REMEDIATION OF SEVENTH GRADE STUDENTS' MISCONCEPTIONS RELATED TO ECOLOGICAL CONCEPTS THROUGH CONCEPTUAL CHANGE APPROACH

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ABSTRACT

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The aims of this study were to identify seventh grade students' misconceptions regarding ecological concepts and to investigate the effect of conceptual change text oriented instruction on remediation of misconceptions concerning ecological concepts and on students' environmental attitudes.

This study included a qualitative and a quantitative part and both parts were conducted in METU Developmental Foundation Private School in 2000-2001 fall semester. In qualitative part of this study, 10 eight grade students were interviewed to obtain information about students' misconceptions related to ecological concepts. In quantitative part of the study, the participants included 58 seventh grade students from two intact classes instructed by the same science teacher.

During the treatment, students in the experimental group worked with conceptual change texts and those in the control group received traditional instruction on unit. The Ecology Concept Test, prepared in a two-tier multiple choice format, was administered in both groups as a pre- and post-test to measure the effect of instruction in terms of remediation of students' misconceptions. An environmental attitude scale was also administered to both groups as a pre- and post-test to measure the effect of instruction on students' attitudes towards environment.

The results indicated that the experimental group achieved significantly better than the control group with respect to understanding of ecological concepts. In other words, the remediation of students' misconceptions in ecological concepts was achieved with the help of conceptual change texts. Although students in the experimental group showed a slightly significant increase in their attitudes towards the environment, no significant difference was found between the experimental group and control group with respect to attitudes towards the environment.

Keywords: Misconception, Conceptual Change Text, Traditional Instruction, Ecological Concepts, Two-tier Diagnostic Test.

ÖZ

YEDİNCİ SINIF ÖĞRENCİLERİNİN EKOLOJİ KONULARINDAKİ KAVRAM YANILGILARININ KAVRAMSAL DEĞİŞİM YAKLAŞIMI İLE GİDERİLMESİ

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Bu çalışmanın amaçları, yedinci sınıf öğrencilerinin ekoloji konularındaki kavram yanılgılarını belirlemek ve kavramsal değişim metinlerinin kavram yanılgılarının giderilmesindeki ve öğrencilerin çevreye karşı tutumlarındaki etkisini araştırmaktır.

Nitel ve nicel bölümlerden oluşan bu çalışma, 2000-2001 öğretim yılı sonbahar döneminde ODTÜ Geliştirme Vakfi Özel Okulu'nda gerçekleştirilmiştir. Çalışmanın nitel bölümünde, öğrencilerin ekoloji konularındaki kavram yanılgıları hakkında bilgi toplamak amacı ile 10 sekizinci sınıf öğrencisi ile görüşmeler yapılmıştır. Çalışmanın nicel bölümünde ise, iki

ayrı sınıfta öğrenim gören 58 yedinci sınıf öğrencisi yer almıştır. Fen bilgisi dersi her iki gruba aynı fen bilgisi öğretmeni tarafından verilmiştir.

Bu çalışmada, deney grubundaki öğrenciler ekoloji konularını kavramsal değişim metinleri ile çalışırken, kontrol grubundaki öğrenciler bu konuları geleneksel öğretim yöntemi ile işlemiştir. İki-aşamalı çoktan seçmeli formatında hazırlanan "Ekoloji Kavram Testi", uygulanan öğretim yönteminin öğrencilerin kavram yanılgılarının giderilmesindeki etkisini ölçmek amacı ile her iki grupta ön-test ve son-test olarak uygulanmıştır. Ayrıca, uygulanan öğretim yönteminin, öğrencilerin çevreye karşı tutumlarına etkisini ölçmek amacı ile, "Çevre Tutum Ölçeği" her iki gruba ön-test ve son-test olarak uygulanmıştır.

Sonuçlar deney grubunun ekoloji konularını anlamada kontrol grubundan daha başarılı olduğunu göstermiştir. Başka bir deyişle, öğrencilerin ekoloji konularındaki kavram yanılgıları, kavramsal değişim metinleri yardımı ile giderilmiştir. Deney grubundaki öğrencilerin, çevreye karşı tutumlarında az da olsa bir artma göstermelerine rağmen, deney grubu ile kontrol grubu arasında öğrencilerin çevreye karşı tutumları açısından anlamlı bir fark bulunamamıştır.

Anahtar Kelimeler: Kavram Yanılgısı, Kavramsal Değişim Metni, Geleneksel Öğretim Yöntemi, Ekolojik Kavramlar, İki-aşamalı Tanı Testi.

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LIST OF SYMBOLS

EG:	: Experimental Group
CG:	: Control Group
CCTI:	: Conceptual Change Texts oriented Instruction
TI:	: Traditional Instruction
ECT:	: Ecology Concept Test
EAS:	: Environmental Attitude Scale
n:	: Sample Size
$\overline{x}$:	: Mean of Sample
s:	: Standard Deviation of the Sample
t-value:	: T statistics
p:	: Significant Level
df:	: Degrees of Freedom
F:	: F statistics
η^2:	: Effect size

CHAPTER 1

INTRODUCTION

Identifying students' misconceptions in science has received a great deal of attention in educational research in the past two decades. The researchers in the field of science education have been interested in the identification of students' misconceptions concerning several biology concepts such as photosynthesis (Smith and Anderson, 1984; Haslam and Treagust, 1987); human body (Mintzes, 1984); homeostasis (Westbrook and Marek, 1992); natural selection (Bishop and Anderson, 1990; Greene, 1990); amino acids and translation (Fisher, 1985); the human circulatory system (Arnaudin and Mintzes, 1985; Yip, 1998; Sungur, Tekkaya and Geban, 2001); diffusion (Westbrook and Marek, 1991); diffusion and osmosis (Odom and Barrow, 1995) food web (Griffiths and Grant, 1985; Griffiths, Thomey and Normore, 1988); ecological concepts (Adeniyi, 1985).

Many concepts in biology are interrelated and they are keys to understanding of other concepts. Thus, many of the hurdles in understanding biological concepts result from the necessity to relate and integrate knowledge from several concepts. For example, without understanding of photosynthesis, the concepts of food chain and food web are meaningless to students. On the other hand, before photosynthesis, students must master the distinction between producers and consumers. Understanding ecological concepts is crucial for students since ecology plays a central role in understanding the entire living world. Students' misconceptions concerning ecological concepts have been investigated by several researchers (Adeniyi, 1985; Griffiths and Grant, 1985; Marek, 1986; Webb and Boltt, 1990; Gallegos, Jerezano and Flores, 1994; and Munson, 1994).

Clinical interviews (Adeniyi, 1985) and concept maps (Okebukola, 1990) have been found as successful methods to determine students' misconceptions concerning ecological concepts. However both clinical interviews and concept maps require large amounts of time and expertise to be interpreted. The development of multiple-choice instruments is an alternative method to identify students' misconceptions. Multiple-choice test can be easily administered and interpreted but it has the limitation that it does not give information about the reasoning of the students. Students may give correct answers for wrong reasons. In order to get students' reasoning behind their choices, Haslam and Treagust (1987), Odom and Barrow (1995) and Rollnick and Mahooana (1999) have recommended the use of two-tier multiple-choice instrument that focuses on helping students reason and detecting common misconceptions. In the present study, two-tier multiple choice instrument was developed to diagnose seventh grade students' misconceptions concerning ecological concepts.

Although the need to identify students' misconceptions concerning science concepts has been widely expressed in recent science education literature, there are few studies on how these misconceptions can be treated (Okebukola, 1990; Lonning, 1993; Songer and Mintzes, 1994; Chambers and Andre, 1997; Beeth, 1998; Sungur, Tekkaya and Geban, 2001). Knowing students' misconceptions does not mean that educators have potential methods to promote meaningful learning. Posner, Strike, Hewson and Gertzog (1982) defined learning as "the result of the interaction between what the student is taught and his current ideas or concepts". Constructivist perspectives on teaching and learning generally assert two principles: knowledge is actively constructed by students, rather than transmitted by teachers; and such knowledge is constructed on the foundation of students' existing knowledge. Thus, for meaningful learning to occur, the existing ideas must be reorganized or replaced by new ideas. Meaningful learning involves students constructing integrated knowledge structures, which contain their prior knowledge, experiences, new concepts and other relevant knowledge (Tsai, 2000). Meaningful learning requires not only an enrichment of knowledge but also a reconstruction of what is already known, which very often is likely to be personal, characteristic, persistent and resistant to change through traditional teaching methods. Students must restructure their existing concepts. Thus, learning can be considered as a process of conceptual change. The conceptual change theory focuses on the conditions where students' existing conceptions are modified by new conceptions. Posner et al., (1982) reported that using strategies of conceptual change in elimination of students' misconceptions promoted the acquisition of new conceptions with existing conceptions. One of the conceptual change strategies is the use of conceptual change texts. In these texts, the identified misconceptions of the students are given first and then students are informed of the intelligible and fruitful scientific explanations supported by examples to create dissatisfaction.

Considering the importance of ecology to students' understanding of their environment, students should learn ecological concepts in a meaningful manner. Although researches had been conducted to show the effectiveness of conceptual change texts on creating conceptual change and promoting meaningful learning in students regarding electricity (Wang and Andre, 1991; Chambers and Andre, 1997), photosynthesis (Mikkilä-Erdmann, 2001) and the human circulatory system (Sungur, Tekkaya and Geban, 2001) concepts, it has not been questioned for ecological concepts yet.

Conceptual change learning in ecological concepts is crucial because changes in attitudes towards the environment are primarily, although not exclusively, based on the knowledge developed about the environmental facts. Mason and Santi (1998) claimed that change in attitudes towards the environment rely on the construction of new, more advanced knowledge about ecological topics. Actually, it has been shown that there is a statistically significant correlation between students' knowledge and their attitudes towards the environment (Bradley, Walinczek and Zajicek, 1999). This finding is crucial because it suggests that increased knowledge may help in improvement of environmental attitudes. Since students begin to develop environmental attitudes at very early ages, they might have misconceptions or erroneous generalizations concerning environmental facts. Thus, the construction of new, more advanced knowledge about ecological concepts through conceptual change approach may change the students' attitudes towards the environment.

Therefore in this study, seventh grade students' misconceptions related to ecological concepts were identified and the effectiveness of conceptual change text oriented instruction in remediation of these misconceptions and in students' environmental attitudes were investigated.

CHAPTER 2

REVIEW OF LITERATURE

This chapter is devoted to the presentation of the previous studies that have produced theoretical and empirical background for this study.

2.1 Addressing Misconceptions

The study of students' misconceptions has become a central issue in science education for the past two decades because they are presumed to be deeply rooted, instruction-resistant obstacles to the acquisition of scientific concepts (Lawson, 1988). Misconceptions do not simply signify a lack of knowledge, factual errors, or incorrect definitions. They represent explanations of phenomena constructed by students in response to their prior knowledge and experience (Munson, 1994). Misconceptions, defined as the ideas that students have about natural phenomena that are inconsistent with scientific conceptions, are pervasive, stable, and often resistant to change at least through traditional instruction (Fisher, 1985; Westbrook and Marek, 1991).

Learning of a complex subject like science is an incremental process. Understanding is sometimes incomplete at every level and it is easy to draw incorrect conclusions from incomplete models. The generation of the misconceptions is thus a natural and probably unavoidable part of the learning process (Fisher, 1985). Meyer (1993) reported that misconceptions might arise from two sources: (a) from errors in understanding new information or (b) from previous misunderstanding remaining a part of the newly formed knowledge. Thus, new knowledge must be reconciled with students' existing conceptions. New concepts cannot be learned if alternative models that explain a phenomenon already exist in the learner's mind. Students' prior knowledge was indicated as the most important factor affecting students' learning since prior knowledge provides an indication of the misconceptions as well as the scientific conceptions possessed by the students (Hewson and Hewson, 1983). Recently, Mak, Yip and Chung (1999) reported that misconceptions originate from (1) informal ideas formed from everyday experiences of students, (2) incomplete or erroneous views developed by students during classroom instruction, (3) inadequate subject matter knowledge of teacher. These findings are crucial because by taking the sources of misconceptions into account, remediation of misconceptions could be achieved.

2.2 Misconceptions Related to Ecological Concepts

2.2.1 Basic Ecological Concepts

The understanding of the basic ecological concepts was studied by Adeniyi (1985) and Gallegos, Jerezano and Flores (1994). According to Adeniyi (1985), four concepts were rather difficult to define or describe for 13-15 years old students. These were ecosystem, habitat, community and population. Data were obtained from 26 students who had received instruction in the ecology unit. The results showed that some students equated habitat with ecosystem, while others equated it with population. Many students thought that ecosystem is the same as population. Most of the students equated biotic community with population. He reported that the students confused the meaning of human population or human community with the meaning of biological population or biotic community. Therefore, most of the students have conflicting or multiple definitions for ecosystem, habitat, community and population concepts.

The studies of Adeniyi (1985) and Gallegos et al., (1994) revealed that students also have misconceptions concerning producer and consumer concepts. Adeniyi (1985) reported that most of the students thought that plants are the only living organisms capable of producing food on their own, and therefore called producers. However, some students consider small animals as producers since they serve as food for bigger animals. On the other hand, Gallegos et al., (1994) reported that students do not consider plant as producer in the construction of food chains. Students begin to construct food chain with the plant correctly, because they think it is the smallest and that it cannot eat an animal. These studies showed that students' preconception of ferocity and size is one of the sources of misconceptions concerning producer and consumer concepts. The misconception was identified as the notion of the stronger organism feeding on the weaker organism.

2.2.2 Food Chain and Food Web

The understanding of food chain and food web concepts was studied by several researchers (Adeniyi, 1985; Griffiths and Grant, 1985; Webb and Boltt, 1990; Gallegos et al., 1994 and Munson, 1994). According to them, students have various misconceptions about food chains and food webs. Adeniyi (1985) reported that students have difficulty with food chains in aquatic environments and many students have the misconception that 'plants do not live in water'.

Griffiths and Grant (1985) explicitly dealt with high school students' understanding of food webs. They used a learning hierarchy model, leading to the ability to determine how a change in the size of one population can affect another population in the same web but not on the same chain, as a tool to identify students' misconceptions regarding food web concept. By this way, they tried to identify the skills fundamental to the understanding of a food web. The required skills range from the understanding of basic predator-prey interactions to more complex relationships between populations in the same food web. They identified five misconceptions held by the subjects of their study:

1. The interpretation of food web dynamics in terms of a food chain.

2. In a food web, a change in one population will only affect another population if two populations are directly related as predator and prey.

3. 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.

4. A change in the size of a prey population has no effect on its predator population.

5. 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.

They also reported that students encounter the food chain model prior to the food web model, which is more complex than the former, according to curriculum. Therefore, students fail to consider food web to be a network of food chains. Rather, they interpret the dynamics of food web in terms of individual food chains considering successive predator-prey relationships along the individual food chains.

Webb and Boltt (1990) suggested that the principle component in the students' construction of a food chain is the predator-prey relation. However, this relationship is not translated to other routes in a food web if there is no contiguity between populations by the students. The misconceptions they identified were based on the proximity of populations in the food web. For example, responses to questions about the effect of a change in one population on other populations separated by any distance on the food web are 'there is no effect as the populations are too far apart', and 'no effect as they are on different parts of the food web', 'nothing happens as they are not really linked at all'.

