THE EFFECT OF GENDER AND REASONING ABILITY ON THE STUDENTS' UNDERSTANDING OF ECOLOGICAL CONCEPTS AND ATTITUDE TOWARDS SCIENCE

HACER SOYLU

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THE EFFECT OF GENDER AND REASONING ABILITY ON THE STUDENTS' UNDERSTANDING OF ECOLOGICAL CONCEPTS AND ATTITUDE TOWARDS SCIENCE

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_____
Prof. Dr. Canan ÖZGEN
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Mater of Science

_____
Prof. Dr. Ömer GEBAN
Head of Department

This is to certify that we read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science

_____	_____
Assoc. Prof. Dr. Ceren TEKKAYA	Assist Prof. Dr. Jale ÇAKIROĞLU
Co-Supervisor	Supervisor

Examining Committee Members

Prof. Dr. Ömer GEBAN	(METU, SSME)	_____
Assist. Prof. Dr. Jale ÇAKIROĞLU	(METU, ELE)	_____
Assoc. Prof. Dr. Ceren TEKKAYA	(METU, ELE)	_____
Assist. Prof. Dr. Semra SUNGUR	(METU, ELE)	_____
Dr. F. Ömer ÖZDEMİR	(METU, SSME)	_____

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Name, Last name : Hacer SOYLU

Signature :

ABSTRACT

THE EFFECT OF GENDER AND REASONING ABILITY ON THE STUDENTS' UNDERSTANDING OF ECOLOGICAL CONCEPTS AND ATTITUDE TOWARDS SCIENCE

Soylu, Hacer
M.S., Department of Secondary Science and Mathematics Education
Supervisor: Assist Prof. Dr. Jale ÇAKIROĞLU
Co-supervisor: Assoc Prof. Dr. Ceren TEKKAYA

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The purpose of this study was to investigate the effect of gender and reasoning ability on the 8th grade students' understanding of ecological concepts and attitude toward science. All 8th grade students from public elementary school in Tosya participated in the study. Students' understanding, attitude toward science and reasoning ability were also measured by means of the Test of Ecology Concept (TEC), the Attitude Scale toward Science (ASTS) and the Test of Logical Thinking (TOLT) respectively. In order to investigate students' understanding deeply, interview was conducted.

Results of the TEC and interview show that students have many misconceptions concerning ecosystem, population, community, decomposers, food chain, food web, energy pyramid and energy flow. Students' understanding for the first tier (M= 55.8), combination of first two tiers (M= 27) and combination of all three tiers (M= 21.2) were calculated according to TEC results.

Multivariate Analysis of Covariance (MANCOVA) conducted to determine the effect of gender on students' understanding of ecological concepts and attitude towards science when reasoning ability was controlled. The results indicated that there was significant gender difference in favor of girls with respect to students' understanding of ecological concepts and attitude towards science when reasoning ability was controlled (Wilks' Lambda=0.97; p=.00).

Key words: Misconception, ecological conception, reasoning ability, gender difference, attitude toward science, three-tier diagnostic test.

ÖZ

CİNSİYETİN VE MANTIKSAL DÜŞÜNME YETENEĞİNİN ÖĞRENCİLERİN EKOLOJİK KAVRAMLARI ANLAMAVE FEN BİLGİSİ DERSİNE YÖNELİK TUTUMLARINA ETKİSİ

SOYLU, Hacer
Yüksek Lisans, Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü
Tez Yöneticisi: Yrd. Doç. Dr. Jale Çakıroğlu
Ortak Tez Yöneticisi: Doç. Dr. Ceren Tekkaya

Eylül 2006, 111 sayfa

Bu çalışmanın amacı cinsiyetin ve mantıksal düşünme yeteneğinin öğrencilerin ekoloji kavramlarını anlama ve fen bilgisine yönelik tutumlarına etkisini araştırmaktır. Bu çalışmaya Tosya ilçesinden ilköğretim okullarında eğitim gören bütün sekizinci sınıf öğrencileri katılmıştır. Öğrencilerin kavram yanılgılarını, fen bilgisi dersine yönelik tutumlarını ve mantıksal düşünme yeteneklerini sırasıyla Ekoloji Kavram Testi, Fen Bilgisi Tutum Ölçeği ve Mantıksal Düşünme Yetenek Testi ile ölçülmüştür. Öğrencilerin kavram yanılgılarını derinlemesine araştırmak için mülakat yapılmıştır.

Ekoloji Kavram testi ve mülakat sonuçları öğrencilerin ekosistem, populasyon, kominite, ayrıştırıcılar, besin zinciri, besin ağı, enerji piramidi ve enerji akışıyla ilgili bir çok kavram yanılgısına sahip olduğunu göstermektedir. Ekoloji Kavram Testi sonuçlarına göre öğrencilerin anlama seviyeleri testin birinci basamağına(M= 55.8), ilk iki basamağın kombinasyonunu (M= 27) ve üç basamağın kombinasyonu (M= 21.2) için hesaplanmıştır.

Cinsiyetin öğrencilerin ekolojik kavramları anlama ve fen bilgisi dersine yönelik tutumlarına etkisini ölçmek için çoklu kovaryans analizi kullanılmıştır. Sonuçlar, öğrencilerin ekolojik kavramları anlama ve fen bilgisi dersine yönelik tutumlarına cinsiyetin kızlar yönünde etkisi olduğu, aynı zamanda cinsiyetle mantıksal yetenek arasında bir etkileşim olduğunu göstermiştir.

Anahtar Kelimeler: Kavram yanılgısı, ekolojik kavramlar, mantıksal yetenek, cinsiyet farklılığı, fen bilgisine yönelik tutum, üç aşamalı tanı testi.

To My Parents

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LIST OF ABBREVIATIONS

TEC	: Test of Ecology Concept
TOLT	: Test of Logical Thinking
ASTS	: Attitude Scale towards Science
MANCOVA	: Multivariate Analysis of Covariance
P	: Significance Level

CHAPTER 1

INTRODUCTION

Most of the research studies from the literature show that students' minds are not empty; they have plenty of ideas or prior knowledge (Arnaudin & Mintzes, 1985; Bell, 1985) when they enter the class. These alternative ideas can be named as ''preconception'' (Novak, 1977), ''misconception'' (Fisher, 1985) or ''children science'' (Osborne & Freyberg, 1985), which is different from scientific views and resistant to change with scientific ones (Driver, 1981; Fisher, 1985; Westbrook & Marek, 1991). Misconceptions are obstacles for students' understanding of concepts and meaningful learning (Carey, 1985; Driver, Guesne, & Tiberghien, 1985; Osborne & Freyberg, 1985; Posner, Strike, Hewson, & Gertzog, 1982). Therefore, researchers have had a great deal of identifying students' misconceptions about many science concepts such as photosynthesis (Halsam & Treagust, 1987; Smith & Anderson,1984;Yenilmez, 2005); human body (Mintzes, 1984); homeostasis (Westbrook & Marek, 1992); natural selection (Bishop & Anderson, 1990; Greene, 1990); amino acids and translation (Fisher, 1985); the human circulatory system (Arnaudin & Mintzes, 1985; Sungur, Tekkaya & Geban, 2001; Yip, 1998); diffusion (Westbrook & Marek, 1991); diffusion and osmosis (Odom & Borrow, 1985); nutrient cycling (Hogan & Fisherkeller, 1996; Okeke, Wood & Robinson, 1980) and ecological concepts (Adeniyi, 1985; Bell 1985, Brehm, Anderson & DuBay, 1986; Bishop & Anderson 1990; Çetin, 2003; Eisen & Stavy, 1992; D'Avanzo, 2003; Gallegos, Jerezano, Flores, 1994; Griffiths, Thomey & Normore, 1988; Griffiths & Grant, 1995; Hogan & Weathers, 2003; Lavoie, 1997; Leach, Driver, Scott & Wood-Robinson, 1996; Munson, 1994; Özkan, Tekkaya & Geban, 2004; Smith & Anderson 1984; Storey 1989). Concepts related to ecology are among such concepts and also students have many misconceptions about concepts related to ecology that must be

identified since students have great difficulty to learn meaningfully. Moreover, misconceptions involving ecological phenomena are particularly important to overcome, because ecology informs students how they are influenced by, and have influence on, the ecosystems and the biosphere (D'Avanzo, 2003; Johnson & Peeples, 1987) so overcoming misconceptions is crucial to students learning and their world-view. When misconceptions are challenged directly and students provided with opportunities to re-construct their world-view, the proportion of students able to use science conceptions to explain phenomena increases significantly. Therefore, in order to increase students' understanding teachers must know how to identify students' misconceptions.

