak sınıflayınız.
Taş, toprak, su, elma ağacı, yumurta, kuş, ışık, oksijen, masa, bakteri, sıcaklık, fosfat.</td></tr>
<tr><td>2. Grubunuzun düşüncesi:
<u>Canlı</u> <u>Cansız</u></td><td>2. Sınıfın genel düşüncesi:
<u>Canlı</u> <u>Cansız</u></td></tr>
</table>

<table>
<tr><td colspan="2">Soru 3. Sizin yaşadığınız çevredeki diğer canlı ve cansızlara ait örnekler veriniz.</td></tr>
<tr><td>3. Grubunuzun düşüncesi:

<u>Canlı</u> <u>Cansız</u></td><td>3. Sınıfın genel düşüncesi:

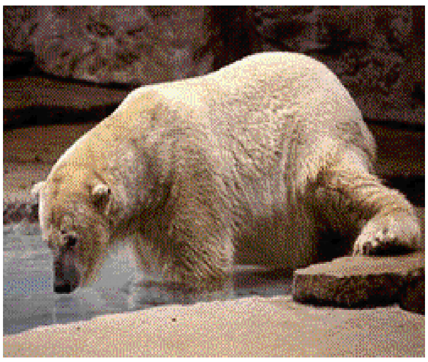
<u>Canlı</u> <u>Cansız</u></td></tr>
<tr><td colspan="2">Soru 4. Genel olarak canlıları etkileyen diğer canlı ve cansızlar çevresel etmenler nelerdir, yazınız.</td></tr>
<tr><td>Grubunuzun düşüncesi:

<u>Canlı</u> <u>Cansız</u></td><td>Sınıfın genel düşüncesi:

<u>Canlı</u> <u>Cansız</u></td></tr>
</table>

ÇALIŞMA YAPRAĞI 2. CANLILARDA BESLENME

Soru 1: Çevremizde pek çok canlı organizma bulunmaktadır. Aşağıda bazı bitki ve hayvan resimleri verilmiştir. Bu resimlerdeki canlılar nasıl beslenir, kısaca belirtiniz?



Grubunuzun düşüncesi:	Sınıfın genel düşüncesi:
<u>Bitki:</u>	<u>Bitki:</u>
<u>Keçi:</u>	<u>Keçi:</u>
<u>Yılan:</u>	<u>Yılan:</u>
<u>Aslan:</u>	<u>Aslan:</u>
<u>Ayı:</u>	<u>Ayı:</u>
<u>İnsan:</u>	<u>İnsan:</u>

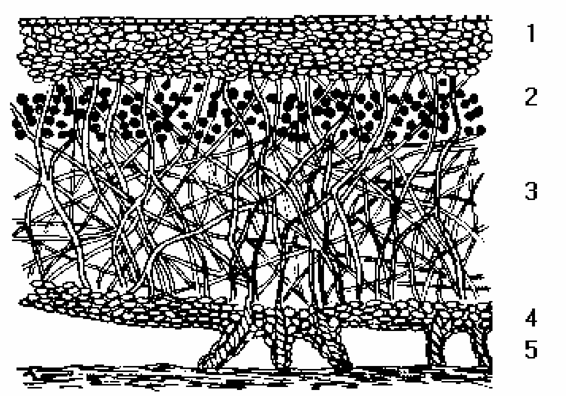
Soru 2: Doğada yaşayan bazı bakteri ve mantarları mikroskopta gördükten sonra, bakteri ve mantarların doğadaki görevleri hakkında bildiklerinizi yazınız.	
2. Grubunuzun genel düşüncesi Bakteriler ve mantarlar:	2. Sınıfın genel düşüncesi Bakteriler ve mantarlar:

ÇALIŞMA YAPRAĞI 3. ORTAK YAŞAM

Bir kişi her sabah arabasıyla işe giderken bir arkadaşını da kendi arabasıyla onu iş yerine bırakıyor. Bir bayan ve bir erkek evlenerek aynı evde yaşamaya başlarlar. İki kardeşten bir sürekli diğerinden borç alıyor ve geri ödemiyor. Soru 1. Bu örneklerdeki kişiler arasında nasıl ilişkiler vardır? Bu ilişkilerin fayda ve zararlarını tartışınız.	
1. Grubunuzun genel düşüncesi:	1. Sınıfın genel düşüncesi:
Soru 2. Aşağıdaki ortak yaşam şekillerini yazınız. a) Bir canlı sürekli diğerinin besin artıklarıyla besleniyorsa, buna...................................denir . b) İki canlı sürekli birbirine destek oluyorsa, buna....................................denir. c) Bir canlı sürekli diğerinden besleniyorsa, buna.................................denir.	
2. Grubunuzun genel düşüncesi: a) b) c)	2. Sınıfın genel düşüncesi: a) b) c)

Soru 3: Aşağıda kabuksu ve yapraksı likenlere ait bir resim ve bir likenin mikroskopta enine kesiti verilmiştir. Bunları inceledikten sonra likenler nasıl canlılardır? Açıklayınız.