Gallegos et al., (1994) conducted interviews with biology teachers in order to determine the curriculum content for the food chain concept. The teachers' interviews showed that the food chain is not taught as a flow of energy through its members. Students describe food chains as 'who eats whom', and 'who is eaten by whom'. When they construct the food chain based on 'who is eaten by whom', the food chain is considered inverted. Students begin with the last predator; they fail to consider notion of the flow of energy that begins with the producer.

2.2.3 Energy Flow

Adeniyi (1985) indicated that students have many misconceptions that tend to block understanding of the notion of energy flow in the ecosystem. Students believe that carnivores are stronger than herbivores and thus are able to kill and feed on them. Therefore, students thought that the most powerful organism has the greatest energy. In addition, many students believed that sun gives energy to plants before consumers take energy from plants and available energy increases. Munson (1994) suggested that students consider the species at the top of a food chain as having advantage of gaining the most energy because they think that energy accumulates up the chain.

2.2.4 Pyramid of Energy

Adeniyi (1985) reported that students possess several misconceptions about pyramid of energy. For example, students thought that pyramid of energy is wider at the base (producer level) than the apex (consumer level) because in terms of number, producers are greater than herbivores. These students believe that the number of producers must be more than that of herbivores so that herbivores can be satisfied with enough food to eat.

Students' misconceptions that block understanding of the notion of energy flow in the ecosystem also affect their understanding of the pyramid of energy. Adeniyi (1985) indicated that many students correctly interpret that the available energy decreases from producer level to consumer level in a food chain but their reasoning is the indicator of their misconceptions. Some students think that available energy decreases because food eaten by herbivores may be digested and herbivores may be hungry at the time carnivores eat them so that carnivores get little energy. In addition, he also reported that students believe that decomposers always terminate a food chain because the teacher placed decomposers in the top rung of a pyramid of energy during instruction and said that bacteria and fungi serve as a limiting factor in the food chain.

2.3 Identifying Misconceptions

An important part of teaching is discovering the students' prior knowledge and using this knowledge to plan instruction that helps students recognize and change their misconceptions. Thus, before misconceptions can be corrected, they need to be identified. The usual means for obtaining information about students' conceptions has been through individual interviews. Students' conceptions have been identified by using interview techniques in many biology topics, including ecological concepts (Fisher, 1985), the human circulatory system (Arnaudin and Mintzes, 1985; Sungur, Tekkaya and Geban, 2001), cell theory and mitosis (Lawson, 1988), cellular respiration (Songer and Mintzes, 1994), diffusion and osmosis (Odom and Borrow, 1995). Concept maps were also used to diagnose student misconceptions in the human circulatory system (Arnaudin and Mintzes, 1985; Sungur, Tekkaya and Geban, 2001), genetics and ecology (Okebukola, 1990), and cellular respiration (Songer and Mintzes, 1994). However, both interview and concept map techniques have limitations for use by classroom teachers. Interviews are difficult to conduct when time is limited and class enrollments are high. They also require large amounts of time to transcribe and interpret. Concept maps, on the other hand, require time for student and teacher training, and additional teacher training for scoring and interpretation (Odom and Barrow, 1995).

Misconceptions of the students can be identified by administering pencil-and-paper multiple choice instruments. The use of such a method is easy and quick but the drawback of this method is that the multiple choice tests do not provide insight into students' ideas on the topic (Rollnick and Mahooana, 1999). Odom and Barrow (1995) reported that multiple choice tests can be used to evaluate students' content knowledge but they have the limitations with determining students' reasoning behind their choices. The use of two-tier multiple choice instruments have been recommended in order to determine students' reasoning and their misconceptions (Haslam and Treagust, 1987; Peterson, Treagust and Garnett, 1989; Seymour and Longden, 1991; Odom and Barrow, 1995; Rollnick and Mahooana, 1999; Tyson, Treagust and Bucat, 1999).

A two-tier diagnostic instrument is developed from the multiple-choice items and consisted of two parts. The first part of each item on the instrument is a multiple-choice content question having usually two or three choices. The second part of each item contains a set of possible reasons for the answer given to the first part. The reasons include identified misconceptions and a scientifically correct answer (Haslam and Treagust, 1987).

The design of the two-tier diagnostic instruments developed by the researchers generally was based on a procedure which involved three steps: (a) the description of science content in terms of propositional knowledge statements and concept maps, (b) the development of items based on interviews, open-ended pencil-and-paper tests, and related literature, and (c) the development of two-tier test items (Haslam and Treagust, 1987).

The two-tier diagnostic instruments were used in several researches to diagnose students' misconceptions in many science concepts including photosynthesis and respiration in plants (Haslam and Treagust, 1987), covalent bonding and structure (Peterson, Treagust and Garnett, 1989), respiration and gaseous exchange (Seymour and Longden, 1991), diffusion and osmosis (Odom and Barrow, 1995), chemical equilibrium (Tyson, Treagust and Bucat, 1999) and thermodynamics (Rollnick and Mahooana, 1999).

All of these studies have shown the effectiveness of two-tier diagnostic instruments in diagnosing students' misconceptions in science. The results indicated that although students had enough content knowledge they had difficulty in reasoning their choices. It was concluded that two-tier diagnostic instrument can be a valuable teaching aid since it enables teachers to assess both student knowledge of facts and the reasoning supporting those facts. Thus in this study, based on the implications in the literature, a two-tier multiple choice test was developed to diagnose students' misconceptions related to ecological concepts.

2.4. The Conceptual Change Theory

The process of learning science is complex because many concepts in science are abstract and counterintuitive, making them difficult to comprehend. Prior knowledge has been acknowledged as a significant factor in comprehension and learning of science concepts in a meaningful manner. As mentioned in the previous chapter, when students' prior knowledge is in conflict with accepted scientific knowledge, it is termed misconception. Research that examines mechanisms involved in altering students' misconceptions to conform with accepted scientific theory has been termed conceptual change research (Ridgeway and Dunston, 2000).

Pintrich, Marx and Boyle (1993) reported that the process of learning in a conceptual change model depends on the extent of the integration of the individual's conceptions with new information. Sometimes students use existing concepts to deal with new information. If they have little knowledge about the topic, new information is likely to be combined easily with their existing ideas. This is called a process of assimilation (Posner et al., 1982). However, generally students' current concepts are inadequate to allow them to grasp new information successfully. Thus, students must replace or reorganize these concepts. This process is what Posner et al. (1982) refer to as accommodation.

Posner et al., (1982) stated four conditions that must be fulfilled for accommodation to occur:

1. There must be **dissatisfaction** with existing conceptions. This suggests that, the more dissatisfied a student is with his or her current concepts or ideas, the more likely he or she will be consider a change of view.

2. A new conception must be **intelligible**. This suggests that, the new conception must provide better explanations for students to understand it.

3. A new conception must appear initially **plausible**. The new concept must have the capacity to solve the problems generated and be consistent with other knowledge.

4. A new concept should suggest the possibility of a **fruitful** research program. This suggests that, the new concept should have the capacity to be extended and suggest new areas for investigation.

These conditions then suggest the need for active instructional strategies. A number of research studies have been conducted to generate teaching strategies based on conceptual change theory to promote meaningful learning in science. Hewson and Hewson (1983) used four teaching strategies to promote conceptual change in students concerning mass, volume and density concepts. These teaching strategies include *integration,* where new conceptions are integrated with existing conceptions, or different existing conceptions with each other; *differentiation*, where existing conceptions are differentiated into more clearly defined, separated, but closely related conceptions; *exchange*, where an existing conception is exchanged for a new one by creating dissatisfaction and *conceptual bridging*, where an appropriate context in which important abstract concepts can be linked with meaningful common experiences is established. In their study, the control group was taught by using only integration strategy in which expositions, discussions, experiments and demonstrations were used as teaching methods. On the other hand, the experimental group was engaged in all four teaching strategies mentioned above. The instruction in the experimental group began with conceptual bridging in the form of a question designed to establish a network of associated concepts in the minds of students. Then, misconceptions were addressed using differentiation and exchange strategies and finally the topic under study was taught using an integration strategy. The results of the post-test scores indicated a significantly greater acquisition of scientific conceptions of mass, volume and density in the experimental group in which students were engaged in teaching strategies based on conceptual change model of learning.

Basili and Sanford (1991) used conceptual change strategies in small cooperative group settings to eliminate students' misconceptions concerning the laws of conservation of matter and energy, and the particulate nature of gases, liquids, and solids. In their study, the small group tasks were designed to bring students' misconceptions to light. During small-group work students took turns explaining their responses to questions posed a week before the group session. They reported that the interaction evoked by the task questions include behaviors suggestive of the four conditions of the conceptual change process depicted by Posner et al. (1982).

Lonning (1993) also used conceptual change teaching methods to teach particle nature of matter. The instructional model used in his study was based on cooperative learning strategies where students involved in discussions with peers and the teacher. Students were given opportunities to make their personal conceptions explicit to other students, the teacher and to themselves; they exchanged ideas with peers and constructed and evaluated new ideas. The results of the study showed that cooperative learning strategies enhance conceptual change instruction. He proposed that when students share and compare their ideas, they are forced to take a different perspective than their own and to evaluate their conceptions. This may create dissatisfaction in students with their existing conceptions.

Teaching of physical science concepts of force and motion by using conceptual change instruction was studied by Beeth (1998). The conceptual change instruction used in this study was based on placing students' science conceptions and their ability to reflect on their conceptions at the center of science instruction. Students tried to define the status constructs of intelligibility and plausibility in response to their teacher's instruction and then applied these constructs when talking about ideas related to force and motion concepts. She suggested that by this way students provide deep insights into their conceptions and they negotiate the meaning of and reasons that support scientific conceptions.

Smith, Blakesiee and Anderson (1993) conducted a study to examine the use of teaching strategies associated with conceptual change theory of science teaching by seventh grade life science teachers. The concepts under consideration were photosynthesis, cellular respiration and matter cycling in ecosystems. Several conceptual change teaching strategies associated with instructional materials were used. These strategies included questioning strategies that focus to reveal students' misconceptions and strategies that focus students' attention on the conceptual content of the lesson by emphasizing and summarizing important parts of the topic. They designed an observation system to produce quantifiable data about the use of these strategies. The results of their study showed that use of conceptual change teaching strategies improved the student performance on tests designed to assess conceptual change learning.

Swafford and Bryan (2000) proposed that instructional strategies based on conceptual change theory should consider not only cognitive development but also social development. They examined instructional strategies that promote middle school students' understandings of counterintuitive science concepts and that address their social, cognitive, and physical needs. These strategies included concept oriented reading instruction, discussion webs, collaborative writing, learning logs, and divided page journals. They claimed that these strategies address students' need for active learning, positive social interaction, metacognitive awareness, and multiple opportunities for exploration. Thus, students become more likely to explore science concepts and engage in conceptual change.

Another instructional strategy targeted at conceptual change is the use of conceptual change texts. Wang and Andre (1991) investigated the effectiveness of conceptual change texts on learning electricity concepts. The conceptual change text included students' preconceptions about electrical circuits. They constructed a series of diagrams of simple electrical circuits and asked students if they believed the circuit would work and to explain why. Then, they gave evidences in the text demonstrating that the misconceptions would lead to incorrect answers. On the other hand, a typical traditional text dealing with direct current electrical circuits was used as a control measure. They reported that as compared to traditional text, conceptual change text improved acquisition of electrical circuits concept.

The effect of conceptual change text on understanding of direct current concepts was also studied by Chambers and Andre (1997). They investigated the relationships between gender, interest and experience in electricity, and conceptual change text on learning direct current concept. The results of their study showed that conceptual change text was effective in learning about electricity for both male and female students.

More recently, Mikkilä-Erdmann (2001) investigated the effect of conceptual change text on 5th grade students' understanding of photosynthesis. 209 students were involved in the study and they were randomly assigned to study either a traditional text version about photosynthesis or a conceptual change text in a classroom situation. The conceptual change text took common student misconceptions about photosynthesis into account and tried to produce a cognitive conflict with students' misconceptions by contrasting them with the scientific knowledge. The results indicated that the conceptual change text used in this study produced conceptual change in students' mind concerning photosynthesis concept.

Sungur, Tekkaya and Geban (2001) investigated the contribution of conceptual change texts accompanied by concept mapping instruction to 10th grade students' understanding of the human circulatory system. The results of their study showed that conceptual change texts accompanied by concept mapping led to better understanding of the human circulatory system through differentiation, exchange, and integration of new conceptions into existing ones.

All of these studies showed that the conceptual change approach has a positive effect in remediation of student misconceptions and acquisition of scientific knowledge in a meaningful manner. In this study, conceptual change texts were used as an instructional material to eliminate students' misconceptions related to ecological concepts.

2.5 Students' Environmental Attitudes

It has long been known that the basis for many environmental problems and issues is irresponsible environmental behavior. Without doubt, one of the most important influences on behavior is attitude (Bradley, Waliczek and Zajicek, 1999). Students' environmental attitudes are particularly important because they ultimately will be affected by and will need to provide solutions to environmental problems. Students may begin to formulate environmental attitudes at a very early age (Jaus, 1982; Hewitt, 1997; Leeming and Porter, 1997). Jaus (1982) indicated that the more instruction students receive at early ages in environmental education, the more positive these students' attitudes toward the environment.

Factors influencing students' environmental attitudes were studied by several researches (Jaus, 1982; Mangas and Martinez, 1997; Hewitt, 1997; Leeming and Porter, 1997; Bradley, Waliczek and Zajicek, 1999; Eagles and Demare, 1999; Kuhlemeier, Bergh and Lagerweij, 1999; Tikka, Kuitunen and Tynys, 2000). Bradley et al., (1999) evaluated the effects of a short-duration environmental science course on environmental knowledge and attitudes of high school students to answer the question of whether increased knowledge about the environment can improve students' environmental attitudes. They reported that increased knowledge may help improve environmental attitude. On the other hand, they claimed that outside influences such as life experiences, socioeconomic status, and culture influence environmental attitudes as well.

Eagles and Demare (1999) revealed that students' attitudes toward the environment correlate with talking about the environment at home, watching nature films, and reading about the environment. They suggested that film, written media and family are very important influences on environmental attitudes.

Hewitt (1997) studied the effects of instructional games relating to the environmental topics on students' environmentally responsible behavior. She reported that games provide a means for students to become more active in learning process and encourage student-to-student interactions that are most influential on students' behavior. The results showed that using games in instruction promotes student participation in their own learning and by learning more about the environment, students' attitudes toward the environment increase.

Leeming and Porter (1997) showed the effectiveness of participation in class activities on students' environmental attitudes. Some examples of activities in which experimental group students involved in their study were recycling aluminium cans and white paper, planting trees and flowers, maintaining school grounds, maintaining a bulletin board of environmental issues, and participating in environmental organizations. The results of their study indicated that students who participated in such activities showed a significantly greater change in attitudes towards the environment from pre-test to post-test than did students in the control group.

The underlying idea in all of these studies is that environmental attitudes of students can be influenced, at least in part, by what is taught in the classroom. Because environmental problems will not be solved unless attitudes of people are changed, effective instructional methods are required to increase students' environmental attitudes positively at early ages.

Based on the implications in the literature, it can be said that the teaching method is one of the important factors affecting not only meaningful learning in students but also students' attitudes towards the subject matter. Therefore, in this study, the effect of conceptual change text oriented instruction on students' understanding of ecological concepts and their attitudes towards environment were investigated.