There are several techniques used to identify students' misconception concerning science were clinical interviews (Adeniyi, 1985), concept maps (Novak & Gowin, 1984; Okebukola, 1990), multiple-choice test (Peterson, Treagust & Garnett, 1989; Taber, 1999; Tan & Treagust, 1999); two-tier diagnostic test (Haslam & Treagust, 1987; Rollnick & Mahooana, 1999; Odom & Borrow, 1995) and three-tier diagnostic test (Eryılmaz & Sürmeli, 2002; Kutluay, 2005; Peşman, 2005; Türker, 2005). Beside some of advantages, most of the identification techniques have limitations. Multiple-choice test can be easily administered and interpreted. On the other hand, it has the limitation that it does not give deep enough inside into the students' ideas on the topic and students give correct answers for wrong reasons. Due to these reasons, Haslam and Treagust (1987), Rollnick and Mahooana (1999) and Odom and Borrow (1995) have recommended that students should justify their answers so researchers added multiple-choice test with several tiers, for instance; in a two-tier test, the first tier presents a multiple choice content question and the second tier presents a set of reasons for the given answers in the first tier (Odom & Borrow, 1995). However, two-tier tests have some deficiencies. Griffard and Wandersee (2001) criticized two-tier test and asserted the test results overestimate the percentage of misconceptions because lack of knowledge can not be discriminated from misconceptions. Because of deficiency in two-tier test, Eryılmaz and Sürmeli (2002) developed a three tier-test to assess students' misconceptions concerning heat and

temperature. By means of the three tier-test, students' lack of knowledge discriminated from their misconceptions since the third tier items assess how confident the students are about their responses for the first and second tiers (Kutluay, 2005; Peşman, 2005; Türker, 2005).

Beside identification misconceptions, factors affecting students' understanding of science concepts and attitude towards science such as reasoning ability and gender have been given special interest by many researches (BouJaodue, 1992; Cavallo, 1996; Cavallo & Schafer, 1994; Lawson, 1983; Lawson & Renner, 1975; Niaz & Lawson, 1985; Noh & Schorman, 1997). Concerning reasoning ability, researches have suggested that significant relationship between reasoning abilities and biology achievement (Cavallo, 1996; Ehindore, 1979; Johnson & Lowson, 1998; Lawson & Thompson, 1988). Cavallo (1996) found that reasoning ability best predicted students' achievement in solving genetic problems. The study carried out by Lawson and Thompson (1988) indicated that misconceptions are consistent and significantly related to the reasoning ability. Moreover, the students with the highest level of formal reasoning might change their alternative conception more easily (Lawson & Thompson, 1998; Oliva, 2003). Moreover, Sungur and Tekkaya (2003) investigated the effect of gender and reasoning ability on students' achievement related with the human circulatory system. The results showed that while there was no statistically significant mean difference between boys and girls with respect to achievement and attitude toward biology, there was statistically significant mean difference between concrete and formal students with respect to achievement and attitude toward biology. Concerning gender effect, Dimitrov (1999) revealed that there was no significant difference between girls and boys with respect to achievement in life sciences. Moreover, Ugwu and Soyibo (2004) reported that no significant gender difference in Jamaican eighth-grade students' performance. Furthermore, Campbell, Voekl and Donohue (1998) reported that boys and girls achieve equally on this standardized measure until the middle school years, when boys begin to have an advantage that lasts through high school. On the other hand, other studies reported that there was a significant gender difference regarding science

achievement (Okeke & Ochuba, 986; Soyibo, 1999; Young & Fraser, 1994). For example, Young and Fraser (1994) revealed significant gender differences in biology achievement in favor of the boys. Stark and Gray (1999) reported that girls performed at significantly higher levels on tasks where the content was drawn from the biological sciences and those written tasks assessing science skills. Boys, however, were found to have greater success in the physical sciences. Girls had significantly higher achievement than boys, regarding students' achievement (Valanides, 1996).

Regarding gender effect on reasoning ability, there is a difference between girls and boys' reasoning ability. Yenilmez, Sungur and Tekkaya (2006) investigated the effect of gender and grade level on students' reasoning abilities. Results showed that boys have higher scores than girls on proportional, probabilistic and combinational reasoning, whereas girls have higher scores on controlling variables and correlation reasoning. It was also found that there was a statistically significant gender difference in favor of boys for proportional reasoning. Furthermore, Boujaude and Giuliano (1994) showed that scores of male students on Test of Logical Thinking (TOLT) were significantly higher than those of female students. On the other hand, Valanides (1996) investigated 12th grade Cypriot students' reasoning abilities with respect to gender. The results show that students' performance was higher on proportional reasoning and controlling variables items. Also, results revealed that boys had significantly better performance than girls on probabilistic reasoning item and girls had significantly higher achievement than boys, regarding students' achievement.

To summarize, students have many misconceptions about ecology which are obstacle for meaningful learning so many scientist gave special importance to identify misconceptions, elimination of sources of misconceptions and factors affecting students' misconceptions about ecology and attitude toward science such as gender and reasoning ability.

1.1 Definition of Important Terms

This part includes some important definitions related to the study.

Misconception: is the "mistakes" or errors, "misconceptions" or misleading ideas, and "misunderstandings" or misinterpretations of facts, saying that teachers and brighter students can correct errors (Barrass 1984). In this study, misconception was an incorrect answer in the first or second tier and confidence for the first two tiers in the third tier of the Test of Ecology Concept.

Three-tier misconception test: An item has one additional tier which asks students confidence about the answer of the former two-tiers (Çataloğlu, 2002).

Ecology: is a complex self-sustaining, natural system with interactions between biotic (living) and a-biotic (non-living).

Reasoning Ability: is ability to do many operations like relating two variables, isolating individual factors, interpreting observations and realizing.

Formal Reasoning Ability: If students have formal reasoning ability, they are able to solve abstract problem in logical fashion and becomes more scientific in thinking. There are five formal operational reasoning modes, namely proportional reasoning, controlling variables, probability reasoning, correlational reasoning and combinational reasoning. Proportional reasoning is important in many quantative aspects of science while correlational reasoning is important for interpretation of data where the potential relationships between variables are considered.

Concrete Reasoning Ability: Students are able to solve concrete problems in logical fashion and understand reversibility.

1.2 The Main Problem and Sub-problems

The research questions investigated in this study can be classified as the main problem and the sub-problems.

1.2.1 Main Problem

The purpose of the study is to investigate the effect of gender on 8th grade students' understanding of ecological concepts and attitude toward science.

1.2.2 Sub- Problems

1. What are the misconceptions that eighth grade students hold about some ecological concepts?
2. What is the effect of gender on students' understanding of ecological concepts and attitude towards science when the effect of TOLT scores are controlled?

1.3 Hypothesis of the study

There is no significant main effect of gender on the population means of understanding of ecological concepts and attitude towards science when the effect of TOLT scores is controlled.

1.4 Significance of the study

Ecology is one of the most important subjects in biology. Ecology informs students how they are influenced by, and have influence on, the ecosystems and the

biosphere. In addition, understanding ecology facilitates understanding photosynthesis and respiration easily (Anderson, Sheldon, & Dubay, 1990; Çapa, 2000, Özkan, 2001); for example, students have to learn distinction between producer and consumer before photosynthesis (Çapa, 2000; Özkan, 2001). On the other hand, students have many misconceptions about ecology (Adeniyi, 1985; Bishop & Anderson 1990; Çetin, 2003; D'Avanzo 2003; Eisen & Stavy, 1992; Gallegos et al., 1994; Griffiths & Grant, 1988; Hogan & Weathers, 2003; Leach et al., 1996; Lavoie, 1997; Munson, 1994; Özkan et al., 2004). Moreover, misconceptions on ecology are obstacle to be learned and taught new concepts. Therefore, it is very important to identify students' misconceptions about ecology for an instructor to help his/her student's understanding the scientific conceptions properly. There are several identification techniques but they have some limitations; for instance, concept map technique is very time consuming and evaluation is not easy. Multiple-choice test can be applied easily to many students but it can not assess students' answers deeply. Although two–tier test eliminates the deficiency of multiple-choice test, it can not differentiate lack of knowledge from misconception. In the three-tier test; however, lack of knowledge can be distinguished from misconception by means of third tier which asking student whether they are confident or not for the first two tiers. So, in the present study, three-tier test was used to identify students' misconception in ecology.

Previous studies provide us with a rich knowledge about students' misconceptions on ecological concepts and remediation methods of these misconceptions. However, there is no study investigating the effect of gender on students' understanding of ecological concepts and attitude towards science. Therefore, this study investigates the effect of gender on students' understanding of ecological concepts and attitude towards science when the effect of reasoning ability is controlled.

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Introduction

In this chapter, literature review is presented in the three sections. The first section is about the misconception and misconceptions in ecology. In the second part, identification of misconception is presented and finally factors affecting students' understanding and attitude toward science are given.