Kabuksu ve Yapraksı Likenler



Liken enine kesitinin ışık mikroskobunda görünümü: 1. Üst kabuk tabakası, 2. Alg tabakası, 3. Medulla (mantar tabakası), 4. Alt kabuk tabakası ve 5. Rizin (Mantardan yapılmış tutunma organı).

3. Grubunuzun genel düşüncesi:	3. Sınıfın genel düşüncesi:

ÇALIŞMA YAPRAĞI 4. BESİN ZİNCİRİ

Soru 1. Şimdi doğada yaşayan bazı canlıların resimlerini görelim. Hangi canlı neyle besleniyor dikkat edin ve gördüğünüz resimlere ait bir besin zinciri örneği yazınız.	
1. Grubunuzun düşüncesi:	1. Sınıfın genel düşüncesi:
Soru 2. Besin zinciri canlıların beslenme ilişkisini görmemize yardımcı olur. Kurbağa, yılan, şahin, çimen ve çekirge arasında beslenme ilişkisi vardır. Bu canlılara ait besin zinciri şemasını çiziniz.	
2. Grubunuzun şeması:	2. Sınıfın genel şeması:

Soru 3. Bu canlılardan hangisi üreticidir? Neden? Soru 4. Bunlardan hangisi birincil tüketicidir? Neden? Soru 5. Bunlardan hangisi ikincil tüketicidir? Neden? Soru 6. Bunlardan hangisi üçüncül tüketicidir? Neden? Soru 7. Bunlardan hangisi dördüncül tüketicidir? Neden?

Grubunuzun düşüncesi:	Sınıfın genel düşüncesi:
3	3
4.	4.
5.	5.
6.	6.
7.	7.

ÇALIŞMA YAPRAĞI 5. BESİN AĞI VE ENERJİ PİRAMİTİ

Bir kara ekosisteminde çimen, fare, tavuk, yılan, koyun, insan, geyik, aslan, kartal bulunur.

Soru 1. Bu besin ağında hangi canlı, hangi canlı/canlılar ile beslenmektedir? Yazınız

Soru 2: Yukarıda verilen canlılara ilişkin besin ağı şeması çiziniz.

Soru 3. Bu kara ekosistemine ait enerji piramidini çiziniz ve açıklayınız.

Grubunuzun düşüncesi:	Sınıfın genel düşüncesi:
1.	1.
2.	2.
3.	3.
Açıklama:	Açıklama:

APPENDIX H

SOME PICTURES FROM THE EXPERIMENTAL GROUP

DENEYSEL GRUPLA İLGİLİ BAZI RESİMLER

APPENDIX I

CORRESPONDENCE

YAZIŞMA

T.C.
BALIKESİR VALİLİĞİ
MİLLİ EĞİTİM MÜDÜRLÜĞÜ

SAYI :B.08.4.MEM.4.10.00.04.311/
KONU: Uygulama Çalışması

03.05.02- 09681

VALİLİK MAKAMINA
BALIKESİR

T.C.Orta Doğu Teknik Üniversitesi Middle East Technical Üniversitesi Eğitim Fakültesi Fen ve Matematik Alanları Eğitimi Bölümü Araştırma Görevlisi ve Doktora Öğrencisi Gülcan ÇETİN'in tez çalışmasının bir gereği olarak İlimiz Gaziosmanpaşa Lisesinde okoloji başarı testi uygulaması ile ilgili Üniversitenin 15.04.2002 tarih ve 2895 sayılı 28.03.2002 tarih ve 386 sayılı yazıları ilişikte sunulmuştur.

Makamlarınızca uygun görüldüğü takdirde; T.C.Orta Doğu Teknik Üniversitesi Middle East Technical Üniversitesi Eğitim Fakültesi Fen ve Matematik Alanları Eğitimi Bölümü Araştırma Görevlisi ve Doktora Öğrencisi Gülcan ÇETİN'in tez çalışmasının bir gereği olarak İlimiz Gaziosmanpaşa Lisesinde okoloji başarı testi uygulama çalışması yapmasını OLUR'larınıza arz ederim.

Alpaslan PEKER
Milli Eğitim Müdürü

OLUR
..../05/2002

O.Nuri ÇOBANOĞLU
Vali a.
Vali Yardımcısı

[..]/05/2002 V.H.K.İ.:G.DEMİRALP
01..../05/2002 Şef : E.KARABIYIK
01/05/2002 Şb.Müd. : A.YALÇIN

VITA

Gülcan Çetin was born in Karacabey, Bursa on May 05, 1968. She received her B.Sc. degree from Biology Department of Ege University in 1989. She worked as a research assistant in the Secondary Science and Mathematics Education Department of Balıkesir University from 1990-1996 and 1998-2000. She had M.Sc. degree from Uludağ University in 1992 and M.Ed. degree from University of Leeds in 1998. She has been working as a research assistant in the Secondary Science and Mathematics Education Department of Middle East Technical University (METU) since 2001. Her main areas of interest are ecology education, misconceptions in biology, conceptual change approaches, conceptual change text design, and teacher education. She will work in the Secondary Science and Mathematics Education Department of Balıkesir University after completing Ph.D. program at METU.