CHAPTER 3

PROBLEMS AND HYPOTHESES

3.1 Main Problem

The purposes of this study were to identify seventh grade students' misconceptions concerning ecological concepts and to investigate the effect of conceptual change text oriented instruction on remediation of seventh grade students' misconceptions concerning ecological concepts and on students' environmental attitudes.

3.2 Sub-Problems

1. Is there a significant difference between the effect of conceptual change text oriented instruction and that of traditional instruction on remediation of students' misconceptions concerning ecological concepts?

2. What is the effect of traditional instruction on remediation of students' misconceptions concerning ecological concepts?

3. What is the effect of conceptual change text oriented instruction on remediation of students' misconceptions concerning ecological concepts?

4. Is there a significant difference between the effect of conceptual change text oriented instruction and that of traditional instruction on students' attitudes toward environment?

5. What is the effect of traditional instruction on students' attitudes toward environment?

6. What is the effect of conceptual change text oriented instruction on students' attitudes toward environment?

3.3 Hypotheses

The problems were statistically tested by the following hypotheses:

$H_0 1(i)$: There is no significant difference between the post-test mean scores of students exposed to conceptual change text oriented instruction and those exposed to traditional instruction with respect to remediation of their misconceptions regarding ecological concepts, holding constant the pre-test results.

$H_0 1$(ii): There is no significant difference between the gain scores of students exposed to conceptual change text oriented instruction and those exposed to traditional instruction with respect to remediation of their misconceptions regarding ecological concepts.

$H_0 2$: There is no significant difference between the pre- and post-test mean scores of students who received traditional instruction with respect to remediation of their misconceptions related to ecological concepts.

$H_0 3$: There is no significant difference between the pre- and post-test mean scores of students who received conceptual change text oriented instruction with respect to remediation of their misconceptions related to ecological concepts.

$H_0 4$: There is no significant difference between the post-test mean scores of students exposed to conceptual change text oriented instruction and those exposed to traditional instruction with respect to attitudes toward environment, holding constant the pre-test results.

$H_0 5$: There is no significant difference between the pre and post-test mean scores of students who received traditional instruction with respect to attitudes toward environment.

$H_0$6: There is no significant difference between the pre and post-test mean scores of students who received conceptual change text oriented instruction with respect to attitudes toward environment.

CHAPTER 4

METHOD

In this chapter, overall research design, information about the subjects of the study, variables of the study, the data collection procedures, treatment and the data analysis procedure to conduct this study are presented.

4.1 Overall Research Design

In this study, the pre-test post-test control group experimental design was employed.

Table 4.1 Research Design of the Study

Groups	Before Treatment	Treatment	After Treatment
EG	ECT, EAS	CCTI	ECT, EAS
CG	ECT, EAS	TI	ECT, EAS

In this table, EG represents the Experimental Group using conceptual change text oriented instruction. CG represents the Control Group receiving traditional instruction. ECT is the Ecology Concept Test and EAS is the

Environmental Attitude Scale. CCTI and TI represent Conceptual Change Text oriented Instruction and Traditional Instruction, respectively.

To investigate the effect of the treatment on remediation of students' misconceptions concerning ecological concepts and on students' environmental attitudes, ECT and EAS were administered as both pre and post-tests in both groups.

4.2 Subjects of the Study

This study included a qualitative and a quantitative part and both parts were conducted in METU Developmental Foundation Private School in 2000-2001 fall semester. In qualitative part of this study, 10 eight grade students were interviewed to obtain information about students' misconceptions concerning ecological concepts. These students had been taught about the topic in the previous year and they had average science success. In the quantitative part of the study, the participants included 58 seventh grade students (33 boys and 25 girls) from two intact classes. Both classes were instructed by the same science teacher and both received identical syllabus-prescribed learning content. Two instructional methods were randomly assigned to groups. The data were obtained from 28 students in the experimental group utilizing conceptual change text oriented instruction, and 30 students in the control group attending traditional instruction. The students were typical seventh graders, with a mean age of 12 years. The socioeconomic status of the students in both groups was similar, with the majority coming from middle- to high-class families.

4.3 Variables

4.3.1 Independent Variables

Treatment (CCTI vs TI) was the independent variable in this study.

4.3.2 Dependent Variables

Students' understanding of ecological concepts measured by ECT and their attitudes towards environment measured by EAS were dependent variables in this study.

4.4 Data Collection Instruments

Data for this study were obtained from three major sources: (1) interviews with students, (2) Ecology Concept Test, and (3) Environmental Attitude Scale.

4.4.1 Interview with Students

The interviews, conducted at the beginning of the study, served as the main source of data and addressed the students' misconceptions concerning ecological concepts. During the interviews, a semi-structured interview schedule (see Appendix A and B) was used. The schedule was left flexible to allow students to express themselves in relative freedom and to enable the interviewer to ask thought-provoking questions. Interview questions covered four main concepts namely, basic ecological concepts, food chain, energy pyramid, and food web. Ten individual interviews were held; each lasted approximately 20 minutes duration. All of the interviews were audiotaped and transcribed. Transcriptions were produced verbatim to provide full representation of the students' responses.

During the interview, the answer of the following questions were obtained:

1. How do students define environment and interpret the living and non-living things? The information obtained from students' responses to this question was used to construct item 1 of the ECT.

2. How do students interpret the meaning of population? Students' responses to this question and their examples to population formed the item 2 of the ECT.

3. How do students interpret the meaning of ecosystem? The information obtained from students' responses to this question was used to construct item 3 of the ECT.

4. How do students interpret the energy source for living organisms? The answer of this question was deeply investigated by thought provoking questions. The information obtained from students' responses to this question was used to construct items 4 and 5 of the ECT.

5. How do students interpret the energy relationship between plants and animals? Students' responses to this question were used to construct item 6 of the ECT.

6. How do students interpret the food chain? The answer of this question was deeply investigated by thought provoking questions. Students' answers to these questions and also their example presentations of food chain were used to form the items 8 and 9 of the ECT.

7. How do students interpret the energy flow within the food chain? The answer of this question was deeply investigated by thought provoking questions. Students' answers to questions were used to construct the items 10 and 11 of the ECT.

8. How do students differentiate the consumers? Students' answers to this question were used to construct the item 12 of the ECT.

9. How do students interpret the energy pyramid? Students' drawings of energy pyramid and their answers to questions were used to construct the item 13 of the ECT.

10. How do students interpret the food web? The answer of this question was deeply investigated by asking thought provoking questions. Students' examples and explanations were used to construct the item 14 of the ECT.

11. How do students interpret the interactions between populations within a food web? The answer of this question was deeply investigated by asking questions about the effect of one population on another population in a sample food web. Students' responses to each question were used to form the items 15 through 21 of the ECT.

The following excerpt from interviews is an example to show how thought-provoking questions help to diagnose students' misconceptions:

Researcher:	**How can you describe the environment?**
Student:	**It is a place.**
Researcher:	**What kind of things we can find in the environment?**
Student:	**All living things…plants, animals and people.**
Researcher:	**What about the non-living things?**
Student:	**Non-living things may be harmful for the environment for example plastics, so we should not include them into the definition of the environment.**

4.4.2 The Ecology Concept Test

Based on the misconceptions provided by students during the interview sessions and related literature, the Ecology Concept Test was developed by the researcher. The test included 21 items based on the two-tier multiple choice format described by Haslam and Treagust (1987). The first tier of each item examined the content knowledge with two or three alternatives. The second tier consists of four reasons for the first tier. These reasons include one scientifically acceptable answer supporting the desired content knowledge in the first tier and three misconceptions identified during the interviews and from the related literature. Students need to have both the content choice and the reason (combination) correct to be awarded 1.

During the development stage of the test, following steps were taken into consideration: First, the content boundaries of the test were defined with a list of propositional knowledge statements (see Table 4.2). Then, students' misconceptions identified by interviews. Finally, using the misconceptions identified through interviews and misconceptions from the related literature were used to develop the items of the test.

Table 4.2 Propositional Knowledge Statements Required for Understanding Ecological Concepts

1. Environment is the total surrounding of a living thing including all other living things and non-living things.

2. Population is a group of living things of the same species occupying a certain area in a certain time.

3. Ecosystem is an array of living things and their interactive physical environment.

4. Sun is the basic energy source for all ecosystems.

5. Plants absorb the light energy from sun, which goes into food.

6. Plants are producers that use sunlight energy to make food.

7. Animals are consumers that use part of the energy produced by the producers.

8. Decomposers are organisms that break down organic matter into inorganic matter.

9. Herbivores are the primary consumers whose energy source is producers.

10. A food chain is a model of how the energy in food is passed from organism to organism in an ecosystem.

11. The movement of energy in a food chain begins with producers.

12. Producers form a base in an energy pyramid.

13. The amount of energy and the number of organisms are high at the base of an energy pyramid.

14. The amount of energy flowing through producers to consumers decrease at each level.

15. A food web is a network of crossing and interlinked food chains.

16. All populations interact and react to changes in a food web.

Table 4.2 Continued

17. The effects of a change in one population spread through a web of pathways.
18. Populations that are not directly related as predator and prey can influence each other.
19. The size of prey and predator populations influences each other.
20. Organisms higher in a food web feed on organisms lower in the food web.

Since the language of the instruction was Turkish in the school, the test was written in Turkish. Each item in the Ecology Concept Test (see Appendix C) was examined by a group of experts regarding content validity and format. The classroom teacher also analyzed the relatedness of the test items to the instructional objectives.

Prior to its use, the test was pilot-tested with experienced students and revised. The reliability coefficient computed by Cronbach alpha estimates of internal consistency of this test was found to be 0.77, when both parts of the items were analyzed. The test was administered to both experimental and control groups as pre-test before the treatment and as post-test after the treatment.

4.4.3 The Environmental Attitude Scale

The attitude scale measuring students' attitudes towards environment was developed by the researcher considering the characteristics of several types of attitude scales. It was a 21-item and 5-point Likert type scale. The choices of each item were strongly agree, agree, undecided, disagree, and strongly disagree. The Environmental Attitude Scale was also written in Turkish. The reliability of the scale was found to be 0.79.

The environmental attitude of the students in the experimental and control groups was measured both before and after the treatment.

4.5 Treatment (CCTI vs TI)

This study was conducted over a period of 5 weeks. A total of 58 students from two intact science classes were involved in the study. The same science teacher gave the classroom instruction for both groups. One of the classes was randomly assigned as the experimental group and the other as the control group. Instructions in both classes were observed by the researcher in order to control the teacher effect and bias and also to verify the treatment. Students in both groups were exposed to same content for the same duration. The duration of the lessons was four- 40 minutes periods per week.

Students in the control group received traditional instruction in which students are passively involved in receiving all information from the teacher and the textbook. Teacher explained the facts on the blackboard and students took notes through the lesson. Teacher generally asked questions to whole class and discussed the answers with the students. The main idea behind this teachercentered instruction was to provide students with clear and detailed information. The misconceptions of students were not taken into consideration.

Students in the experimental group worked with conceptual change texts. Conceptual change texts were prepared by the researcher by using information obtained from related literature and interviews (see Appendix D and E). Four conceptual change texts were written concerning the following topics: (1) general ecological terms such as ecosystem, population; (2) producer, consumer and decomposer; (3) food chain and food web, and (4) energy pyramid. In each of the texts, students were introduced with questions and their possible answers that may include misconceptions held by the students. Each possible answer was then discussed in the texts. By this way students were first introduced with their misconceptions if exist and they were aimed to be dissatisfied with them. Then scientifically acceptable explanations that were more plausible and intelligible provided with examples and figures were mentioned.

Prior to beginning the study, teacher was informed about the use of conceptual change texts in two one-hour training sessions. During the study, several meetings with teacher were conducted in order to facilitate the proper use of conceptual change texts. The texts were given to students to be read 3 or 4 days before the class hour when the related topic would be covered. The teacher discussed the conceptual change texts with the students during the lesson. First, students read the texts silently and teacher provided students with wait-time to think about the questions. Then, the teacher emphasized misconceptions in students' answers by providing opportunities for students to be involved in discussions while studying conceptual change texts. During this period, students examined a model of energy pyramid that had been prepared and colored by the researcher. Then, students were asked to develop their own energy pyramid. Similarly, while discussing concepts of food chain and food web, they developed their own food chains and food webs. By this way, teacher-student and student-student interactions were maximized. Thus, students in the experimental group played an active role during the instruction.

4.6 Analysis of Data

In this study, Analysis of Covariance (ANCOVA), paired-samples t-test and independent-samples t-test statistical techniques were used to analyze the data collected from the instruments described above.

4.7 Assumptions and Limitations

During this study, assumptions and limitations encountered are given as below:

4.7.1 Assumptions

1. The teacher who applied this study was not biased during the treatment.
2. There was no interaction between the students in the experimental and control groups.
3. All students' responses to the test items were sincere.

4.7.2 Limitations

1. The subjects in the interview were limited to ten students from 8^{th} grade.
2. The subjects in the treatment were limited to 58 students from 7^{th} grade.
3. The study was limited to the unit of " The Living Things and The Environment".

CHAPTER 5

RESULTS AND CONCLUSIONS

In this chapter, the results obtained from the interviews, the Ecology Concept Test and the treatment are presented.

5.1. Results

5.1.1 Interview Results

To identify the students' misconceptions 10 individual interviews were conducted with 8^{th} grade students who studied related topics in previous year. Selected examples of excerpts from interviews are as follows:

1. How do students define environment and interpret the living and non-living things?

Question: How can you describe the environment?

Student 1: It is a place where all living things exist.

Student 6: It is a place that we (people) live in and must keep clean.

Question: What kind of things we can find in the environment?

Student 1: All living things, that is plants and animals.

Student 6: All living things...plants, animals and people.

Question: What about the non-living things? Are there any non-living things in the environment?

Student 1: Yes, there are. For example, desks, chairs, books, buildings, cars etc.

Student 6: Non-living things may be harmful for the environment for example plastics, so we should not include them into the definition of the environment.

Question: Then, is there a relationship between living things and non-living things?

Student 1: Yes, we use the non-living things. For example, we live in buildings; use bus to travel and read books to learn.

Student 6: People produce garbage by using non-living things and this garbage makes environment dirty.

These answers showed that students do not have an accurate environment definition in their mind. They believed that just living things that they can see around occupy the environment. Their responses to the question about non-living things revealed that they have misconceptions on the concepts of living and non-living. They thought that the non-living things are the only materials or equipment that people use. They did not mention on non-living things such as soil, minerals, water that living things directly depend on. Some students believed that the non-living things are harmful for the environment so they did not mention non-living things while defining the environment. In addition, responses of students showed that they do not have enough conceptual knowledge about the classification concept. They thought that there are plants, animals and people. They do not include the people in the kingdom of animals. These students' answers were used to construct item 1.

2. How do students interpret the meaning of population?

Question: What do you understand from the word "population"?

Student 1: Population is the all living things in a place.

Student 2: The number of people living in a city or country.

Student 3: It is the number of living things-plants, animals and people.

Question: Can you give an example to population?

Student 1: For example, flowers and animals in a garden.

Student 2: Five thousand people in Ankara may be an example.

Student 3: For example, the number of people in Turkey; that is population of Turkey.

These answers showed that students confused the meaning of human population with the meaning of biological population. They interpreted the population as the number of people or other living things in a given place.

Actually, none of the students participated the interview considered the population as a group of individuals of the same species occupying a given area in a given time. Students' explanations and examples to these questions were used to construct item 2.

3. How do students interpret the meaning of ecosystem?

Question: When I say "ecosystem", what do you understand?