2.2. Misconception

Misconception is defined as scientifically incorrect interpretations and responses to problems may be provided by students (Driver, 1985; Osborne & Freyberg, 1985). Also, Strike and Posner (1985) described misconception as explanations of phenomena constructed by a student in response to the students' prior knowledge and experience. Many scientists named misconceptions differently like preconception (Novak, 1977), misconception (Fisher, 1985) or children science **(**Osborne & Freyberg, 1985). Moreover, the extensive research on misconceptions has also focused on characteristics of misconceptions, source of misconception and identification of misconceptions. Some of the key characteristics of science misconceptions may be summarized as follows: (a) stated misconceptions could represent elements of a coherent conceptual framework constructed by the individual (Hewson & Hewson, 1988), (b) misconceptions are constructed by individuals in response to their verbal and empirical experiences (Carey, 1985; Pines & West, 1986), (c) misconceptions are stable elements of an individual's conceptual framework and highly resistant to change, (d) traditional teaching is unlikely to

change a student's conceptual understanding (Champagne & Klopfer, 1983; Hewson & Hewson, 1988; Osborne & Freyberg, 1985; Posner, Strike, Hewson, & Gertzog, 1982). Furthermore, misconceptions prevent learning new concepts. In order to increase learning new concepts, identification misconception and elimination source of misconception are very important. Interview, concept map, multiple-choice test, two-tier diagnostic test and three-tier diagnostic test are the most common identification techniques. Previous studies showed several sources of misconceptions (Adeniyi, 1985; Ivowi, 1983; Helm, 1980; Klammer, 1988, Lee & Diong, 1999). Lee and Diong (1999) stated many word in science confused with everyday language, which caused misconception. For example, students perceived respiration as breathing or food was perceived as only human food. In addition, Bell (1985) found that students used energy and food as everyday language meaning. Also, Sanders (1993) stated that unscientific use of everyday language, everyday experiences, incorrect concept formation or incorrect information are taught during instruction and wrong explanations in the textbook were the sources of misconception. For example, Eyidoğan and Guneysu (2001) investigated misconceptions in eight-grade science textbook in the unit of cell and cell division. They found 21 misconceptions: 11 are about cell division (52%), 5 are on reproduction (24%) and 5 are about inheritance and environment (24%) and lack of knowledge in this science textbook. Moreover, Çapa (2000) investigated misconceptions concerning photosynthesis and respiration in plants. She concluded that the source of students' misconceptions were textbooks and suggested science textbook should be examined to check misconception and renewed. Aşcı, Özkan and Tekkaya (2001) investigated students' misconception about respiration and they found that high school and university textbooks have many misconceptions. Furthermore, Adeniyi (1985) found that some misconceptions were expressed by the teacher. For example, in his study, Adeniyi reported that students put the decomposers in the top of the energy pyramid because their teacher included decomposers in the top rung of a pyramid during instruction. In addition, Adeniyi reported another source of misconceptions that held by students was the inadequacy of the curriculum.

To sum up, misconceptions are scientifically incorrect interpretations. They are pervasive, stable and resistant to change. There are many sources like everyday language, textbooks, instruction, and teachers' misconception. Therefore, students hold many misconceptions that should be identified by using appropriate techniques before instruction and be remediated during instruction.

2.2.1 Misconceptions in Ecology

There are many science education research that emphasized the importance of understanding students' misconceptions on ecological terms, such as food chain, food web, energy pyramid and decomposers (Adeniyi, 1985; Çetin, 2003; D'Avanzo, 2003; Eisen & Stavy, 1992; Eilam, 2002; Gallegos et al., 1994; Griffiths & Grant, 1985; Lavoie, 1997; Leach, Driver, Scott & Wood-Robinson, 1996; Lin & Hu, 2002; Munson, 1991; Reiner & Eilam, 2001; Özkan et al., 2004; Webb & Boltt, 1990). Cherrett, (1989) listed 50 most important ecological concepts by surveying the members of the British Ecological Society. Twenty important concepts from the Cherrett's list would be recognized and endorsed as essential to environmental literacy by some of the environmental educators (Munson, 1994). Munson listed these 20 most important concepts: the ecosystem, succession, energy flow, conservation of resources, competition, niche, materials cycling, the community, life history strategies, ecosystem fragility, food web, ecological adaptation, environmental heterogeneity, species diversity, density dependent regulation, limiting factors, carrying capacity, maximum sustainable yield, population cycles, and predator-prey interaction. As seen in the list, ecosystem, energy flow, food chain, food web and prey-predator interaction are among the most important 20 concepts.

Ecological concepts are prominent aspect of science syllabuses. While science teachers identified ecological concepts as important and believed them easy for students to understand (Finley, 1982), there are many studies that revealed certain misconceptions particularly about environment, population, community, habitat and decomposers (Adeniyi, 1985; Brehm et al., 1986; D'Avanzo, 2003; Eisen & Stavy,

1992; Leach et al., 1996; Munson, 1991). For example, working with junior high students, Eisen and Stavy (1992) developed a unit that they hoped would change pre-existing misconceptions and prevent the formation of new ones by ignoring details and avoiding information overload. They focused on the role of plants in moving materials (like carbon, hydrogen, and oxygen) cyclically through the ecosystem. They found that students have misconception that plants are dependent on people, not vice versa. Other misconception about producer is that green plants are only producers of carbohydrates in ecosystems (Storey, 1989). In addition, some students believed that plants take food from the outside environment, or plants get their food from the soil via roots (Bell 1985; Smith & Anderson 1984). Leach et al. (1996) found several misconceptions about consumers; for example, the number of producers is high to satisfy consumers and there are more herbivores because people keep and breed them and humans provide food for other organism.

Adeniyi (1985) studied Nigerian students' misconceptions about ecology. After instruction, 26 students aged from 13 to 15 at elementary school were assessed by the essay test and clinical interview. Results of the essay test and interview revealed that students failed to define ecosystem, habitat, community, population, and many students confused ecosystem with habitat and population. They also stated community is the same as population. Adeniyi found that students remembered the everyday language meaning when population was asked. Thus, students thought population as human population. Also, Adeniyi reported that there are more herbivores than carnivores because plants eaters produce more young ones at one time and people breed more plant eaters than meat eaters. Adeniyi stated students described carnivores as big or ferocious and herbivores as passive or smaller. Students also thought that bacteria are the source of energy in ecosystem because heat and gases are produced by decomposing dead plants and animals. Student ordered food chain in aquatic environment as small fish was eaten by large fish that was eaten by crocodile and lastly it was decomposed by bacteria. Students thought that plants do not live in water so they could not understand food relationship in aquatic environment. Adeniyi (1985) found that students believed that the base

(producer level) of the energy pyramid is wider than apex (consumer level) since the number of producers is higher than the herbivores to provide enough food for herbivores. Also, he indicated that students thought that energy decreases from producer level to consumer level since herbivores use some energy for digesting or herbivores may be hungry at time of eating or energy evaporates into the atmosphere during respiration so carnivores get little energy from herbivores. On the other hand, some students in his study considered that available energy increases from the base to the apex of the energy pyramid so carnivores are the most powerful because energy accumulates up; thus, carnivores get their energy from both producers and herbivores. Moreover, students assumed that decomposers locate at the top of the energy pyramid and they said that bacteria are the source of energy. Moreover, Lavoie (1997) reported that decomposers release some energy that is cycled back to plants.

The study conducted by Munson (1994) related to ecology indicated that some students do not perceive organism exist within a system of interacting biotic and abiotic factors. Students also believed that varying the population of an organism might not affect an ecosystem because some organisms in the ecosystem are not important. Furthermore, he found that students do not have clear explanation about species, population and community in their minds and students do not understand that each species has unique needs, and therefore each species has a unique effect on an ecosystem. On the other hand, some students believed that the needs of a species are general and typical of similar species that carry out the same role within the ecosystem. Munson reported that students interpreted food webs as simple food chains. He stated that populations higher on a food web increase in number because they deplete those lower in the web. Similarly, Brehm et al. (1986) revealed that students described ecosystem that are not an organized whole, but a collection of organisms. In another study, Leach, Driver, Scott, and Wood-Robinson (1996) investigated students' ideas about ecology and found that most pupils aged 5 and 16 are inconsistent in the form of explanation used in different contexts; for example, they may explain relative population size in different communities in different ways.

Özkan, Tekkaya and Geban (2004) studied seventh grade Turkish students' misconceptions related to ecological concepts. They conducted an interview and by using results of the interview and literature, they developed two-tier diagnostic test. Eighteen misconceptions were identified by means of this test related to the concepts of environment, ecosystem, decomposer, population, energy resources in ecosystem and food chain and food web. They reported that students defined food chain as a kind of feeding relation including different food materials such as proteins and vitamins. Also, students had difficulty in identification of first consumer, second consumer or producer; for example, they maintained carnivores are the first consumer as they are wild and strong. On the other hand, several students claimed that humans are the first consumer because they consume everything. Moreover, they found that ecosystem is the interaction among living things and population is the number of people in a certain area; such as, population of city. Furthermore, they reported three misconceptions about decomposers such as decomposers eat dead plants and animals to keep environment, decomposers are not important because they are found on dead animals and they have no effect on ecosystems because they are too small to be seen by naked eye. They found several misconceptions about energy flow and energy pyramid. They reported that the strongest one has more energy; for example, when asked to which one has the greatest energy among grass, sheep and man, students believed that man has the greatest amount of energy since he is stronger so he has more energy. However, other students responded the reason of this question as man gets his energy from both grass and ship. On the other hand, students believed that energy flows from the stronger one to weaker one; for example, student stated in a food chain including plant, chicken and man, energy flows through man to plant because man has the greatest energy while some students thought that energy does not pass from one organism to other organism. Also, other students in her study believed that there is no relationship between plants and animals since plants and animals have own energy. Moreover, students claimed that plants get their energy from soil because they grow in soil and their food of mineral and water are present in soil.