Student 2: I think it is a continuous interaction between the living things. For example, the interaction between producers and consumers is the ecosystem because consumers eat producers to keep continuity of ecosystems.

Student 3: I suppose it is something related to ecology.

Student 5: Ecosystem is the continuous change in way of life of living things.

Student 10: It means ecology and so it is something related to nature.

Students' explanations showed that students have misconceptions on basic ecological terms like population, ecosystem and ecology. They equated ecosystem with ecology. Some students were seemed to be familiar with the ecosystem term but it was rather difficult for them to define it. They thought that it was something related to only living things and their interaction. They failed, however, to recognize that the non-living things were also the components of the ecosystems. Students' answers were used to construct the item 3.

4. How do students interpret the energy source for living organisms?

Question: What can you say about the main energy source in nature?

Student 3: Foods are the main energy source for us but plants use sun, they make photosynthesis.

Student 6: Sun is the main energy source because it gives us light and heat.

Student 8: Sun. Plants use it for photosynthesis, people and animals don't use it for energy, and they use it just for heat.

Student 1: Electricity is the main energy source because without it, life would be terrible, any machine could work.

Question: What about the sun energy?

Student 1: Yes, sun is another energy source; we use it for light and heat.

These responses showed that most of the students know that the sun is basic energy source in nature. However, students considered sun energy as light and heat source. On the other hand, some students considered electricity and foods as the main energy sources. Although majority of the students realized that the sun is the energy source for plants, in the light of literature the energy source for plants was still questioned in the test. These answers showed that students have misconceptions on energy concept. Items 4 and 5 were constructed by using these answers.

5. How do students interpret the energy relationship between plants and animals?

Question: Do you think that, is there a relationship between plants and animals in terms of energy? Why?

Student 1: No, because both plants and animals have their own energy.

Student 9: No, because animals are stronger than plants and have their own energy. They just eat plants.

Student 4: Yes, animals eat plants and get their energy.

Question (to student 4): How do animals get plants' energy?

Student 4: After they eat the plants, they digest food and so energy releases.

These responses largely confirmed the findings in the previous question that students have conceptual hurdles in energy sources of living organisms and how energy is transferred among the living organisms. By using these answers item 6 was constructed.

6. How do students interpret the food chain?

Question: How can you describe the "food chain"?

Student 1: Food chain is something related to who eats whom.

Student 2: Food chain exists when an animal eats a plant.

Student 3: I don't know exactly but it includes different animals.

Student 10: It must be a kind of feeding relation including different food materials such as vitamins, proteins etc.

Question: Can you give an example to food chain?

Student 1: Wheat ← mouse ← snake ← eagle

Student 2: Grass → cow → man

Student 3: Eagle → snake → mouse → plant

Question (to student 1 and student 2): Why did you begin your food chain with the plant?

Student 1: Because plant is the smallest organism so it should be the first, and the eagle is the biggest organism so it should be the last.

Student 2: Grass cannot eat the cow and man, but man can eat both of them.

Question (to student 3): Why did you begin your food chain with the eagle?

Student 3: Because eagle is the most ferocious animal so it can eat all other organisms.

Students' answers to the question "what is food chain" indicated that while some students have misconceptions about the food chain, others have no idea about this concept. These answers showed that students do not consider the food chain as a flow of energy through its members. Student 1 and student 3 represented inverted and incorrect food chains, respectively. Student 1 began with the producer correctly but the direction of arrows did not correct, they did not follow the direction of the flow of energy that begins with the producer. On the other hand, student 3 drew a completely incorrect food chain by beginning with the eagle. These examples of students and their reasoning indicated that students used the predator-prey relation and the ferocity and size characteristics of animals as the two criteria to construct a food chain. Students' answers to these questions were used to construct items 8 and 9.

7. How do students interpret the energy flow within the food chain?

Question: What can you say about the direction of energy flow in a food chain including grass, insect, chicken and man?

Student 1: Since man should have the greatest amount of energy, energy flows through grass to man.

Student 4: Energy does not pass from one organism to another because every organism has its own energy.

Student 5: Energy flows through grass to man because man does not give energy to any other organism.

Student 10: It flows through man to grass because man has the greatest amount of energy.

Question: Then, what about the amount of energy? Which organism has the greatest amount of energy in the food chain "grass→sheep→man"?

Student 1: Man. He gets his energy both from grass and sheep.

Student 4: Man has more energy because he needs more energy to live.

Student 5: Energy accumulates up to man, so man has the greatest amount of energy.

Student 10: Among these, man is the strongest one and therefore he has the most energy. Also he is the most complex organism in nature.

These answers represented that some students think wrongly that energy is transferred from the strongest organism to weaker organism in a food chain. On the other hand, others gave the right direction of energy flow that begins with the producer but their reasoning indicated their misconceptions about the flow of energy in a food chain. They believe that energy accumulates up to the end of the food chain. Still others correlated the amount of energy with size or complexity of that organism. They think that the biggest or the most complex organism in a food chain has the greatest amount of energy. By using these answers, items 10 and 11 were constructed.

8. How do students differentiate the consumers?

Question: As you know, insect, chicken and man are all consumers in the following food chain: "grass→insect→chicken→man". What do you think how you can we differentiate these consumers from each other?

Student 3: Insect eats grass, chicken eats insect and man eats everything. Thus, we can differentiate them if we know what they eat.

Student 8: Since insect cannot eat the chicken, chicken consumes more than the insect, but man is the primary consumer because he consumes everything.

These responses showed that although students could interpret that consumers are categorized according to their feeding habit, they interpreted incorrectly that who eats more is the primary consumer. These answers were used to construct item 12.

9. How do students interpret the energy pyramid?

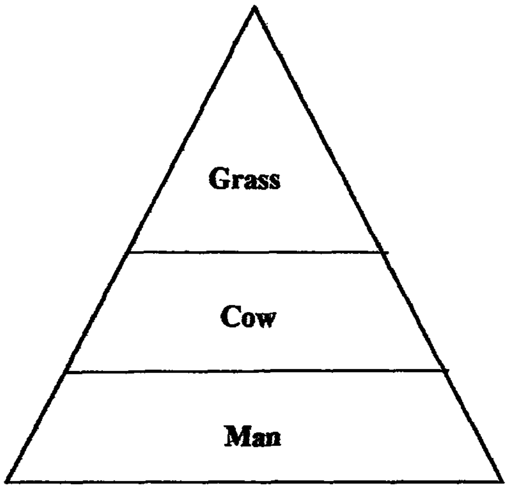
Question: Do you know what energy pyramid is?

Student 3: As I remember, it looks like a triangle where producers and consumers are placed.

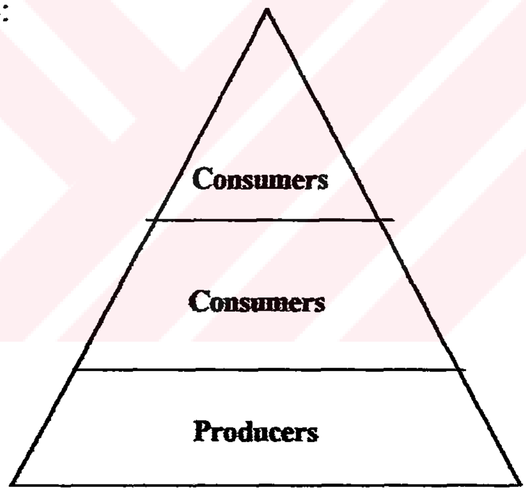
Student 4: It is same as food chain but in the shape of triangle.

Question: Can you draw an energy pyramid and fill in it?

Student 3:



Student 4:



Question: What about the decomposers? Do we include them in the energy pyramid?

Student 3: I don't know where I can put them in the pyramid exactly. But I think that they should be at the top of it because they eat dead animals and plants. So, they come after all other organisms.

Student 4: There is no need to include decomposers because they are too small to be seen by naked eye. They are just found on dead animals.

Question: What do you think why the base of the energy pyramid is wider?

Student 3: There are consumers at the base. Since consumers are stronger and larger in size than producers, the base must be wider.

Student 4: There are producers in the base of the pyramid and the number of producers must be higher in nature, otherwise consumers cannot find enough food to live.

These answers showed that students did not interpret the pyramid of energy as a model of energy flow between organisms. They thought wrongly that each level of pyramid represents the number of organisms. In addition, students have misconceptions about decomposer concept. Decomposers are either placed at the end of the food chain or not included in the food chain in textbooks. Therefore, students did not sure about where the decomposers are in an energy pyramid. During the interviews, it was noticed that students do not comprehend the importance of decomposers for ecosystems. From these answers items 7 and 13 was constructed.

10. How do students interpret the food web?

Question: How can you describe the "food web"?

Student 1: It must be something related to food chain, but I am not sure.

Student 2: It is same as food chain, like plant→cow→man.

Student 4: Food web looks like food chain.

Student 8: Food web is same as food chain that is who eats whom.

Question: In the following food web, what do arrows indicate.

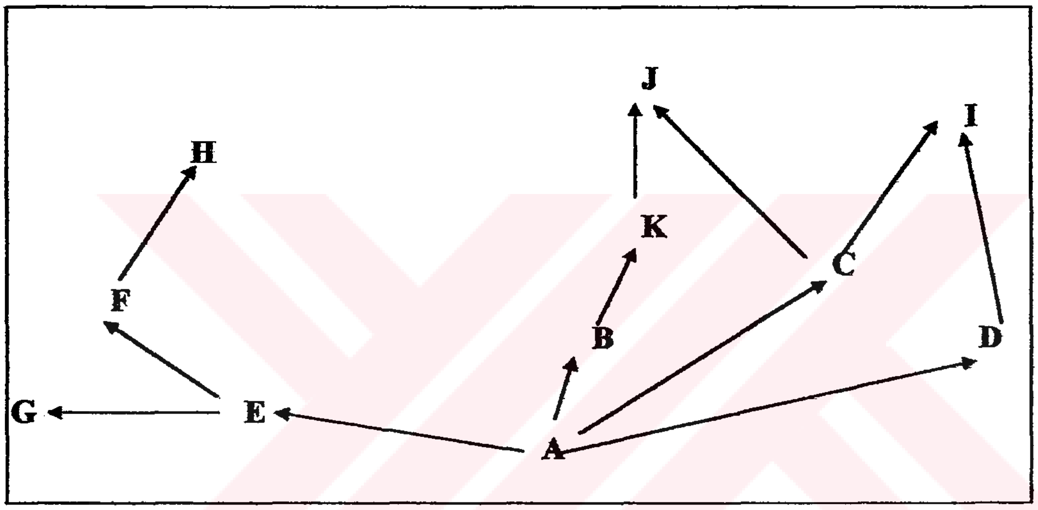


Figure 5.1 A sample food web (Webb and Boltt, 1990).

Student 1: They show the arrangement of animals in a food web, that is each arrow shows who eats whom.

Student 6: They show who eats whom, for example B eats A.

Student 10: Populations eat each other and the arrows indicate who eats whom.

Question: What may be the **A**?

Student 1: **A** eats everything in this web.

Student 2: It may be a plant that animals can eat.

Student 4: Sun, because sun gives the energy that initiates the food web.

Students' answers showed that they had difficulty in differentiating the food chain and food web and in construction of a food web. Students' responses to following questions confirm this finding also. These responses were used to construct item 14.

11. How do students interpret the interactions among populations within a food web?

Question: Does a sudden decrease in population **F** affect the population **H** in the Figure 5.1? How?

Student 1: Population **H** will increase because the **F** is the predator of it. The number of animal who eats **H** will decrease.

Student 4: It doesn't affect because a change in prey population does not affect the predator population. It finds another prey.

Student 8: Population **H** is located higher and so it would not be affected the changes in the populations located lower.

These answers showed that students lack the ability to interpret “the effect of a sudden size change in a prey population on its predator population.” On the other hand, student 1 considered the food chains as inverted and made the same mistake in all other questions. Students’ answers to this question were used to construct item 15.

Question: Does a sudden decrease in population **E** affect the population **H** in the Figure 5.1? How?

Student 2: It doesn’t affect because they are not linked.

Student 8: No effect. They are not located side by side.

Student 9: Population **H** is located upper and it can be affected by only population that is located upper than it.

Student 10: It doesn’t affect because there is no prey-predator relationship between the two populations.

This question measured the students’ ability to determine “the effect of a sudden size change in one population on a second non-adjacent population located higher on the same food chain when the effect is transmitted along only one route.” Students’ responses showed that they have misconceptions about the non-adjacent populations in the same food web. This question and the responses of students to this question constitute the item 16.

Question: Does a sudden increase in population **G** affect the population **F** in the Figure 5.1? How?

Student 2: Population **E** would be exhausted so population **F** would also be exhausted.

Student 4: No effect. They are not closely linked.

Student 8: They are located side by side. Only population **E** will be affected.

Student 10: There is no relationship between these two populations so it doesn't affect.

Students' answers showed that students do not have the ability to determine "the effect of a sudden size change in one population on a second population not located on the sane food chain." This question and the students' answers to this question form the item 17.

Question: Does a sudden decrease in population **H** affect the population **E** in the Figure 5.1? How?

Student 2: It does. Population **F** would increase and population **F** would eat and exhaust the population **E**.

Student 4: No effect. Because population **E** is located lower.

Student 8: No. They are not located side by side.

Student 9: **H** is located upper so it doesn't affect the populations located lower.

These answers indicated that students lack the ability to determine "the effect of a sudden size change in one population on a second non-adjacent population located lower on the same food chain." This question and the answers of students form the item 18.

Question: Does a sudden size change in population **A** affect the population **J** in the Figure 5.1? Show me the ways through which the effect is passed.

Student 1: The way is **A→B→K→J**. But since they are too far apart from each other, probably little effect would be transmitted.

Student 4: They are not really closely linked so no effect will be transmitted.

Student 8: There are two ways: **A→B→K→J** and **A→C→J**. But in both ways, a change in population **A** doesn't affect population **J** because they are not located side by side.

Student 9: The easiest way is the **A→C→J** but little affect will be passed because they are too far apart to affect each other.

Students' answers showed that they did not recognize all of the pathways through which "the effect of a change in one population is transmitted to another in the same food web." Their answers were all based on the proximity of populations on the web. This question and the students' responses were used to construct the item 19.

Question: Does a sudden increase in population **B** affect the population **J** in the Figure 5.1? How?

Student 4: Population **J** is located upper and it eats all the others located below, so it also increases.

Student 8: Only population **A** and **K** would be affected from this increase.

Student 9: They are far away from each other.

Student 10: If population **B** increases, population **K** will decrease and so population **J** will increase.

Students' answers showed that they do not have the ability to determine "the effect of a sudden size change in one population on a second non-adjacent population located higher on the same food chain when the effect is transmitted along more than one route." This question and the answers of students form the item 20.

Question: Does a sudden increase in population **I** affect the population **K** in the Figure 5.1? How?

Student 1: No effect. They are not linked.

Student 2: It does because a change in a food web may influence the entire web in the same way.

Student 4: They are not located side by side so it doesn't affect.

Student 8: No. There is no link between them.

Student 9: They are too far apart to affect each other.

Students' answers showed that they lack the ability to interpret "the effect of a sudden size change in one population on a second population that is not on the same food chain." This question and the students' answers to this question form the item 21.

5.1.2 The Ecology Concept Test Results

In the Ecology Concept Test, students need to have both the content choice and the reason (desired combination) correct to be awarded 1. Average percentages of students in both experimental and control groups selecting the desired combination were evaluated for both pre and post-test. In the pre-test, the average percent of the correct responses of the students who selected the desired combination was 31.9% in the experimental group and 32.7% in the control group. In the post-test, while 63.8% of the students in the experimental group selected the desired combination, 55.2% of the students in the control group selected the desired combination. For example, in the pre-test, for item 8 dealing with the definition of the food chain, 42.9% of the students in the experimental group and 40.7% of the students in the control group selected the desired combination, which is "food chain is the transfer of energy from one organism to another, because the energy stored by producers is passed through the organisms in a food chain." In the post-test, the majority of the students in the experimental group (96.4%) selected the desired combination. On the other hand, 66.7% of the students selected the desired combination in the control group.

In item 11, it was asked students to determine the organism that has the greatest amount of energy in a food chain including grass, sheep and man. In the pre-test, only 14.3% of the students in the experimental group and 13.3% of the students in the control group selected the desired combination, which is "grass has the greatest amount of energy, because energy comes into the food chain through grass." In the post-test, the percentage of the students who selected the desired combination increased to 82.1% in the experimental group and to 43.3 % in the control group.

The misconceptions included in the distractors of the test items are the common misconceptions held by the students in ecological concepts. Table 5.1.2.1 presents a list of students' misconceptions identified through Ecology Concept Test.

Table 5.1.2.1 A List of Students' Misconceptions Identified through Ecology Concept Test

A. Basic Ecological Terms

1. Environment is a place where living things exist because it includes plants and animals in it.
2. Environment is a place where people live because it is a place that people must keep clean.

3. All living things in Turkey is an example of population because population is the group of living things in a certain area.
4. The number of people in Turkey is an example of population because population is the group of people in a certain area.
5. Ecosystem is the continuous interaction between producers and consumers because consumers eat producers to keep continuity of ecosystems.
6. Ecosystem is the continuous interaction between producers and consumers because living things always interact with each other.
7. Ecosystem is the continuous change in way of life of living things because living things always interact with each other.
8. Ecosystem is the organisms living in a certain area and their interaction with the living and non-living surrounding because consumers eat producers to keep continuity of ecosystems.
9. Decomposers are important for ecosystems because they eat dead plants and animals to keep environment clean.
10. Decomposers are not important for ecosystems because they are found on dead animals.
11. Decomposers have no effect on ecosystems because they are found on dead animals.

B. Energy Sources in Ecosystems

1. Sun is the basic energy source for all ecosystems because living things use sun as heat source.
2. Producers are the basic energy source for all ecosystems because they make food for other living things.
3. Food materials are the basic energy source for all ecosystems because living things cannot survive without food.
4. The energy source for plants is soil because plants grow in soil.

Table 5.1.2.1 continued

5. The energy source for plants is soil because plants feed on water and minerals found in the soil.

6. The energy source for plants is air because they use the gases in air to get energy.

7. There is a relationship between plants and animals with respect to energy because animals eat plants.

8. There is no relationship between plants and animals with respect to energy because both plants and animals have their own energy.

9. There is no relationship between plants and animals with respect to energy because animals are stronger than plants and they have their own energy.

C. Food Chain

1. Food chain is a kind of feeding including different food materials because it is consisted of proteins and vitamins found in foods.

2. Food chain is the transfer of energy from one living thing to another because food chain exists when an animal eats a plant.

3. "grass→cow → milk → man" can be an example of food chain because cow as a producer, produces milk which is a food for man.

4. "Plant → fish → man" cannot be an example of a food chain because plants do not live in water, so fish do not feed on plants.

5. "Grass → grasshopper → frog → snake → eagle" cannot be an example of food chain because a food chain cannot include more than four living things.

D. Notion of Energy

1. In a food chain including plant, insect, chicken and man, energy does not pass from one living thing to another because every living thing has its own energy.

Table 5.1.2.1 continued

2. In a food chain including plant, insect, chicken and man, energy does not pass from one living thing to another because man does not give energy to anything.
3. In a food chain including plant, insect, chicken and man, energy flows through man to plant because man has the greatest energy.
4. In a food chain including plant, insect, chicken and man, energy flows through plant to man because man has the greatest energy.
5. In a food chain including plant, insect, chicken and man, energy flows through plant to man because man does not give energy to anything.
6. In a food chain including grass, sheep and man, sheep has the greatest energy because meat is a powerful energy source and a nutritious food for man.
7. In a food chain including grass, sheep and man, man has the greatest energy because he gets his energy both from grass and sheep.
8. In a food chain including grass, sheep and man, man has the greatest energy because he is the strongest one.
9. Among lion, rabbit and man, lion is the primary consumer because lion is wild and strong animal.
10. Among lion, rabbit and man, lion is the primary consumer because lion is a carnivore.
11. Among lion, rabbit and man, man is the primary consumer because he consumes everything.
12. In an energy pyramid, man occupies the base because the number of man is highest in nature.
13. In an energy pyramid, man occupies the base because he eats both animals and plants.
14. In an energy pyramid, consumers occupy the base because they have the greatest energy.

Table 5.1.2.1 continued

E. Food Web

Using the sample food web in the Figure 5.1 the following misconceptions were identified.

1. "**A**" is the sun because sun provides the energy that initiates the food chain.
2. "**A**" is the sun because sun has the greatest energy.
3. "**A**" is the man because man eats all living things.
4. A sudden decrease in population **F** affects the size of population **H** because the predator of population **H** will decrease and so population **H** will increase.
5. A sudden decrease in population **F** affects the size of population **H** because population **H** is stronger than population **F**.
6. A sudden decrease in population **E** affects the size of population **H** because population **E** is the predator of both populations **F** and **H**.
7. A sudden decrease in population **E** does not affect the size of population **H** because population **H** is located highest.
8. A sudden decrease in population **E** does not affect the size of population **H** because they are not located as side by side.
9. A sudden increase in population **G** does not affect the size of population **F** because only population **E** would be affected.
10. A sudden decrease in population **H** affects the size of population **E** because population **H** is the predator of both populations **F** and **E**.
11. A sudden decrease in population **H** does not affect the size of population **E** because they are not related as predator and prey.
12. A sudden decrease in population **H** does not affect the size of population **E** because population **H** is the predator of both populations **F** and **E**.
13. A sudden size change in population **A** affects the population **J** because population **J** is the predator of all populations located below it.

Table 5.1.2.1 continued

14. A sudden size change in population **A** does not affect the population **J** because they are too far away.
15. A sudden size change in population **A** does not affect the population **J** because **J** is the predator of all populations located below it.
16. A sudden increase in population **B** affects the size of population **J** because if population **B** increases, population **K** decreases and population **J** increases.
17. A sudden increase in population **B** does not affect the size of population **J** because an increase in population **B** affects only populations **A** and **K**.
18. A sudden increase in population **I** affects the size of population **K** because a change in food web affects the entire web in the same way.
19. A sudden increase in population **I** does not affect the size of population **K** because there is no link between population **I** and **K**.
20. A sudden increase in population **I** affects the size of population **K** because a change in food web affects the entire web in the same way.

5.1.3 Statistical Analyses of Hypotheses

In this section, the results obtained from the treatment are presented according to the hypotheses stated in Chapter 3. All hypotheses are tested at a significance level of 0.05. Statistical analyses were carried out by using SPSS/PC (Statistical Package for Social Sciences for Personal Computers).

All of the subjects were administered the Ecology Concept Test and Environmental Attitude Scale as both pre- and post-test. The pre-test results in both groups were used to evaluate students' prior knowledge in ecological concepts and their attitudes towards environment before treatment. Also, students' prior knowledge in science was also taken into consideration, by using their grades in science course in the previous year, to ensure that there was homogeneity between the experimental and control groups. Table 5.1.3.1 reveals the results of independent-samples t-test analyses conducted for comparison of the groups concerning those variables prior to treatment.

Table 5.1.3.1 The Comparison of the Experimental and Control Groups with respect to Measures before the Treatment.

Variable	Group	n	$\bar{x}$	s	t-value	p
ECT	EG	28	6.71	2.05	-0.395	0.69
	CG	30	7.00	3.26		
EAS	EG	28	81.2	9.56	-0.340	0.74
	CG	30	82.1	10.96		
Science Grades	EG	28	4.07	0.86	0.595	0.55
	CG	30	3.93	0.91		

The results presented in Table 5.1.3.1 indicates that there were no statistically significant differences between the two groups in terms of their prior knowledge in science and ecological concepts, and their attitudes towards environment before the treatment. Thus, students in both groups were equivalent concerning those variables prior to treatment.

Hypothesis $H_0 1(i)$:

Analysis of Covariance (ANCOVA) was used to test the hypothesis $H_0 1(i)$ stating that there is no significant difference between the post-test mean scores of students exposed to conceptual change text oriented instruction and those exposed to traditional instruction with respect to remediation of their misconceptions regarding ecological concepts. The results of the analysis indicated that this hypothesis should be rejected, $F(1,55)=6.14$, $p=0.008$, and the partial η^2 of 0.12 suggests a strong relationship between treatment and the post-test scores, controlling for pre-test scores. As a result, it can be said that there was a significant difference between the post-test mean scores of students in experimental group and those in control group with respect to remediation of their misconceptions regarding ecological concepts, in the favor of experimental group.

Hypothesis $H_0 1(ii)$:

To answer the question posed by the hypothesis $H_0 1(ii)$ stating that there is no significant difference between the gain scores of students who received conceptual change text oriented instruction and those received traditional instruction with respect to remediation of their misconceptions regarding ecological concepts, independent-samples t-test was used. The measures obtained are given in Table 5.1.3.2.

Table 5.1.3.2 The Results of Data for Group Comparison with respect to Gain Scores of ECT.

Groups	n	$\bar{x}$	s	df	t-value	p
CTTI	28	6.61	2.50	56	2.530	0.01
TI	30	4.63	3.35			

The results showed that there was a significant difference between the gain scores of students in experimental and control groups. Students in the experimental group who engaged in conceptual change text oriented instruction achieved greater gain scores.

The statistical analyses of hypotheses $H_0 1(i)$ and $H_0 1(ii)$ revealed that the conceptual change text oriented instruction has a significant effect on remediation of students' misconceptions regarding ecological concepts and improvement of conceptual change in students.

Hypothesis $H_0 2$:

Paired-samples t-test was used to analyze the hypothesis $H_0 2$, stating that there is no significant difference between the pre- and post-test mean scores of students who received traditional instruction with respect to remediation of their misconceptions related to ecological concepts. The results of analysis are given in Table 5.1.3.3

Table 5.1.3.3 The Comparison of the Pre- and Post-test Mean Scores of ECT in Control Group.

Tests	n	$\bar{x}$	s	df	t-value	p
Pre ECT	30	7.00	3.27	29	-7.581	0.00
Post ECT	30	11.6	2.88			

The results showed that there was a significant difference between the pre- and post-test mean scores of the students who received traditional instruction with respect to remediation of their misconceptions concerning ecological concepts. In other words, there was a significant increase in Ecology Concept Test scores of the students in the control group after the instruction.

Hypothesis $H_0$3:

To answer the question posed by the hypothesis $H_0$3, stating that there is no significant difference between the pre- and post-test mean scores of students who received conceptual change text oriented instruction with respect to remediation of their misconceptions related to ecological concepts, paired-samples t-test was used. The results of analysis are given in Table 5.1.3.4.

Table 5.1.3.4 The Comparison of the Pre- and Post-test Mean Scores of ECT in Experimental Group.

Tests	n	$\bar{x}$	s	df	t-value	p
Pre ECT	28	6.71	2.05	27	-13.988	0.00
Post ECT	28	13.3	2.45			

The results showed that there was a significant difference between the pre- and post-test mean scores of the students who received conceptual change text oriented instruction with respect to remediation of their misconceptions concerning ecological concepts. In other words, there was a significant increase in Ecology Concept Test scores of the students in the experimental group after the instruction.

Hypothesis $H_0 4$:

Analysis of Covariance (ANCOVA) was used to test the hypothesis $H_0 4$, stating that there is no significant difference between the post-test mean scores of students in experimental and control groups with respect to attitudes towards environment. The results of the analysis indicated that this hypothesis should not be rejected, F (1,55)=3.287, p=0.075 values suggest that there is no significant relationship between treatment and the post-test scores, holding constant the pre-test results. Therefore, it can be said that there was no significant difference between the post-test mean scores of students in the experimental group and the control group with respect to attitude towards environment.

Hypothesis $H_0 5$:

To answer the question posed by the hypothesis $H_0 5$, stating that there is no significant difference between the pre- and post-test mean scores of students who received traditional instruction with respect to attitudes towards environment, paired-samples t-test was conducted. The results of analysis are given in Table 5.1.3.5.

Table 5.1.3.5 The Comparison of the Pre- and Post-test Mean Scores of EAS in Control Group.

Tests	n	$\bar{x}$	s	df	t-value	p
Pre EAS	30	82.1	10.9	29	-1.729	0.09
Post EAS	30	84.6	9.34			

The results showed that there was no significant difference between the pre- and post-test mean scores of the students who received traditional instruction with respect to attitudes towards environment. In other words, there was no significant increase in Environmental Attitude Scale scores of the students in the control group after the instruction.

Hypothesis $H_0 6$:

To answer the question posed by the hypothesis $H_0 6$, stating that there is no significant difference between the pre- and post-test mean scores of students who received conceptual change text oriented instruction with respect to attitudes towards environment. The results of analysis are given in Table 5.1.3.6.

Table 5.1.3.6 The Comparison of the Pre- and Post-test Mean Scores of EAS in Experimental Group.

Tests	n	$\bar{x}$	s	df	t-value	p
Pre EAS	28	81.2	9.56	27	-5.849	0.00
Post EAS	28	86.7	8.18			

The results showed that there was a significant difference between the pre- and post-test mean scores of the students who received conceptual change text oriented instruction with respect to attitudes towards environment. In other words, there was a significant increase in Environmental Attitude Scale scores of the students in the experimental group after the instruction.

5.2 Conclusions

The following conclusions can be deduced from the results of this study:

1. Conceptual change text oriented instruction caused a more significant remediation of students' misconceptions concerning ecological concepts than traditional instruction did.

2. The comparisons of the pre- and post-test mean scores of the Ecology Concept Test in group receiving traditional instruction showed an increase in post-test scores. As a conclusion, remediation of misconceptions concerning ecological concepts by traditional instruction was statistically significant.

3. The comparisons of the pre and post-test mean scores of the Ecology Concept Test in group receiving conceptual change text oriented instruction showed an increase in post-test scores. As a conclusion, remediation of students' misconceptions concerning ecological concepts by conceptual change text oriented instruction was statistically significant.

4. The comparisons of the pre- and post-test mean scores of the Environmental Attitude Scale in group receiving conceptual change text oriented instruction showed an increase in post-test scores. As a conclusion, achievement of an increase in students' attitudes towards environment by conceptual change text oriented instruction was statistically significant.

5. The comparisons of the pre- and post-test mean scores of the Environmental Attitude Scale in group receiving traditional instruction did not show an increase in post-test scores. Therefore, achievement of an increase in students' attitudes towards environment by traditional instruction was not statistically significant.

6. Conceptual change text oriented instruction did not cause a more significant increase in students' attitudes towards environment than traditional instruction did.

CHAPTER 6

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

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

6.1 Discussion

The main purposes of this study were to identify seventh-grade students' misconceptions concerning ecological concepts by using two-tier multiple-choice test and to investigate the effectiveness of conceptual change text oriented instruction in remediation of these misconceptions.