Griffiths and Grant (1985) investigated tenth grade students' misconceptions related to food web that a hierarchy 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, and identification of specific misconceptions held by subjects concerning food web. Data were collected from 200 students. In their study, they found five misconceptions about food web. These are:

1. 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 affect 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.

Gallegos et al. (1994) found that students thought there is no producer in the food web. They thought that food web involves only prey and predator. Also, they thought that carnivores are big or ferocious and herbivores are passive or smaller so they considered that producers are small and passive like herbivores. Therefore, students started food chain with a producer correctly although they held misconception of ferocity and size. Student also thought that in a food web, a change in one population would only affect another population if the two populations were directly related as predator and prey. Moreover, they reported that student considered the relative sizes of prey and predator populations have no bearing on the size of other.

Reiner and Eilam (2001) studied changes in students' ideas of a food chain and they looked for underlying ontological belief that may explain students' ideas. Data were collected by observing 28 ninth grade students during 24 instructional sessions on ecology in Israel. Results of the study showed that there are several

factors that effect students' consideration in identifying a food chain such as eating event, size hierarchy and total elimination; for instance, students thought that a big fish fed on smaller fish fed on a smaller one. Furthermore, they reported that students considered if the organism is eliminated when consumed, it is assumed as an element in a food chain otherwise, it could not constitute food chain.

The study conducted by Eilam (2002) indicated that students considered bacteria as the microscopic-sized bacteria to diseases when asked whether bacteria in the human body constitute a food chain. Some of the student defined food chain as cyclic that white blood cell swallows the bacteria that feed on the human body. On the other hand, most of students thought bacteria as decomposers but they stated that decomposers feed only on the last element of the chain. Furthermore, Eliam reported that most of the students did not consider nectar as the first link of the feeding relations because it is not contained the green parts of plants. They thought that only a green component of plants is the part of a food chain since it contains photosynthesis products to pass on the subsequent consumers. In addition, students in this study believed that humans in feeding relations are always at the top of the pyramid and that larger organisms always feed on smaller ones. Results of the study about prey and predator relationship supported fourth and fifth misconceptions of Griffith and Grand's findings.

In another study, Webb and Boltt (1990) examined the ability of high school pupils and university students to answer questions on relationship within food webs using sound ecological principles. Data were collected from 108 pupils aged 15-17 years old. They developed food web diagram using letters that represent populations in the food web and arrows that shows the relationship. Nine open-ended questions were asked to students. Results of the study showed that misconceptions appeared regularly at all levels were based on the proximity of populations in the food web; for example, if the populations are too far apart, there is no effect or there is not too much effect if the chains are spread out. Thus, the distance or links among the

populations are important. However, they reported that misconceptions described by Griffiths and Grant (1985) occurred occasionally.

Çetin (2003) investigated the ninth grade Turkish students' understanding of ecology unit. Data were collected from 79 high school students from four different classes through ecology concept test. Her study covered non-living, living factors of the environment, producer, consumer, decomposer, relationship in matter and energy flow, food web, food chain, cycle of matter, population, community, ecosystem, and environmental pollution. Results of the study showed that students have some misconceptions about ecology unit and these misconceptions prevent meaningful learning. She reported that students had several misconceptions concerning food chain that the tertiary consumer takes its food from producers and secondary consumers feed on the tertiary consumers.

D'Avanzo (2003) investigated common misconceptions about photosynthesis, respiration, food webs, evolution and ecosystems to help improve college ecology instruction, ecology faculty and researchers who study learning should collaborate to design research about ecology teaching and ecological thinking. D'Avanzo reported that students believed that energy is not lost in trophic transfer since diagrams of energy pyramids that indicate decreases in energy, without indicating that energy is given off as heat, can reinforce students' misconception that energy is not conserved.

Lin and Hu (2002) investigated energy flow and matter cycling. Data were collected from 106 pupils in the seventh grade aged 13 years old from five secondary schools in the Taipei. The 12 items related with produces, consumers, decomposers, matter, and energy were provided for concept mapping. The results indicate that most of the pupils failed to recognize the interrelationships among the various concepts concerned with units of energy flow and matter cycling. It was the relationship between the living world and the non-living world that presented the greatest difficulty to understanding.

To sum up, these studies show that students have many misconceptions about ecological terms, such as food chain, food web, energy pyramid and decomposers. Main misconceptions on ecological terms are as below:

- Varying the population of an organism will only affect the others that are directly connected through a food chain (Griffiths & Grant, 1985; Munson 1991).
- Food webs are interpreted as simple food chains (Munson, 1991; Griffiths & Grant, 1985).
- If the organism is eliminated when consumed, it is assumed as an element in a food chain otherwise, it could not constitute food chain (Reiner & Eilam, 2001).
- Decomposers feed only on the last element of the chain (Eilam, 2002).
- Only a green component of plants is the part of a food chain since it contains photosynthesis products to pass on the subsequent consumers (Eilam, 2002).
- If the populations are too far apart, there is no effect or there is not too much effect if the chains are spread out (Webb & Boltt, 1990)
- Varying the population of an organism may not affect an ecosystem, because some organisms are not important (Munson, 1991).
- Varying the population of an organism will affect all other organisms to the same degree (Griffiths & Grant, 1985).
- Organisms higher in a food web eat everything that is lower in the food web (Griffiths & Grant, 1985).
- The top of the food chain has the most energy because it accumulates up the chain (Adeniyi, 1985).
- Populations higher on a food web increase in number because they deplete those lower in the web (Munson, 1994).
- Ecosystems are not an organized whole, but a collection of organisms (Brehm et al., 1986).

- There are more herbivores because people keep and breed them (Leach et al., 1996).
- Decomposers release some energy that is cycled back to plants (Lavoi, 1997).
- The number of producers is high to satisfy consumers (Leach et al., 1996).
- Carnivores have more energy or power than herbivores do (Adeniyi, 1985)
- Carnivores are big or ferocious. Herbivores are passive or smaller (Gallegos et al., 1994)
- Plants do not live in water (Adeniyi, 1985).
- Plants take in food from the outside environment, and/or plants get their food from the soil via roots (Bell, 1985; Smith & Anderson, 1984).
- Plants are dependent on people, not vice versa (Eisen & Stavy, 1992).
- Energy is not lost in trophic transfer (D'Avanzo, 2003).
- Humans provide food for other organisms (Leach et al., 1996)

2.3 Identifying Misconception

The identification of misconception has been the aim of many of the studies carried out over the last two decades (Pfundt & Duit, 1991). However, there is often little time invested by instructors in finding out in depth what students already know or what they do not know, what they are confused about, what their preconceptions are and whether they perceive new concepts or not despite their preconception (Carey, 1985; Driver, Guesne, & Tiberghien, 1985; Osborne & Freyberg, 1985; Posner, Strike, Hewson & Gertzog, 1982). So instruction may not be influenced to students that we might expect. Students bring to class their ideas, experience and preconceptions, which are resistant to change. Therefore, identification of prior knowledge is important part of the instruction for meaningful learning. Students' conceptions have been identified by means of interview, concept map, open-ended questions, multiple-choice test, and two or three tier diagnostic test.

Interview technique was used to identify students' misconceptions in many biology topics; such as ecology (Adeniyi, 1985; Çetin, 2003; Fisher, 1985; Özkan,

Tekkaya & Geban, 2004), the human circulatory system (Arnaudin & Mintzes, 1985; Sungur, Tekkaya & Geban, 2001), cellular respiration (Songer & Mintzes, 1994), diffusion and osmosis (Odom & Borrow, 1995), respiration in plants and photosynthesis (Çapa, 2000). Interview permits follow-up questions and interactions that can also provide insight into how a student is thinking and how thinking may change over time. It has some advantages; for example, it can be applied over a wide range of age, and provide deep investigation by getting students view rather than the correct scientific view. However, it has some limitations; for instance, interviews, transcribing and analysis of transcripts are time consuming and it can be applied for limited sample size.

Concept map is the other effective tool used for identifying students' misconception. It is used for a large number of researchers in different subject area in biology (Odom & Kelly, 2001). It provides more or less direct measures of the pupils' knowledge structure, in which it is conceived of as a combination of a task, a response format, and a scoring system (Ruiz-Primo & Shavelson 1996). It also gives a permanent record of student understanding at a particular time, which is useful to show changes in student understanding. However, concept map has some limitation; for example, it must be learned how to apply, how to score, and students must be taught how to construct them. This takes too much time (Zelik, n.d)

The other way of identifying students' misconception is multiple-choice tests. They can permit coverage of wide range of topics in a relatively short time (Tamir, 1990). Also, they can be scored easily, quickly and objectively, but they do not provide deep insight into students' ideas (Rollnick & Mahooana, 1990). Although they can measure students' contents knowledge, they can not give any idea about students' reasoning behind their choices; thus, students choose correct answer with wrong reasons (Odom & Borrow, 1995).