The study was also interested in determining the effectiveness of the conceptual change text oriented instruction, dealing with ecological concepts, on students' environmental attitudes.

As indicated before, the Ecology Concept Test was administered to all subjects both before and after the treatment. Prior to the treatment, no significant difference was found between the pre-test mean scores of the two groups.

According to this result, it can be said that both groups were equal in terms of achievement related to ecological concepts before the treatment. In addition, students' prior knowledge in science was determined by their grades in science course in the previous year. It was found that there was no significant difference between the two groups regarding their science knowledge before the treatment. These findings are crucial in two aspects: First, since students' prior knowledge influences learning of new concepts, it must be taken into consideration. Second, homogeneity between the experimental and control groups is of great importance on investigation the effectiveness of the treatment. The Ecology Concept Test was given to all students as a post-test after the treatment to investigate and compare the effects of two different instructional techniques (CCTI vs. TI) on remediation of students' misconceptions concerning ecological concepts.

The results of this study showed that the development of two-tier multiple-choice test to evaluate commonly held misconceptions regarding ecological concepts provided one starting point for helping the teacher to improve students' learning of these concepts. Teachers are not generally critical of students' answers that reveal misconceptions. Such multiple-choice tests can help the teacher to address existing students' conceptions that are not compatible with scientific conceptions and to determine students' reasoning behind their choices. The effectiveness of this test was demonstrated by its ability to diagnose misconceptions of students who provide the correct answer for the wrong reason. Once misconceptions are identified, a teacher can more easily help students acquire the scientifically acceptable conception by developing alternative teaching approaches that address students' misconceptions.

In this study, the experimental group received instruction using conceptual change texts, while the control group received traditional instruction following the logical presentation of concepts seen in textbooks. The results showed that both groups showed gains with respect to understanding of ecological concepts after treatment. Of more interest than the changes within each treatment group are the relative changes between them. The experimental group had higher improvement than that of the control group after the treatment. The conceptual change text oriented instruction caused a significantly better acquisition of scientific conceptions than the traditional instruction. In other words, the remediation of students' misconceptions concerning ecological concepts was achieved with the help of conceptual change texts. The conceptual change text oriented instruction explicitly dealt with students' misconceptions while the traditional instruction did not. The conceptual change texts included a set of guidelines providing special learning environments such as identifying common misconceptions, activating students' misconceptions by presenting simple examples, presenting descriptive evidence that the typical misconceptions are incorrect, and giving students the opportunity to practice the correct explanation by using questions. These properties of conceptual change approach may have caused remediation of misconceptions and a better understanding of ecological concepts when compared to the traditional instruction.

The results of this study showed that there were still some misconceptions in both groups after treatment. The students in both groups have not absolutely mastered some concepts related to decomposers and food web. For example, after instruction students still thought that decomposers were important for ecosystems because they helped to keep environment clean by eating dead animals and plants. The review of the textbook used in the lecture revealed that the textbook mentions the role of decomposers as the garbage collector of the nature (Çığırgan et al., 2000:31). Changing students' beliefs is not an easy task because previously acquired knowledge is highly resistant to change, and the change may occur if the students find their existing conceptions inadequate or unsatisfactory. Fellows (1994) claimed that conceptual change and/or knowledge restructuring is a developmental process that takes a long time, even with good instructional strategies. Moreover, many students in both groups had difficulty in determining the effect of a change in numbers of one population on another population when the effect was transmitted along more than one route. During the interviews, students tended to select one of the several pathways without explaining why they chose that particular route. Griffiths and Grant (1985) proposed that misconceptions might occur if students consider a food web to be functionally like a network of individual food chains. Moreover, the most common misconception in the food web concept was based on the proximity of populations in the food web. Students believed that a change in one population would only affect another population if two populations were directly related as predator and prey. When asked to determine the effect of a change in one population on a second population in another part of the web, students' responses included "there is no effect as the populations are too far apart", and "the two populations are not really closely linked". As Gallegos et al., (1994) claimed, it would be possible to overcome students' difficulties in the food web concept if food chains are taught not as a simple set of isolated organisms, but as an interactive population embedded in an ecological context.

The misconceptions identified in this study seemed to lie on a continuum from basic rote memory errors and textbook errors to deep seated conceptual misunderstandings. The misconceptions revealed by this study might readily be missed by teachers; teachers may assume that if students know the correct answer to a particular question, then no misconceptions are present. Often students learn the correct answers through rote memorization of information presented by the teacher. This tactic may enable a student to do well on a test, but may have little effect in changing his/her misconceptions.

In summary, the conceptual change text oriented instruction caused a statistically better acquisition of ecological concepts and elimination of misconceptions related to these concepts than the traditional instruction. This result is consistent with the results presented by Wang and Andre (1991), Hydn et al., (1994) and Chambers and Andre (1997).

Students' attitudes towards the environment both before and after the treatment were also investigated. Students who received conceptual change text oriented instruction showed a slightly significant increase in their attitudes towards the environment after the treatment. However, no significant difference was found between the conceptual change text oriented instruction group and traditional instruction group with respect to attitudes towards the environment. This finding that instruction did not cause a significant effect on students' attitudes is not surprising because environmental attitudes are formed by many influences over a long period of time. As Eagles and Demare (1999) claimed, students tend to trust information about the environment which they gained through personal experience or from their family at early teen years. Thus, these sources of environmental information form their environmental attitudes also. At this time the attitudes solidify and become less amenable to change. As a conclusion, for an instruction to be affective in influencing attitudes, students must be engaged in that instruction in a long-duration. The instructional strategy used in this study, conceptual change text oriented instruction, focused on students' misconceptions concerning ecological concepts and tried to help students in acquisition of scientific concepts. Although post-test scores indicated an increase in students' knowledge in ecological concepts after the instruction, this increase in knowledge did not cause an increase in their attitudes towards the environment. This finding is consistent with the finding of Newhouse (1991) stating that environmental attitudes are most likely formed as a result of life experiences rather than exposure to any specific course. These reasons may have caused no significant difference between the groups in terms of attitudes towards the environment.

6.2 Implications

The findings of this study have important implications from the particular points of view.

Given that family, daily life experiences and direct observation are important sources of knowledge about the environment as well as instruction and textbooks, it is important that teachers should become aware of the students' prior knowledge gained through the sources other than instruction. Since prior knowledge assessment can identify strengths, gaps, and weaknesses in the students' knowledge and identify areas which may require extra coverage.

In any area of science, students' prior knowledge may include misconceptions. For this reason, teachers should develop tests to diagnose students' misconceptions. Findings of this study suggest that two-tier multiple choice tests would be desirable to assess both student knowledge that may include misconceptions and the reasoning supporting this knowledge.

Students' own conceptions are likely to be more useful to student and so resistant to change. The instruction should be designed in a way that the student is persuaded that the scientific conception is more useful than his or her existing conception. It is clear from the findings that conceptual change approach would be desirable instructional strategy to deal with students' misconceptions.

Learning is a complicated and attentive process and students should be encouraged to construct their own knowledge and skills through active processing rather than passive listeners. This can be done by asking students to think about their ideas, to listen to the ideas of other. Instructional materials such as conceptual change texts, that help students in acquisition of science concepts and in remediation of their misconceptions should be included in the curriculum.

Teachers should know their subject matter deeply and be aware of the range of misconceptions held by the students. They should be informed about the applications and importance of the conceptual change texts and they need to experience the process of conceptual change.

It is clear from the findings of this study that students find it difficult to interpret the food web concept. There is a need to ensure that the interactions among populations within a food web are explicitly taught. In addition, in preparing to teach food chain and food web concepts on 7^{th} grade science course, it should not be assumed that students have a good understanding of basic ecological concepts such as producer, consumer, decomposer, ecosystem etc.

Figures in school science textbooks should be in high quality and should provide clear explanation and exposition. Beside figures, examples should be high in number and should be chosen from daily life.

Findings of this study suggest that if students are to develop their environmental attitudes, they need a better understanding of ecological issues such as the ways in which organisms affect and are affected by their environments, and therefore what might be the results of hunting, air pollution, deforestation. For this reason, effective instructional methods should be developed to increase students' attitudes towards environment.

6.3 Recommendations

On the basis of findings of this study, the following recommendations can be given:

Similar research studies are needed to be constructed for different grade levels.

The sample size was small (n=58) in this study. For further studies, the sample size can be increased to obtain more accurate results.

Two-tier multiple choice instruments can be developed to diagnose students' misconceptions in different science concepts.

The effect of conceptual change text oriented instruction on remediation of students' misconceptions regarding other science concepts can be examined.

Further studies can be conducted to assess the effectiveness of other instructional methods based on conceptual change approach on remediation of students' misconceptions concerning ecological concepts (eg. Small-group discussions, problem based learning, discussion webs).

Further research is needed to be conducted to identify the common problems in environmental education that may interfere with students' attitudes towards environment.

The effect of instruction including field-trip on students' understanding of ecological concepts can be examined.

This research can be conducted with students from rural and urban areas to investigate the effect of different living environment on students understanding of ecological concepts and on their attitudes towards environment.

This research can be followed by further research into identifying means of incorporating these findings into the design and organization of science curricula.

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APPENDIX A

INTERVIEW SCHEDULE

INTERVIEWEE'S:	INTERVIEW NO:
GENDER:	DATE:
AGE:	START & FINISH TIME:

Hello, my name is Özlem Özkan. I am a research assistant at Middle East Technical University, department of Secondary Science and Mathematics Education. I am conducting a research about students at your age. We will talk about some topics in Science. This is not an oral examination and so you will not be graded. Thus, there is no need to be stressed. Our interview would last nearly 20 minutes. If you do not have any objection, I want to use tape recorder during the interview. The reason for using a recorder is not to lose time by taking notes. Nobody will listen this record except me. Before starting, would you like to ask anything? Let's begin.

ENVIRONMENT

We always see a sign in our surrounding like: " Keep your environment clean". Then, what is the environment? How can you describe the environment?

What kind of things we can find in an environment?

Can you differentiate these things as living and non-living?

Is there a relationship between living and non-living things?

If "Yes", what kinds of relationship exist between living and non-living things?

BASIC ECOLOGICAL CONCEPTS

What do you understand from the word "population"?

Can you give an example to population?

When I say "ecosystem", what do you understand?

NOTION OF ENERGY

What can you say about the main energy source in nature?

If "Sun", how do living things use sun as an energy source?

Do you think that, is there a relationship between plants and animals in terms of energy?

If "No", where do plants and animals get their energy?

If "Yes", how? Please tell me a little bit more.

FOOD CHAIN

How can you describe the "food chain"?

Can you give an example to food chain?

If "start with plant", why did you begin your food chain with the plant?

If "start with animal", why did you begin your food chain with the animal?

What can you say about the direction of energy flow in a food chain including grass, insect, chicken and man? Why?

What about the amount of energy. Which organism has the greatest amount of energy in the following food chain: "grass→sheep→man"?

As you know, insect, chicken and man are all consumers in the following food chain: "grass→insect→chicken→man". What do you think how you can differentiate these consumers from each other?

ENERGY PYRAMID

Do you know what energy pyramid is?

Can you draw an energy pyramid and label it?

If "do not put decomposers" What about the decomposers? Why don't you include them in the energy pyramid?

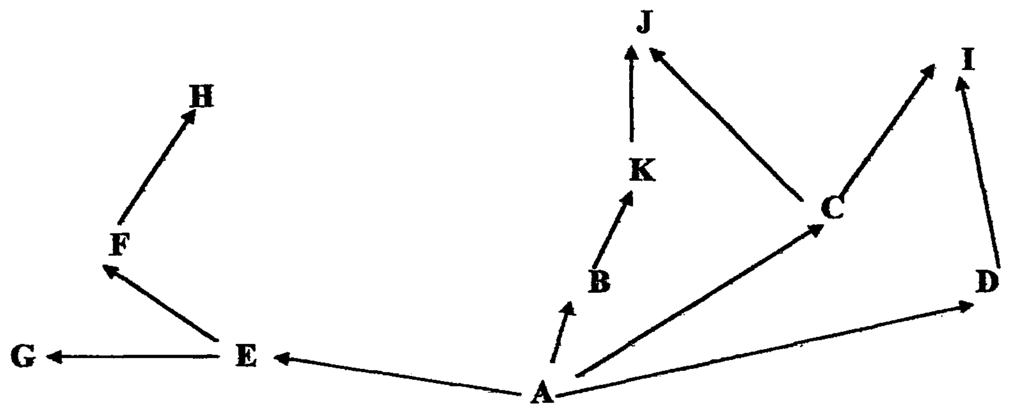
What do you think why the base of the energy pyramid is wider?

FOOD WEB

How can you describe the "food web"?

In the following food web, what do arrows indicate?

What may be the "A"?



Think that some sudden changes due to environmental factors occur in the populations of the food web above. Let's try to interpret the effects of these changes on other populations.

Does a sudden decrease in population F affect the population H?

If "Yes", How?

If "No", Why?

Does a sudden decrease in population E affect the population H?

If "Yes", How?

If "No", Why?

Does a sudden increase in population G affect the population F?

If "Yes", How?

If "No", Why?

Does a sudden decrease in population H affect the population E?

If "Yes", How?

If "No", Why?

Does a sudden size change in population A affect the population J?

If "Yes", show me the ways through which the effect is passed.

If "No", Why?

Does a sudden increase in population B affect the population J?

If "Yes", How?

If "No", Why?

Does a sudden increase in population I affect the population K?

If "Yes", How?

If "No", Why?

APPENDIX B

ÖĞRENCİ GÖRÜŞME FORMU

<u>GÖRÜŞÜLEN ÖĞRENCİNİN</u>: GÖRÜŞME NO:

CİNSİYETİ: TARİH:

YAŞI: BAŞLAMA VE BİTİŞ SAATİ:

Merhaba, ismim Özlem Özkan. Orta Doğu Teknik Üniversitesi Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümünde araştırma görevlisiyim. Bir araştırma yapıyorum; seninle fen bilgisi dersindeki bazı konular üzerine sohbet edeceğiz. Bu bir sözlü sınav değil, söylediklerin notlandırılmayacak. Endişelenmene gerek yok sadece sohbet edeceğiz. Bu sohbet süresince eğer senin için sakıncası yoksa teyp kullanmak istiyorum. Teyp kullanmamızın sebebi not almaya çalışarak vakit kaybetmemizi engellemek istememdir. Bu kaseti benden başka kimse dinlemeyecek. Başlamadan önce sormak istediğin herhangi birşey var mı? İstersen başlayalım.

ÇEVRE

Sürekli okuduğumuz bir tabela vardır : " Çevrenizi temiz tutunuz.".

Bana çevre nedir söyler misin?

Bir çevre içinde ne gibi şeyler bulabiliriz?

Verdiğin örnekleri canlı ve cansız varlıklar olarak ayırır mısın?

Çevrede canlı ve cansız varlıklar arasında bir ilişki var mı?

"Evet" derse, çevrede canlı ve cansız varlıklar arasında nasıl bir ilişki var?

TEMEL EKOLOJİK KAVRAMLAR

"Popülasyon" sözünden ne anlıyorsun?

Popülasyona bir örnek verebilir misin?

Sana "Ekosistem" nedir diye sorsam, bana neler söyleyebilirsin?

ENERJİ

Doğadaki temel enerji kaynağı nedir? Bu konuda neler söyleyebilirsin?

"Güneş" derse, peki canlılar güneşi bir enerji kaynağı olarak nasıl kullanır?