To determine students' reasoning, misconception and conceptual understanding, many researchers suggested using a two-tier diagnostic instrument

(Haslam & Treagust, 1987; Odom & Borrow, 1995; Rollnick & Mahoona, 1999; Tyson, Treagust & Bucat, 1999). A two tier diagnostic instrument has two parts. The first part having content questions with two or three choices is a kind of multiple-choice test. The second part of the two tier diagnostic instrument includes a set of possible reasons for the answer given to the first part. Distracters are designed to elicit misconceptions known from the literature. They can be applied a large number of students and scored easily but they can not differentiate lack of knowledge or error from misconception. Generally, in objective test all wrong answers are treated as misconception. On the other hand, reason of the wrong answers may be lack of knowledge or error. Eryılmaz and Sürmeli (2002) claimed that misconception has a connotation of error, but not all errors are misconceptions. Therefore, in order to identify misconception from lack of knowledge and error, they developed a three-tier diagnostic test. In three-tier test, first and second tier are the same as two-tier diagnostic instrument; thus, the first tier is the content questions with two or three choices and the second tier is the reasons of the choices in the first tier. The third tier presents whether confident or not for the first two tiers. For example, if students' answers for the first tier are incorrect, then the reasons of the answers for the first tier are chosen in the second tier, and student is confident about the answers for the first two tiers, we can think that students have misconceptions. Assessing misconception with multiple-choice test or two-tier diagnostic test overestimates the percentage of students having misconception and all wrong answers treated as misconception. Therefore, Eryılmaz and Sürmeli calculated percentage of students having misconception for each tier. They reported that 46% of the students had in average at least one misconception according to the first tier, 27% of the students had in average at least one misconception according to the first two tiers, and 18% of the students had in average at least one misconception according to all three tiers. They concluded that assessing misconception with one-tier or two-tier test overestimates the percentages of students having misconceptions due to all wrong answers treated as misconception. Some of the incorrect answers may be due to misconceptions but some of them may be due to randomly given answers or lack of knowledge so three

tier diagnostic test decreases assuming error, mistakes or lack of knowledge as misconception.

2.4 Factors affecting Students' Understandings and Attitude

There are many factors affecting students' understanding and attitude toward science. Of a special interest, in this part only two of them, will be discussed: Gender and reasoning ability

2.4.1 Gender Difference

Many researches have showed that mean scores on measures of both science achievement and attitudes toward science begin to differentiate by gender, favoring boys, during the middle school years (Catsambis, 1995; Baker & Leary, 1995; Jovanic & King, 1998; Jones, 2000; Lightbody & Durndell, 1996; Simpson & Oliver, 1990; Sullins, Hernandez, Fuller & Tashiro, 1995). Although there is no difference in achievement of boys and girls until the middle school years, boys begin to have greater success that lasts through high school (Campbell, Voekl & Donohue, 1998). Moreover, Simpson and Oliver (1990) showed that both attitudes toward science and science motivation for boys and girls from grades 6 to 10 declined but boys have more positive science attitudes and achievements than the girls across the level. Furthermore, results of the studies showed that there is a significant gender difference in science experiences, attitudes, and perceptions of science courses and careers. While males have more extracurricular experiences with a variety of tools such as batteries, electric toys, fuses, microscopes, and pulleys, females have more experiences with bread-making, knitting, sewing, and planting seeds. More male students showed they were interested in atomic bombs, atoms, cars, computers, x-rays, and technology while more females reported interest in animal communication, rainbows, healthy eating, weather, and AIDS. In addition, Jones (2000) reported that girls and boys have different attitude towards science for the last three decades. He stated that girls have different experiences outside the school and this affects their

attitude. Although students often have different experiences with science in and out of school based on gender, more females than males graduate from post secondary institutions and get higher grades in science and engineering courses. On the other hand, more males than females major in the natural sciences or engineering (Keeves, 1991; Kotte, 1992; National Academy Press, 1991; National Science Board, 1998; Rosser, 1995). Studies also reported that gender differences begin as early as elementary school and boys have possessed more positive attitude in studying science than girls (Clarke, 1972; Clark & Nelson, 1972; 1971; Kotte, 1992). Kahle and Lakes (1983) examined data from the National Assessment of Educational Progress (NAEP) in the US and found that girls described their science classes as facts to memorize and boring. In addition, girls' attitudes toward science tend to decline until middle school and this continue to high school (Sullins, Hernandez, Fuller, & Tashiro, 1995). Catsambis (1995) examined data from 19,000 eighth grade students who participated in the National Educational Longitudinal Study and found that males liked more science lesson and thought science would be useful to their future, and were less afraid to ask questions in science classes than their female peers were. According to Catsambis, girls have less positive attitudes although they performed better than boys and got higher grades in science classes. In addition, Catsambis reported that middle school boys more interested in a future career in science than girls. He stated the reasons of the gender gap in science achievement beginning in the middle school, a decline in girls' science self-concept and in other components of their attitudes towards science.

Keeves and Kotte (1992) examined students from ten different countries and found that males held more positive attitudes toward science than females, even though females were more interested in school and school learning in general. Also, they reported males thought science was easy to learn whereas female students thought science was difficult to learn. They also found that more males enrolled in physics and chemistry courses in secondary school but more females enrolled biology in secondary school. They also reported that male students aged 10, 14, and 18 had higher achievement in chemistry, earth science, and physics than female

students did. On the other hand, there were no significant differences between males and females for biology.

Baker and Leary (1995) also found differences in attitudes and understanding of science as students progressed from middle through high school. They reported that eighth grade girls in the study liked science in spite of their peers' discouragement for their career choice in science. However, in eleventh grade peers thought differently from eighth grade peers though they believed that girls do not like science. Furthermore, they found that the girls do not like physical sciences because of not allowing them to help or care people. They prefer biology in order to help people, animals, or the earth instead of physical sciences.

Jones (1990) reported that while boys generally preferred research in physical sciences, girls wanted to make research in the area of biology in the sample of the pre-college students' research. He also found that girls thought as biology as a more caring branch of science whereas they described as physics are related with war and destruction.

The study conducted by Jovanic and King (1998) showed that girls rather than boys make comparative judgments across academic domains so years progressed girls perceived themselves to be better at the other school subject and therefore not as good at science. The study of Osborne and Collins (2000) revealed reason of the girls' rejection of science that was the perception of science as a difficult subject and also showed that most of the curriculum lack of the demanding activities and observing problem so this affects girls' attitude towards science negatively. Furthermore, Lightbody and Durndell (1996) have found that boys were far more liking science than girls. However, Archer (1992) has found that girls aged between 10 and 15 reported liking most strongly the three subjects: mathematics, science and games. Moreover, Elver and Comber (1995) have shown that girls are successful as well as boys.

More recently, Osborne (2003) investigated a major literature about attitudes to science and its implications over the past 20 years. Moreover, analysis by gender shows that the male to female ratio remains 3.4: 1 in physics, while it is at least approximately equal in chemistry; biology by contrast is still dominated by girls. Results revealed that there are many factors that affect attitude such as gender, teachers, curricula, cultural and other variables, but the most effective factor is gender and quality of teaching. Furthermore, classroom activities and classroom environment may affect positively students' interest to science. Oliver and Simpson (1988) have reported that social support from peers and attitude towards enrolling for a course are strong determinants of girls' choice to pursue science courses voluntarily.

Results of the Colley, Comber and Hargreaves's (1994) studies showed that there was significant gender difference among 11 years old and 13 years old pupils with girls favoring English and Humanities, boys favoring science. On the other hand, The Research Business (1994) in England showed that there was no significant gender difference with the sample aged 14-16 who found science as useful (68%) and interesting (58%).

2.4.2 Reasoning Ability

On the basis of Piagetian Theory, schemes which are organized patterns of behaviors or thoughts that allow mentally representing or thinking objects or events in our world evolve through four stages. Although these stages reflect a generally continues pattern of cognitive development, children do not suddenly jump from one stage to the next. These stages of cognitive development are sensory motor (0-2 years), preoperational (2-7 years), concrete operational (7-11 years), formal operational (11-adult). Understanding occurs in concrete and formal operational level (Johnson, 1993). While students at the concrete operational stage are able to concrete (hands on) problems in logical fashion, understands laws of conservation and reversibility, and are able to classify and seriate, they can not make non-observable

or imaginatory operations. Moreover, Bigs and Collins (1982) reported that students who are identified at the concrete operational students might have an inefficient working memory and have difficulty multiple concepts simultaneously and they fail to recognize which concepts is best answer to the problem. Concrete operational students will often consider a problem to have a single correct solution and will have difficulty to identifying responses for open-ended questions that have multiple answers. In formal operational students have deep working memory so they are able solve abstract problems in logical fashion, becomes more scientific in thinking such as testing the hypothesis and analyzing data and they can keep concepts and their interrelationships in their mind while considering answers. According to developmental theory, descriptive and theoretical concepts constructions are linked to intellectual development because the process depends on reasoning patterns and also reasoning ability relies on not only maturation but also individual self-regulatory mechanisms. Furthermore, students normally progress from concrete to abstract stage with increasing age, grade level, and practice. Students who have reached the formal stage can use logical operations (Bybee & Sund, 1990), which are important for science learning and achievement (Lawson, 1995; Piaget, 1964).

Learning of science requires intellectual skills and high levels of reasoning ability of students (Bigs & Collins, 1982; Bitner, 1991; Johnson, 1993; Lawson, 1982). For successful learning in science, five formal reasoning modes consisting of controlling variables, proportional, probabilistic, correlational, and combinational reasoning abilities are essential (Bitner, 1991; Lawson, 1982). On the other hand, Lawson, Karplus and Adi (1978) found little or no difference between sixth graders' and eighth graders' use of proportional and probabilistic reasoning. They found huge advances in the use of proportional and probabilistic reasoning from 8th to 10th graders. In a sample of 6130 Korean students, Hwang, Park and Kim (1989) found generally similar performances on measures of proportional, combinational, probabilistic and correlational reasoning among 12-, 13-, and 14- years old. They found substantial performance improvements by the 15-year-olds. Students science achievement at secondary level depends on solving algorithm and conceptual

problems whose solution requires sound understanding of underlying concepts and application and manipulation of certain mathematics and science formulae but students sometimes solve problems by applying scientific formulae without understanding underlying scientific concepts (Heywoth, 1999; Mason et al., 1997)

Therefore, a large number of researchers gave special importance to reasoning ability and reported that positive relationship between students' logical thinking ability and their science achievement (Abraham et al., 1992; Atkinson, 2004; BouJaodue et al., 2004; Chandran et al., 1987; Cavallo, 1996; Cavallo et al., 2003; Johson & Lawson, 1998; Jones et al., 2000; Hupper et al., 2002; Lawson & Thompson 1988; Lawson et al., 2000; Oliva, 2003; Robinson & Niaz, 1991, Sungur & Tekkaya, 2003; Valanides, 1997; Yenilmez et al., 2006). For example, Lawson (1978) investigated students' formal reasoning levels with 523 students from eighth grade to tenth grade. He found that 35% of the students were at the concrete level, 15% of the students at the formal level and 35% of the students at the transitional level which was named by Lawson. Transitional level is the beginning of the formal thought. He reported that students at the concrete level fail to understand in abstract concepts. Furthermore, Tobin and Capie (1982) found that formal reasoning ability is the strongest predictor of process skill achievement and retention with 36% of variance. Also, Lawson and Thomson (1988) reported higher reasoning ability and larger mental capacity eliminate some misconceptions. They tested hypothesis of formal operational students hold significantly fewer misconceptions than their concrete operational classmates did. Data were collected from 131 seventh grade students by application of essay test about genetics and natural selection after instruction. On the other hand, Oliva (2003) found that the students with higher levels of formal reasoning tend to have more structured misconceptions than the ones having lower level of formal reasoning but they change their misconceptions more easily. Kwan and Lawson (2000) maintained there is a relationship between maturation of brain growth during adolescence and scientific reasoning ability including capacity to reject misconceptions and accept scientific conceptions.

In other study, Johson and Lawson (1998) investigated the effect of the reasoning ability and prior knowledge on biology achievement in expository and inquiry classes and examined that 366 students enrolled in a one-semester nonmajors biology course at a large suburban southwestern community. They found that the effect of reasoning ability on achievement is more than prior knowledge effect and the improvement of reasoning ability in inquiry classes is higher than expository classes since reasoning patterns are used to inquire into biological phenomena, generate and test alternative hypotheses, and otherwise construct meanings from potentially confusing and disequilibrating inquiry experiences. These processes correspond to the concrete, transitional, and formal stages within Piagetian theory (Inhelder & Piaget, 1958; Karplus & Lavatelli, 1969; Piaget & Inhelder, 1962). They also reported that reasoning ability explained more of the variance in final examination scores for students enrolled in expository classes (18.8%) than in inquiry classes (7.2%). On the other hand, some researchers have found student's prior knowledge of biology is the primary determinant of the achievement, while others have found reasoning ability is the primary determinant of the achievement, for example, Blurton (1985) found that prior genetics knowledge, but not reasoning ability, significantly predicted performance on a genetics posttest. However, Lawson and Worsnop (1992) found high school biology students' reasoning ability to be significantly related to gains in conceptual knowledge because concept acquisition requires equilibrium between assimilation and accommodation in which several interrelated reasoning pattern. Therefore, concept acquisition should also be dependent on students' reasoning ability (Lawson, 1985, 1991; Wollman & Lawson, 1977). In addition, Lawson et al. (1991) found reasoning ability to be highly correlated with performance on concept acquisition tasks for high school biology and chemistry students. On the other hand, Westbrook and Marek (1991, 1992) showed no relationship between reasoning ability and understanding diffusion but they found that a relationship between reasoning ability and understanding homeostasis. Bitner (1991) showed there was a high correlation between success and reasoning ability and reported that reasoning ability explained 62% of the variance in high school science grades. Moreover, Robinson and Niaz (1991) found reasoning ability to be

related to chemistry students' success at solving stoichiometry problems. Although it seems reasonable to expect that both prior conceptual knowledge and reasoning ability contribute to learning, perhaps the extent to which prior knowledge and reasoning ability predict achievement depends to some extent on the instructional method employed. Shayer and Adey (1993) reported design of the instruction to develop reasoning patterns also resulted in larger differences in science achievement between control and experimental groups.Some research has shown a gender difference in reasoning ability favoring males (Liben & Golbeck, 1980) although other studies have shown little difference between males and females on reasoning ability (Kahle & Meece, 1994).

Germann (1994) tested a model of science process skills acquisition and interaction with parents' education, preferred language, gender, science attitude, cognitive development, academic ability, and biology knowledge. Path analysis techniques were used to test a hypothesized structural model of direct and indirect causal effects of student variables on science process and data collected at the beginning and end of the school year from sixty-seven 9th- and 10th-grade biology students who lived in a rural Franco-American community in New England. Results of the study showed that academic ability, biology knowledge and language preference had significant direct effects and there were significant mediated effects by cognitive development, parents' education, and attitude toward science in school. The variables of cognitive development and academic ability had the greatest total effects on science process skills. Concept construction often engages hypothetico deductive reasoning skills.

Cavallo (1996) explored relationships among school students' meaningful learning orientation, reasoning ability and acquisition of meaningful understandings of genetics topics, and ability to solve genetics problems. After measured students' meaningful learning orientation (meaningful and rote) and reasoning ability (preformal and formal), students were tested before and after laboratory-based learning cycle genetics instruction using a multiple choice assessment format and an

open-ended assessment format (mental model) and regression analyses were conducted to examine the predictive influence of meaningful learning orientation, reasoning ability, and the interaction of these variables on students' performance on the different tests. Results revealed that meaningful learning orientation best predicted students' understanding of genetics interrelationships, whereas reasoning ability best predicted their achievement in solving genetics problems. The interaction of meaningful learning orientation and reasoning ability did not significantly predict students' genetics understanding or problem solving. Cavallo, Potter and Rozman (2004) measured students' learning approaches, motivational goals, self-efficacy, epistemological beliefs, scientific reasoning abilities, and understanding of central physics concepts at the beginning and end of the course. The findings showed that male students had significantly higher self-efficacy, performance goals, and physics understanding compared to females, which persisted throughout the course. Differential shifts were found in students 'meaningful learning approaches, with females tending to use less meaningful learning from beginning to end of the course; and males using more meaningful learning over this time period. For both males and females, self-efficacy significantly predicted physics understanding and course achievement. For females, higher reasoning ability was also a significant predictor of understanding and achievement; whereas for males, learning goals and rote learning were significant predictors, but in a negative direction.

Lawson, Abraham, and Renner (1989) reported that many inquiry-based curricula were developed to help promote students critical thinking, concept understanding, and scientific reasoning abilities. Research on these curricula found that students in inquiry-based classrooms formulate more sound understandings of science processes and content, as compared to those in classrooms with more passive learning, such as listening to a lecture (Gabel, 1994).

Main points of the literature review was listed as below

1. Students have several misconceptions about ecological conceptions which are persistent to change and they influence further understanding and learning

(Adeniyi, 1985; Brehm et al., 1986; Çetin, 2003; D'Avanzo, 2003; Eisen & Stavy, 1992; Eilam, 2002; Gallegos et al., 1994; Griffiths & Grant, 1985; Leach, Driver, Scott, Wood-Robinson, 1996; Munson, 1991; Reiner & Eilam, 2001; Özkan, 2001; Webb & Boltt, 1990).

2. Sources of misconceptions according to previous studies are science textbook (Ivowi, 1983), teachers' instructions (Adeniyi, 1985), popular sayings of students (Helm, 1980) and a curriculum (Klammer, 1988).