Bitkilerle hayvanlar arasında enerji bakımından bir ilişki olduğunu düşünüyor musun?

Var derse, nasıl? Biraz açıklayabilir misin.

Yok derse, o zaman bitkiler ve hayvanlar enerjilerini nereden edinirler?

BESİN ZİNCİRİ

"Besin zinciri"ni nasıl tanımlayabilirsin?

Bana bir besin zincirine bir örnek verir misin?

"Bitki ile başlarsa", besin zincirine neden bitki ile başladın?

"Hayvan ile başlarsa", besin zincirine neden hayvan ile başladın?

Ot, böcek, tavuk ve insandan oluşan bir besin zincirinde, enerjinin akış yönü hakkında ne dersin?

Neden böyle düşünüyorsun?

Peki enerji miktarı hakkında ne söyleyebilirsin? "Ot→ koyun→ insan" besin zincirinde, hangi canlı en fazla enerjiye sahiptir?

Bildiğin gibi, "bitki → böcek → tavuk → insan" besin zincirinde hem böcek, hem tavuk, hem de insan tüketicidir.

Peki bu tüketicileri birbirinden nasıl ayırtedebilirsin?

ENERJİ PİRAMİDİ

"Enerji piramidi" nedir, biliyor musun?

Bana bir enerji piramidi çizip içini doldurur musun?

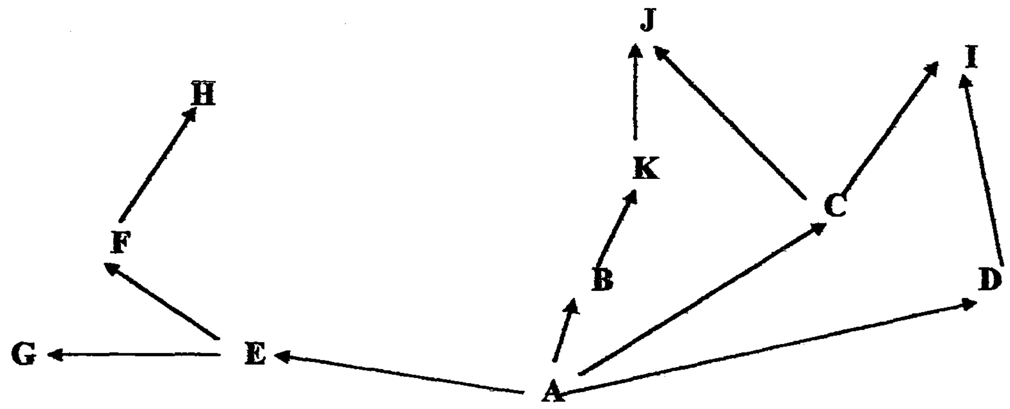
"Ayrıştırıcıları koymazsa", peki ayrıştırıcılar hakkında ne düşünüyorsun? Neden enerji piramidinde ayrıştırıcılara yer vermedin?

Eğer, doğru çizerse: neden piramidin alt kısmı üst kısmından daha geniş?

BESİN AĞI

"Besin ağı"nı nasıl tanımlayabilirsin?

"Bu bir besin ağını gösteren şekildir. Bu harflerin herbiri belli bir popülasyonun bir üyesini simgelemektedir. Buna göre şu sorulara cevap verir misin?"



Oklar neyi ifade ediyor olabilir?

"A" ne olabilir?

Şimdi bazı çevresel faktörler yüzünden yukarıdaki besin ağında bulunan populasyonların büyüklüklerinde ani değişikliklerin olduğunu düşünelim. Buna göre, bu değişikliklerin diğer populasyonlar üserindeki etkisini bulmaya çalışalım.

F popülasyonundaki ani azalma H popülasyonunu etkiler mi?

Etkiler derse, nasıl etkiler, neden?

Etkilemez derse, neden?

Etkilemez derse, neden?

E popülasyonundaki ani azalma H popülasyonunu etkiler mi?

Etkiler derse, nasıl etkiler, neden?

Etkilemez derse, neden?

G popülasyonundaki ani artış F popülasyonunu etkiler mi?

Etkiler derse, nasıl etkiler, neden?

Etkilemez derse, neden?

H popülasyonundaki ani azalma E popülasyonunu etkiler mi?

Etkiler derse, nasıl etkiler, neden?

Etkilemez derse, neden?

A popülasyonunda olan ani bir değişiklikten J popülasyonu etkilenir mi?

Etkilenir derse, nasıl ve hangi yoldan, harfleri işaretler misin?

Etkilemez derse, neden?

B popülasyonundaki ani artış J popülasyonunu etkiler mi?

Etkiler derse, nasıl etkiler, neden?

Etkilemez derse, neden?

I populasyonundakiani artış K popülasyonunu etkiler mi?

Etkiler derse, nasıl etkiler, neden?

Etkilemez derse, neden?

APPENDIX C

EKOLOJİ KAVRAM TESTİ

Adı Soyadı:

Sınıf:

21 sorudan oluşan bu test, ekoloji konuları üzerine bilginizi ölçmektedir. Her soru iki bölümden oluşmaktadır: Birinci bölüm konu bilgisini içeren çoktan seçmeli soruyu; ikinci bölüm ise olası nedenleri içermektedir. Her soru için bir cevap ve her cevap için bir neden işaretlemeniz gerekmektedir. Hiçbir soruyu boş bırakmayınız.İyi şanslar.

1. Çevre nedir?
   a) Canlıların yaşadığı ortamdır.
   b) Canlı ve cansız varlıkların bulunduğu ortamdır.
   c) İnsanların yaşadığı yerdir.

Çünkü:

   a) Çevre, bitki ve hayvanların bulunduğu park ve bahçe gibi yerlerdir.
   b) Çevre, herhangi bir canlının çevresindeki canlı ya da cansız tüm varlıklardan oluşur.
   c) Cansız varlıklar çevreyi etkilemezler.
   d) Çevre temiz tutulması gereken bir yerdir, cansız varlıklar çevreyi kirletirler.

2. Aşağıdakilerden hangisi popülasyona bir örnektir?

a) Türkiye'deki tüm canlılar
b) Türkiye'deki insan sayısı
c) Karadeniz'deki hamsiler

Çünkü:

a) Popülasyon belli bir bölgede yaşayan canlılardan oluşan topluluktur.
b) Popülasyon belli bir bölgedeki insan topluluğudur.
c) Popülasyon nüfus demektir.
d) Popülasyon belli bir zamanda, belli bir bölgede yaşayan, bir türe ait bireylerden oluşan topluluktur.

3. Ekosistem nedir?

a) Üreticilerin ve tüketicilerin zincirleme reaksiyonudur.
b) Doğadaki canlıların yaşayış biçimlerinin sürekli olarak değişmesidir.
c) Belli bir bölgede yaşayan canlılar ve ilişki içinde oldukları tüm canlı ve cansız etmenlerdir.

Çünkü:

a) Tüketiciler üreticileri yiyerek ekosistemin devam etmesini sağlarlar.
b) Belli bir alandaki canlı ve cansız varlıklardan oluşur.
c) Canlılar kendi aralarında sürekli bir ilişki içindedirler.
d) Bir ekosistem belli bir alanda yaşayan canlılardan oluşur.

4. Bütün ekosistemlerin temel enerji kaynağı hangisidir?

a) Güneş
b) Üreticiler
c) Besinler

Çünkü:

a) Üreticiler diğer canlılar için besin maddelerini hazırlar.
b) Besinler olmadan canlılar yaşayamaz.
c) Üreticiler güneş enerjisini kullanarak besin yapar.
d) Canlılar güneşi ısı enerjisi olarak kullanırlar.

5. Bitkilerin enerji kaynağı nedir?

a) Toprak
b) Hava
c) Güneş

Çünkü:

a) Bitkiler toprakta yetişirler.
b) Bitkiler havadaki gazları kullanarak enerji elde ederler.
c) Bitkiler topraktaki su ve mineraller ile beslenirler.
d) Bitkiler güneş enerjisini kullanarak besin yaparlar.

6. Bitkilerle hayvanlar arasında enerji bakımından bir ilişki var mıdır?

a) Vardır.
b) Yoktur.

Çünkü:

a) Hayvanlar bitkileri yer.
b) Hayvanların ve bitkilerin kendi ayrı besinleri vardır.
c) Hayvanlar bitkilerden daha güçlüdür ve kendi enerjileri vardır.
d) Bitkilerin enerjilerinin bir kısmı hayvanlar tarafından kullanılır.

7. Ayrıştırıcılar doğa için önemli midir?

a) Önemlidir.
b) Önemsizdir.
c) Doğayı etkilemezler.

Çünkü:

a) Organik maddeleri inorganik maddelere dönüştürürler.
b) Gözle görülemeyecek kadar küçüktürler.
c) Ölü hayvanların üzerinde bulunurlar.
d) Ölü bitki ve hayvanları yiyerek çevrenin temiz kalmasını sağlarlar.

8. Besin zinciri nedir?

a) Farklı besinler içeren bir beslenme şeklidir.
b) Enerjinin bir canlıdan diğerine aktarılmasıdır.
c) Bir tohumun meyva olana kadar büyümesidir.

Çünkü:

a) Besin zinciri, besinlerin içinde olan proteinler ve vitaminlerden oluşur.
b) Bir bitkinin ya da hayvanın büyümesi besin sayesinde gerçekleşir.
c) Bitkilerde depolanan enerji, besin zinciri biçiminde diğer canlılara dağılır.
d) Bir hayvanın bir bitkiyi yemesi ile besin zinciri oluşur.

9. Aşağıdaki besin zincirlerinden hangisi **yanlıştır**?

a) ot → inek → süt → insan

b) bitki → balık → insan

c) ot → çekirge → kurbağa → yılan → kartal

Çünkü:

a) Bitkiler suda yaşamazlar, bu yüzden de balıklar bitki ile beslenemez.

b) İnek süt ürettiği için bir üreticidir ve insana besin sağlar.

c) Bir besin zinciri dörtten daha fazla canlıdan oluşamaz.

d) İnek süt için bir enerji kaynağı değildir.

10. Bitki, böcek, tavuk ve insandan oluşabilecek besin zincirinde enerji hangi canlıdan hangi canlıya geçer?

a) Enerji bir canlıdan diğerine geçmez.

b) İnsandan tavuğa, tavuktan böceğe, böcekten bitkiye doğru geçer.

c) Bitkiden böceğe,böcekten tavuğa, tavuktan insana doğru geçer.

Çünkü:

a) Her canlının kendi enerjisi vardır.

b) Besin zincirine enerji bitkiler yolu ile girer.

c) En çok enerji insandadır.

d) İnsan hiçbirşeye enerji vermez.

11. Ot, koyun ve insandan oluşabilecek besin zincirinde **en çok** enerji hangi canlıdadır?

a) Ot
b) Koyun
c) İnsan

Çünkü:

a) İnsan hem otun hem de koyunun enerjisini alır.
b) İnsan daha güçlüdür ve daha çok enerjisi vardır.
c) Koyun eti insanlar için enerji verici ve çok besleyici bir besindir.
d) Ot besin zincirinin başında yer alır.

12. Aşağıdaki canlılardan hangisi **birinci derecede tüketicidir** ?

a) Aslan
b) Tavşan
c) İnsan

Çünkü:

a) İnsan herşeyi tüketir.
b) Tavşan otçuldur.
c) Aslan vahşi ve güçlüdür.
d) Aslan etçildir.

13. Enerji piramidinin **tabanını** hangi canlılar oluşturur?

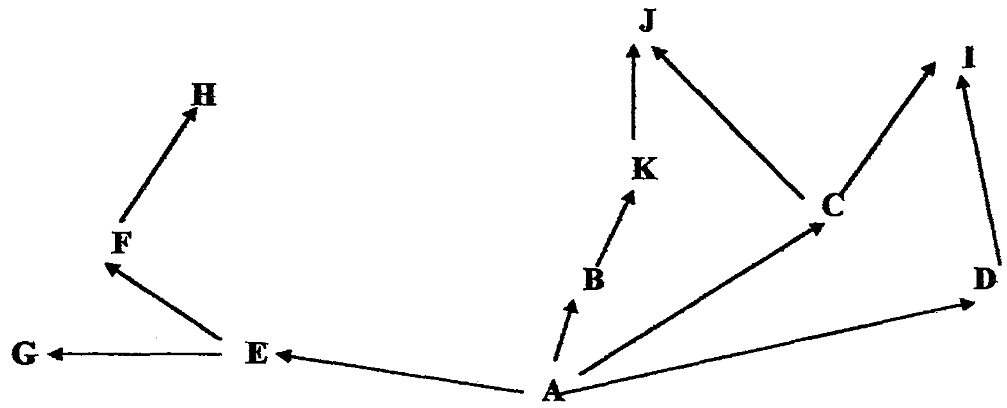
a) İnsanlar
b) Tüketiciler
c) Üreticiler

Çünkü:

a) Üreticiler sayı olarak tüketicilerden fazladır.
b) Tüketiciler enerji bakımından daha zengindir.
c) Doğada en çok insan bulunur.
d) İnsanlar hem bitkileri hem de hayvanları yer.

14 – 21 arasındaki soruları aşağıdaki şekle göre cevaplayınız.

"Bu bir besin ağını gösteren şekildir. Bu harflerin herbiri belli bir popülasyonun bir üyesini simgelemektedir. Buna göre aşağıdaki sorulara cevap verir misin?"



14. A nedir?

    a) Güneştir.
    b) Bitkidir.
    c) İnsandır.

Çünkü:

   a) Güneş besin zincirini başlatan enerjiyi sağlar.
   b) İnsan bütün canlıları yer.
   c) Bitkiler besin akışının ilk kaynağını oluşturur.
   d) En fazla enerji güneşte bulunur.

15. **F** popülasyonundaki ani bir azalma **H** popülasyonunu etkiler mi?

a) Etkiler.

b) Etkilemez.

Çünkü:

a) **H** popülasyonunu yiyen sayısı azalır ve **H** popülasyonu artar.

b) **F** popülasyonu **H** popülasyonunun besin kaynağıdır.

c) **H** popülasyonu, **F** popülasyonunun avcısıdır av sayısının azalmasından etkilenmez.

d) **H** popülasyonu, **F** popülasyonundan daha güçlüdür.

16. **E** popülasyonundaki ani bir azalma **H** popülasyonunu etkiler mi?

a) Etkiler.

b) Etkilemez.

Çünkü:

a) E popülasyonu hem F popülasyonu ile hem de H popülasyonu ile beslenir.

b) Yanyana değiller.

c) **H** popülasyonu en yukarıdadır, sadece kendinden sonra geleni etkileyebilir.

d) Aynı besin ağı içindeler.

17. **G** popülasyonundaki ani bir artış **F** popülasyonunu etkiler mi?

a) Etkiler.

b) Etkilemez.

Çünkü:

a) F popülasyonunu azalır.

b) Aralarında av-avcı ilişkisi yok.

c) Sadece **E** popülasyonu etkilenir.

d) Yanyana değiller.

18. **H** popülasyonundaki ani bir azalma **E** popülasyonunu etkiler mi?

a) Etkiler.

b) Etkilemez.

Çünkü:

a) Yanyana değiller.

b) Aralarında av-avcı ilişkisi yok.

c) **H** popülasyonu hem **F** popülasyonunun hem de **E** popülasyonunun avcısıdır.

d) **F** popülasyonu artacağından **E** popülasyonu azalır.