3. Identification of misconception has been the aim of many of the studies carried out over the last two decades (Pfundt & Duit, 1991). There are many techniques to identify misconceptions such as interview technique (Adeniyi, 1985; Arnaudin & Mintzes, 1985; Çapa, 2000; Çetin, 2003; Fisher, 1985; Lawson, 1988; Sungur, Tekkaya & Geban, 2001; Songer & Mintzes, 1994; Odom & Borrow, 1995;Özkan, Tekkaya & Geban, 2004), concept map (Odom & Kelly 2001), multiple-choice tests (Rollnick & Mahooana, 1990; Tamir, 1990), two-tier diagnostic instrument (Haslam & Treagust, 1987; Odom & Borrow, 1995; Rollnick & Mahoona, 1999; Tyson, Treagust & Bucat, 1999), three-tier diagnostic test (Eryılmaz & Sürmeli, 2002, Kutluay, 2005; Peşman, 2005; Türker, 2005).

4. Some of the incorrect answers may be due to misconceptions but some of them may be due to randomly given answers or lack of knowledge so three tier diagnostic test decreases assuming error, mistakes or lack of knowledge as misconception (Eryılmaz & Sürmeli, 2002).

5. Gender and reasoning ability are the most important factors that affect students' understanding of science and attitude towards science (Sungur & Tekkaya, 2003).

6. Studies also reported that gender differences begin as early as elementary school and boys have possessed more positive attitude in studying science than girls (Clarke, 1972; Clark & Nelson, 1972; 1971; Kotte, 1992). Kahle and Lakes (1983).

7. There are large number of studies have focused on identifying cognitive variables that affect students' achievement and their understanding of science concepts (BouJaodue 1992, Cavallo 1996, Cavallo & Schafer, 1994; Giuliano, 1992; Lawson, 1983; Niaz, 1987; Niaz & Lawson, 1985, Niaz & Robinson, 1992; Noh & Scharmann, 1997).

8. There is a positive relationship between students' logical thinking ability and their science understanding (Abraham et al., 1992; Atkinson, 2004; Boujaude et al., 2004; Cavallo, 1996; Cavallo et al., 2003; Chandran et al, 1987; Hupper et al., 2002; Jones et al., 2000; Johson & Lawson, 1998; Lawson et al., 2000; Lawson & Thompson 1988; Valanides, 1997; Oliva, 2003; Robinson & Niaz, 1991; Sungur & Tekkaya, 2003; Yenilmez et al, 2006).

9. Several studies have established a clear link between scientific reasoning ability and concept understanding (Baker, 1994; Choi & Hur, 1987; Johson & Lawson, 1998; Kim & Kwon, 1994; Lawson & Renner, 1975; Lawson, 1985; Robinson & Niaz, 1991; Ward & Herron, 1980).

CHAPTER 3

METHOD

In the previous chapters, purpose, problems, and hypotheses of the study were presented, related literature was reviewed and the essence of the study was justified. In this chapter, population and sampling procedure, description of variables, instruments of the study, procedure, and methods used to analyze data and assumptions and limitations will be explained briefly.

3.1 Population and Sample

The target population of the study is all eight grade elementary school students in Turkey. The accessible population contains all eight grade students in Tosya, the biggest district of Kastamonu, in Turkey. The study was conducted in all 8^{th} grade classes in elementary school in Tosya and a sample of 600 students participated in this study. There were 313 female students and 287 male students. Students' ages ranged from 13 to 16 with the mean of 14.1. The mean of the science grade of the students was 3 over 5.

Table 3.1 shows the demographic information regarding the mother educational level (MEL), father educational level (FEL) as indicators of socioeconomic status of the students in the study, students' age and their grades. As it can be deduced from the table, majority of the parents graduated from primary school. Moreover, most of the students are 14 years old and most of the students' grades are 2 or 3.

Table 3.1 Sample Characteristics

Educational Level	MEL	FEL
Illiterate	48	11
Primary School	466	322
Secondary School	63	112
High School	14	95
University	9	56
MS	0	4
PhD	0	0
Age	girls	boys
13	14	11
14	238	258
15	38	33
16	3	5
Grade	girls	boys
2	106	116
3	70	72
4	88	57
5	49	42
Total	313	287

3.2 Instruments

Data were collected by four means. These were the Test of Ecology Concepts (TEC), the Attitude Scale towards Science (ASTS), the Test of Logical Thinking (TOLT) and interviews.

3.2.1 The Test of Ecology Concepts (TEC)

A three-tier diagnostic test, the test of ecology concepts, was used to assess students' understanding on Ecological concepts (Appendix B). This scale was developed by researcher based on previous studies (Reiner & Eilam, 2001; Özkan, 2001; Eilam, 2002). Some of items in the TEC, developed by Özkan (2001), were revised by reviewing related literature about ecology. Final version of TEC consists of 19 items concerning basic ecological terms, food web, food chain, energy pyramid and energy flow. The first tier of the TEC is the multiple-choice content question and the second tier presents a set of reasons for the given answer in the first tier. The last tier asks the students whether he/she is sure or not for the given answers for the first two tiers. Then, the test was given to two science teachers and two science educators in order to establish content validity. The test was pilot tested and its reliability was found to be .83. Students were categorized different levels of understanding according to the test scores they got. Scoring procedure is as given below

1. Complete Understanding: When student gave the correct response for the first and second tier, then chose the 'I am sure' alternative in the third tier, two points are given, which is called complete understanding.
2. Partial Understanding: Students were not sure in the third tier although choosing right answers in the first and second tier. One point is given.
3. Lack of Understanding: If students' responses for one of the tiers or both are false and they are not sure for the first two tiers, half point is given.
4. Misconception: If students' responses for one of the tiers or both are false and they are sure for the first two tiers, zero point is given to students' responses.

3.2.2 Attitude Scale towards Science (ASTS)

In this study, the Attitude Scale towards Science was used to determine students' attitude towards science (Appendix C). This scale was developed by Geban, Ertepınar, Yılmaz, Altın and Şahbaz (1994). The reliability of the scale found as 0.83. The ASTS has 15 items with a 5-point likert type scale: strongly agree, agree undecided, disagree, and strongly disagree. It consists of both positive and negative statements. Negative statements were translated to the scores of positive statements. Then total score was calculated. Its range was from 0 to 58. While higher scores showed positive attitudes towards science, lower scores showed negative attitudes towards science. Reliability of ASTS for this study was found to be .77.

3.2.3 The Test of Logical Thinking (TOLT)

The Test of Logical Thinking (TOLT) was used to determine students' reasoning ability. It was originally developed by Tobin and Capie (1981) and translated and adapted into Turkish by Geban, Aşkar and Özkan (1992; Appendix D). The TOLT contains ten items measuring five reasoning modes. These are proportional reasoning (Items 1&2), controlling variables (Items 3&4), probabilistic reasoning (Items 5&6), correlational reasoning (Items 7&8), and combinatorial reasoning (Items 9&10). Items 1-8 have two parts that students have to give right answers both parts to get 1 point. In the items 9 and 10, a subject needs to be list all the possible combinatorial reasoning for 1 point. Total score of the test is 10. Its reliability was found as .81. In this study, reliability of the TOLT was found to be .63.

3.3 Variables

There are two types of the variables in this study: the dependent variable and the independent variable.

3.3.1 Dependent Variable

In this study, two variables were dependent variables: students' ecological concepts test scores and students' attitude towards science scores. These scores were obtained by the instruments The Test of the Ecology Concepts (TEC) and The Attitude Scale towards Science (ASTS) respectively.

3.3.2 Independent Variable

In this study, there were two independent variables: students' test of logical thinking (TOLT) scores and gender. TOLT was considered as continuous variable and measured on interval scale. TOLT scores are used as covariate. Gender was considered as discrete variable and it was measured on nominal scale.

Characteristics of the variables were summarized in the Table 3.2

Table 3.2 Characteristics of the variables

Type of Variable	Name	Type of value	Type of Interval Scale
DV	TEC	Continuous	Interval
DV	ASTS	Continuous	Interval
IV	TOLT	Continuous	Interval
IV	Gender	Discrete	Nominal

3.4 Interview with Students

Ten students from an elementary school in Tosya in the fall semester of 2005-2006 were selected for the interview. These ten students were chosen according to

previous science grade obtained from their teachers; 3 from high achievers (grade= 5), 4 from medium achievers (grade= 3-4) and 3 from low achievers (grade= 2).

The interviews were conducted at the end of the study in order to investigate students' misconceptions concerning ecological concepts deeply. A semi-structured interview schedule was used. Interview questions covered 5 main concepts; basic ecological concepts, food chain, food web, energy pyramid and energy flow. Each interview lasted about 25 minutes duration. During the interview sessions, notes were taken and a tape recorder was used.