19. **A** popülasyonunda olan ani bir değişiklikten **J** popülasyonu etkilenir mi?

a) Etkilenir.

b) Etkilenmez.

Çünkü:

a) Av popülasyonundaki değişiklikten avcı popülasyonu etkilenmez.

b) Aynı besin ağı içinde yer alıyorlar.

c) Birbirlerinden çok uzaktalar.

d) **J** popülasyonu, alttaki diğer bütün popülasyonları yer.

20. **B** popülasyonundaki ani bir artış **J** popülasyonunu etkiler mi?

a) Etkiler.

b) Etkilemez.

Çünkü:

a) B popülasyonundaki artış sadece A ve K popülasyonlarını etkiler.

b) **B** popülasyonu artarsa, **K** popülasyonu azalır ve **J** popülasyonu artar.

c) **J** popülasyonu azalır.

d) **B** popülasyonu ile **J** popülasyonun arasında bir ilişki yoktur.

21. I popülasyonundaki ani bir artış K popülasyonunu etkiler mi?

a) Etkiler.

b) Etkilemez.

Çünkü:

a) Aralarında hiçbir bağ yok.

b) Birbirlerinden çok uzaktalar.

c) Besin ağındaki bir değişiklik bütün besin ağını aynı şekilde etkiler.

d) Aynı besin ağı içindeler.

APPENDIX D

SAMPLE CONCEPTUAL CHANGE TEXT

What kind of relationship exists between producers, consumers and decomposers?

There is a relationship between living organisms. Whether they are producers, consumers or decomposers all living organisms need energy to survive. Remember that through the process of photosynthesis, producers use light energy from the sun to make their own food. Consumers, on the other hand, cannot make their own food and they feed on other organisms. In other words, they eat or consume other organisms to get energy. Decomposers extract energy from the remains or end products of organisms.

In brief, producing, consuming and decomposing to obtain food are ways organisms interact. So, there is a feeding relationship and one-way flow of energy between all living organisms. Think of how could it be possible? Let's try to answer following questions by considering the explanations above as a clue.

Question 1: What is food chain?

Question 2: What is food web?

I advice you to read the followings before you come to your final decision:

☹ Some students define the food chain as a two-way relationship occurred when an animal eats a plant. When it is asked these students to give an example to food chain, they respond like this "sheep eats the grass". When it is asked who eats the sheep, their answer is the "man". However, they failed to realize that in a food chain an animal eats the other animals as well.

Let's try to find out the deficiencies in the ideas of these students.

☺ In order to understand the food chain concept better, let's examine the following example. "Grass→ sheep → man" is an example of a simple food chain. Here, the energy stored in the grass is passed from grass through man in a model of food chain. Producers harness sunlight energy and convert it to forms that they and the other organisms in the ecosystems can use. In other words, the energy stored in the form of food in plants is passed from producers to consumers in a model of food chain.

Therefore, the food chain is not just a feeding relationship occurred when an animal eats a plant. Whether you observe a small ecosystem or a large ecosystem you will find feeding relationship and energy flow between the organisms.

☹ When asked to discriminate the consumers in the food chain "grass→ sheep→ man", some students say, "man is the living organism that consumes more". These students think that since man can eat both plants and animals, he is the strongest living organism. According to these students man is the primary consumer.

Unfortunately, these students' ideas are not correct.

☺ Now, we know that a food chain includes more than one consumer organism. Then, how can we differentiate these consumers from each other? Animals that feed on only plants are called primary consumers or herbivores. For example, in a food chain "grass → rabbit → fox → lion", rabbit is primary consumers. Animals that feed on the primary consumers are called secondary consumers or carnivores. For example, fox that feeds on rabbit is a secondary consumer. Animals like lion and eagle are the tertiary consumers and feed on secondary consumers. As a conclusion, consumers are categorized according to their feeding habits, not to their physical size and ferocity.

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I advice you to read the followings before you come to your final decision:

☹ Some students think that if the size of one population is altered, all other populations in the web will be altered in the same way. These students remember that all populations directly or indirectly depend on each other in terms of food but they ignore basic predator-prey relationships. Therefore, they believe that whatever happens to one population in a food web, will happen to all populations in the web.

☺ It is true to say that all populations interact and react to changes in the web but not all react in the same way. For example, in the food web above, a sudden decrease in mole population causes a decrease in fox population also because mole is a food source for fox. Then, a decrease in fox population leads to an increase in rabbit population since the number of fox that eats rabbits will decrease. As a conclusion, if the size of one population in a food web is altered, all other populations in the web will not be altered in the same way.

☹ Some students believe that a change in one population will only affect another population if two populations are directly related as predator and prey. These students think that a sudden decrease in earthworm population will have effect only on mole population. They suggest that mole is the one that directly feeds on earthworm. On the other hand, some students think that since earthworm and rabbit populations are not closely linked, a sudden decrease in earthworm population will have no effect on rabbit population.

Let's try to find out these students' mistakes.

☺ In a food web, populations that are not directly related as predator and prey can still influence each other because they are part of a common food web. For example, in the food web above, a sudden decrease in earthworm population will affect the plant population because earthworms eat plants. Similarly, fieldfare and partridge populations will also be affected by a decrease in earthworm population. On the other hand, populations that feed on plants, such as rabbit, caterpillar and snail, will also be affected by this decrease because when the number of earthworm eating plants declines, other populations' food supply will increase. As a conclusion, populations that are not directly related as prey and predator can influence each other.

Now, let's try to construct a food web with different living organisms and to determine the effect of a sudden size change in one population on a second population.

APPENDIX E

ÖRNEK KAVRAM DEĞİŞİM METNİ

Üreticiler, tüketiciler ve ayrıştırıcılar arasında nasıl bir ilişki vardır?

Canlılar arasında beslenme yönünden ilişkiler vardır. Üretici, tüketici ya da ayrıştırıcı olsun her canlının yaşamak için enerjiye ihtiyacı vardır. Bildiğiniz gibi üreticiler fotosentez yoluyla kendi besinlerini yapıyordu. Tüketiciler ise dışarıdan hazır besin alarak enerjilerini bu besinlerden karşılıyordu. Ayrıştırıcılar da ölü hayvan ve bitkilerle beslenerek enerji elde ediyordu. Demek ki bütün canlılar arasında bir besin alışverişi ve enerji akışı var. Peki ama bu nasıl gerçekleşiyor? Bu açıklamalardan ipucu alarak aşağıdaki soruları cevaplamaya çalışalım.

Soru 1: Besin zinciri nedir?

Soru 2: Besin ağı nedir?

Son kararınızı vermeden önce aşağıdakileri okumanızı öneriyorum:

☹ Bazı öğrenciler besin zincirini bir hayvanın bir bitkiyi yemesi ile oluşan ikili bir ilişki olarak tanımlıyor. Bu öğrencilerden besin zincirine örnek vermeleri istendiğinde "koyun otu yer" şeklinde yanıt veriyorlar. Koyunu kim yer şeklinde bir soruya ise "insan" şeklinde yanıt veriyorlar ama besin zinciri tanımının içine "bir hayvanın başka bir hayvanı yemesi" şeklinde bir ifade koymuyorlar.

Bu öğrencilerin düşüncelerindeki yanlış yerleri birlikte bulmaya çalışalım.

☺ Besin zinciri sadece bir üretici ve bir tüketiciden oluşan bir beslenme ilişkisi değildir. Peki besin zinciri nedir? Bildiğiniz gibi bir ekosistem içindeki tüm canlılar beslenme açısından birbirlerine bağlıdır. Üreticiler güneş enerjisini kullanarak besin üretir ve böylelikle kendileri için gereken enerjiyi sağlar. Üreticilerde besin olarak depolanan enerjinin bir kısmı, besin zinciri biçiminde tüketicilere dağılır. Yani besin zinciri dediğimiz şey sadece bir hayvanın bir bitkiyi yemesi ile oluşan besin alışverişi değildir. "Ot → Koyun → İnsan" bir besin zinciri örneğidir. Otta depolanan enerji, koyuna ve insana besin zinciri yolu ile aktarılır.

☹ Bazı öğrencilere "Ot → Koyun → İnsan" besin zinciri içinde yer alan tüketicileri birbirinden nasıl ayırırız diye sorulduğunda, bu öğrencilerin bir kısmı insana "en tüketici canlı" diyerek ayırabilecekleri yanıtını veriyor. Bu öğrenciler, hem bitkileri hem de hayvanları yiyebildiği için insanın en güçlü canlı olduğunu bu yüzden de birinci dereceli tüketici olduğunu düşünüyorlar.

Bu öğrenciler yanlış düşünüyorlar.

☺ Artık bir besin zincirinde birden fazla tüketici canlının yer aldığını biliyoruz. Peki bu tüketicileri birbirinden nasıl ayırtedeceğiz? Sadece bitkilerle beslenen hayvanlara birinci dereceden tüketiciler denir. **Tavşan, koyun** gibi otçul hayvanlar **birinci dereceden tüketicidir**. Bu hayvanlarla beslenen canlılara da ikinci dereceden tüketiciler denir. Örneğin, tavşanla beslenen **tilki ikinci dereceden bir tüketicidir**. İkinci dereceden tüketicilerle beslenen **aslan, kartal** gibi hayvanlara da **üçüncü dereceden tüketiciler** denir. Yani bir tüketici fiziksel büyüklüğüne ya da gücüne göre birinci dereceli tüketici olamaz; tüketiciler beslenme şekillerine göre derecelendirilir.

☹ Bazı öğrenciler besin zincirini şu şekilde çizmektedir: "Kartal → Yılan → Fare → Buğday". Besin zinciri bu şekilde çizildiğinde şu anlama gelmektedir: "Buğday fareyi yer, fare yılanı yer ve yılan da kartalı yer". Tabii ki bu anlamlı bir ifade değildir, okların yönü yanlış çizilmiştir.

Bu öğrencilerin hatalarını birlikte düzeltelim.

☺ Şimdi bu besin zincirinin doğru şeklini çizelim:

Buğday→ Fare → Yılan → Kartal

Bu besin zincirinde buğday üretici, fare birinci dereceden tüketici, yılan ikinci dereceden tüketici, kartal üçüncü dereceden tüketicidir. Burada okların yönü bize besinin dolayısı ile enerjinin akış yönünü göstermektedir. Yani okların yönü besinin ilk kaynağı olan üreticilerden, tüketicilere doğrudur. Besin zinciri enerjinin üreticilerden başlayarak tüketicilere geçmesi olarak düşünülürse okların yönünün üreticilerden tüketicilere doğru olduğu kolayca hatırlanır.

Peki doğada farenin tek besin kaynağı buğday mıdır ya da kartal sadece yılanla mı beslenir?

☹ Bazı öğrenciler yukarıdaki sorulara "evet" şeklinde cevap vermektedir. Bu öğrenciler doğada ayrı ayrı besin zincirleri olduğunu ve her besin zincirinin üyelerinin sadece o besin zincirine ait olduğunu düşünmektedir.

☺ Buğday sadece farenin besin kaynağı değil, bazı böceklerin, koyunların ve insanların da besin kaynağıdır. Aynı zamanda fare de sadece yılanın besin kaynağı değildir. Tilkiler ya da kediler de fare ile beslenebilir. Demek ki doğada bir canlı, birden fazla canlı ile beslenebilir ve birden fazla canlının da besini olabilir. Sonuç olarak her ekosistem çok sayıda farklı besin zinciri içerir ve bu besin zincirleri biraraya gelerek çok daha karmaşık bir besin ağı oluşturur. Böylece tüm canlılar çok büyük ve karmaşık bir besin ağı içinde birbirlerine bağlanmış olur.

Aşağıdaki resim bir besin ağı örneğini göstermektedir. Bu ağ içindeki canlılar kendi popülasyonlarının birer üyesidir. Bu besin ağını birlikte inceleyelim ve aşağıdaki sorulara cevap vermeye çalışalım.

Soru 3: **Solucan** popülasyonundaki ani bir azalma **tilki** popülasyonunu etkiler mi? Nasıl?

Soru 4: **Tavşan** popülasyonundaki ani bir artış **tırtıl** popülasyonunu etkiler mi? Nasıl?

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Son kararınızı vermeden önce aşağıdakileri okumanızı öneriyorum:

☹ **Bazı öğrenciler besin ağı içinde herhangi bir popülasyonunun** miktarının değişmesinin bütün diğer popülasyonları da **aynı şekilde** etkileyeceğini düşünüyorlar. Bu öğrenciler besin ağı içindeki bütün canlıların beslenme açısından birbirine bağlı olduğunu hatırlıyor ancak bu popülasyonlardan birinin sayısı azalırsa, diğerlerinin de aynı şekilde azalacağına inanıyor. Bu öğrenciler besin ağının temelinde yatan av-avcı ilişkisini düşünmüyor.

☺ **Evet, bir besin ağı içindeki tüm popülasyonlar arasında ilişki** vardır ve tüm popülasyonlar besin ağı içindeki değişikliklerden etkilenir. Ancak bütün popülasyonlar aynı şekilde etkilenmez. Örneğin yukarıdaki besin ağında köstebek popülasyonundaki ani bir azalma, tilki popülasyonunun da azalmasına neden olur çünkü köstebek popülasyonu tilki popülasyonu için bir besin kaynağıdır. Tilki popülasyonunun azalması tavşan popülasyonunun artmasına neden olacaktır çünkü tavşanı yiyen tilki sayısı azalacaktır. **Demekki besin ağı içinde herhangi bir popülasyondaki bir değişiklik diğer bütün popülasyonları da aynı şekilde etkilemez.**

☹ **Bazı öğrenciler** bir besin ağında bir popülasyondaki değişikliğin başka bir popülasyonu etkileyebilmesi için bu iki popülasyon arasında mutlaka bir av-avcı ilişkisi olması gerektiğine inanıyor. Bu öğrenciler yukarıdaki besin ağında solucan popülasyonundaki azalmanın sadece köstebek popülasyonunu etkileyeceğine inanıyor çünkü solucanı direk olarak yiyen köstebek diyorlar. Bazı öğrenciler tavşan popülasyonunun solucan popülasyonundaki azalmadan etkilenmeyeceğini düşünüyor çünkü bu öğrenciler bu iki popülasyonun yanyana olmadıkları için birbirlerini etkilemeyeceklerine inanıyor.

Şimdi bu öğrencilerin nerede hata yaptıklarını bulalım:

☺ **Bir besin ağında birbirleri ile direk av-avcı ilişkisi olmayan** popülasyonlar da birbirlerini etkileyebilir çünkü hepsi aynı besin ağının içinde yer almaktadır. Örneğin yukarıdaki besin ağında solucan popülasyonundaki azalma bitki popülasyonunu da etkiler çünkü solucanlar bitki ile besleniyorlar, yada ardıç kuşu ve keklik popülasyonları da etkilenir. Bunun yanısıra bitki ile beslenen diğer canlılar da (tavşan, tırtıl, salyangoz gibi) bu azalmadan etkilenir çünkü bitkiyi yiyen solucan azalırsa, diğer canlılar daha fazla bitki bulacaklardır ve sayıları artacaktır. **Demekki bir besin ağı içinde popülasyonların birbirini etkileyebilmesi için birbirlerinin direk olarak avcısı ya da avı olmaları gerekmiyor.**

Şimdi siz de bildiğiniz canlıları kullanarak yukarıdaki gibi bir besin ağı yaratmaya çalışın ve popülasyonlarda meydana gelen değişikliklerden diğer popülasyonların nasıl etkilenebileceğini bulmaya çalışın.