3.5 Procedure

Design of the study was survey since students' misconceptions about ecology were identified and students' reasoning ability and attitude towards science were investigated. The study started with a detailed review of the literature. After determining a keyword list, the researcher searched Dissertation Abstracts International (DAI), Social Science Citation Index (SSCI), Educational Resources Information Center (ERIC), Ebscohost and search engine Google were searched systematically. After searching of works done abroad, the studies made in Turkey were searched from YÖK, Hacettepe Eğitim Dergisi and Eğitim ve Bilim Dergisi. The photocopies of the available documents were taken from METU library, library of Bilkent University and TUBİTAK Ulakbim. All of the documents obtained were read. After the reviewing the literature, some items of the ecology concept test were determined to change. Before conducting TEC, it was examined by two science teachers and science educators for establishing the content validity. Results of the study were analyzed and evaluated and necessary changes were done.

3.6 Descriptive Statistics

The mean, median, mode, standard deviation, skewness, kurtosis and range of the total score of TOLT, ASTS, TEC are found. A description and frequencies of misconceptions are also presented in descriptive statistics.

3.7 Inferential Statistics

The inferential statistics of this study performed by using statistical package program for social sciences (SPSS).The significance level was set to the .05 because it is mostly used value in educational studies.

In order to test the hypotheses, Multivariate Analysis of Covariance (MANCOVA), statistical technique, was used to see the effect of gender on students' understanding of ecological concepts and attitude toward science when the effect of reasoning ability is controlled.

3.8 Assumptions and Limitations

3.8.1 Assumptions

1. Test was administered under standard conditions.
2. Students answered test questions seriously.
3. Duration was assumed to be enough for answering all questions in each instrument.

3.8.2 Limitations

1. The study was restricted to some ecological terms.
2. The sample of this study was limited to public schools. This sample was not the good representation for students in the private school.
3. The subjects in the interview were restricted to 10 8^{th} grade students.

CHAPTER 4

RESULTS

In this chapter, the results of descriptive statistics related to the students' understanding of ecology measured by the Test of Ecology Concepts (TEC), the reasoning ability measured by the Test of Logical Thinking (TOLT) and attitude towards science measured by Attitude Scale towards Science (ASTS), results of the inferential statistics of testing 2 null hypotheses, the results of the interviews and a brief summary of the findings are given by means of the four different sections.

4.1 Descriptive Statistics

Descriptive statistics of the Test of Ecological Concepts scores (TEC), Test of Logical Thinking (TOLT) scores, and Attitude Scale towards Science (ASTS) scores were given in Table 4.1.

Table 4.1 Descriptive statistics related to the scores of TEC, TOLT, and ASTS.

	N	Mean	Std. Dev	Mode	Skewness	Kurtosis
TEC	600	4.03	2.5	2	0.65	-.04
TOLT	600	2.05	1.8	1	1.5	3.0
ASTS	600	55.5	8.5	54	0.9	-.03

As seen from the Table 4.1 that the mean of TEC is very low (M=4.03). Most of the students answered 2 items correctly out of 19. Students' scores in TEC range from 0 to 13.

Students' scores in TOLT range from 0 to 2. Only one item out of 10 was answered correctly by the most of the students. The mean of the TOLT score is 2.05 which indicates very low level of reasoning ability as seen in figure 4.1.

As shown in Table 4.1, the mean of the ASTS scores is 55.5 that implies that most students have positive attitude towards science. In the figure 4.1 a frequency of attitude scores has normally distributed but understanding of ecological concepts scores has right skewed distribution indicating a low level of knowledge about the ecological concepts.

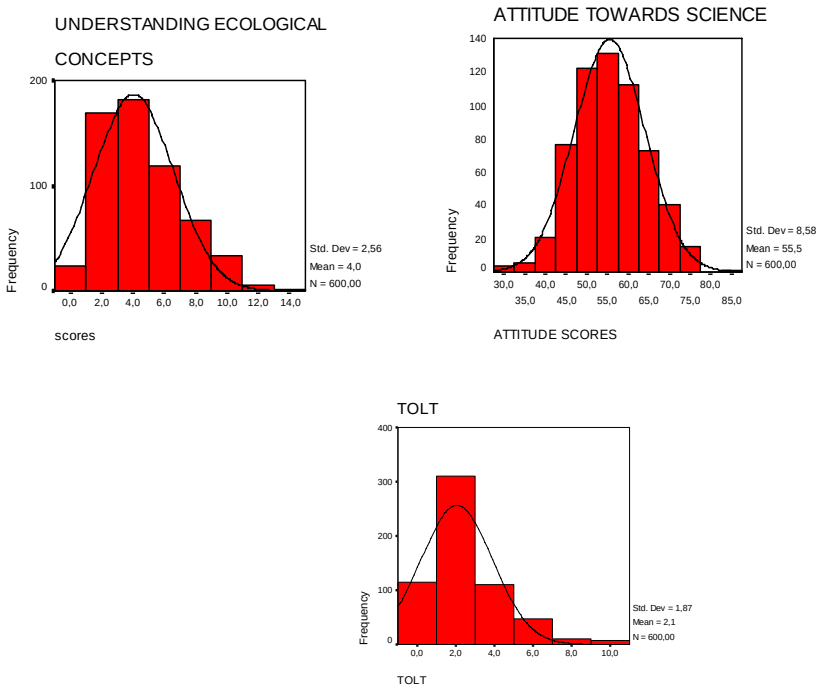


Figure 4.1 Frequencies of understanding of ecological concepts scores, attitude scores towards science scores and test of logical thinking scores

4.1.1 Descriptive statistics of the TEC

In the Test of Ecology Concept, each item has three tiers. First tier is the content question and the second tier presents a set of reasons for the given answer in the first tier. The last tier asks the student whether he/ she is sure or not for the given answers for the first two tiers.

Students' responses to TEC were analyzed and scored according to four types of understanding that are complete understanding, partial understanding, lack of understanding and misconception. Table 4.2 shows distribution of students and their points according to types of understanding.

Table 4.2 Distribution of students and their points according to types of understanding

Types of Understanding	Points	Number of Students
Complete Understanding	26	1
	24	2
	22	3
	20	15
	18	17
	16	26
	14	42
	12	55
	10	64
	8	88
	6	93
	4	96
	2	72
	0	26
Partial Understanding	9	1
	6	3
	5	7
	4	15
	3	60
	2	101
	1	163
	0	250

Table 4.2 Continued

Types of Understanding	Points	Number of Students
Lack of Understanding	9.5	22
	9	61
	8.5	93
	8	91
	7.5	80
	7	62
	6.5	55
	6	42
	5.5	25
	5	17
	4.5	15
	4	3
	3.5	2
	3	9
	2	5
	1	7
	0	11
Misconception	19	250
	18	164
	17	100
	16	59
	15	15
	14	8
	13	3
	10	1

Types of understanding were calculated for item 7 related to decomposers that is one of the most common misconception. Moreover, interpretation of the Table 4.2 is given below.

1. Complete Understanding: In item 7 related to decomposers, 14.7% students gave the correct response for both first and second tier, then chose the 'I am sure' alternative in the third tier, they took 2 points. Table 4.2 shows that only one student who has complete understanding gave desired answers to all 13 items in TEC.

2. Partial Understanding: In item 7, 6 % of the students were not sure in the third tier although choosing right answers in the first and second tier. They took

one point. The highest point is 9 that only one student took according to TEC results and 250 students were sure what they chose as seen in Table 4.2.

3. Lack of Understanding: 36.2 % of the students' responses for one of the tiers or both are false in item 7 and they are not sure for the first two tiers, they took half point. Table 4.2 shows that 22 students have the highest points in lack of understanding.

4. Misconception: 43.1 % of the students' responses for one of the tiers or both are false in item 7 and they are sure for the first two tiers, they took zero point. As seen in the Table 4.2, 250 students were sure for the first two tiers of 19 items though they failed to give right responses for one of the tiers or both.

The percentages of the students' correct answers for each item and each tier are given in Table 4.3 and Figure 4.2. For the first tier percent of the answers for most of the items are high. The percentage of correct response ranged from 19% to 92.2% (M=55.8%). For the first and second tier were combined, the percentage of correct response was reduced the range of 6.6% to 78.5% (M=27%). When all three tiers combined in terms of correct and sure responses, the range was 3.6% to 75.5% (M=21.2%).

Table 4.3 Percentages of 8th grade students' content knowledge, its reason and their confidences for the first two tiers.

Items	1st Tier (%)	Combination of first two tiers (%)	Combination of all three tiers (%)
1	92.2	78.5	75.5
2	44.5	24.5	20
3	19	6.6	3.6
4	59.2	52	48
5	79.5	37.2	29.8
6	66.3	24	15.6
7	87	20.8	15
8	42.3	24.6	17
9	56.3	25.5	22
10	40.5	15.2	9.1
11	22.6	13.2	11.8
12	22.3	17.8	15.6
13	55.6	43.2	33.1
14	78.3	41.5	28.1
15	59.3	8.5	4.2
16	60.2	26.3	18.3
17	50.8	12.6	7.6
18	67.8	32.3	22.6
19	56.8	10.3	5.6
Average	55.8	27	21.2

In Figure 4.2, students' desired responses for the first tier, combination of first two tiers and combination of all three tiers for all items can be seen clearly.

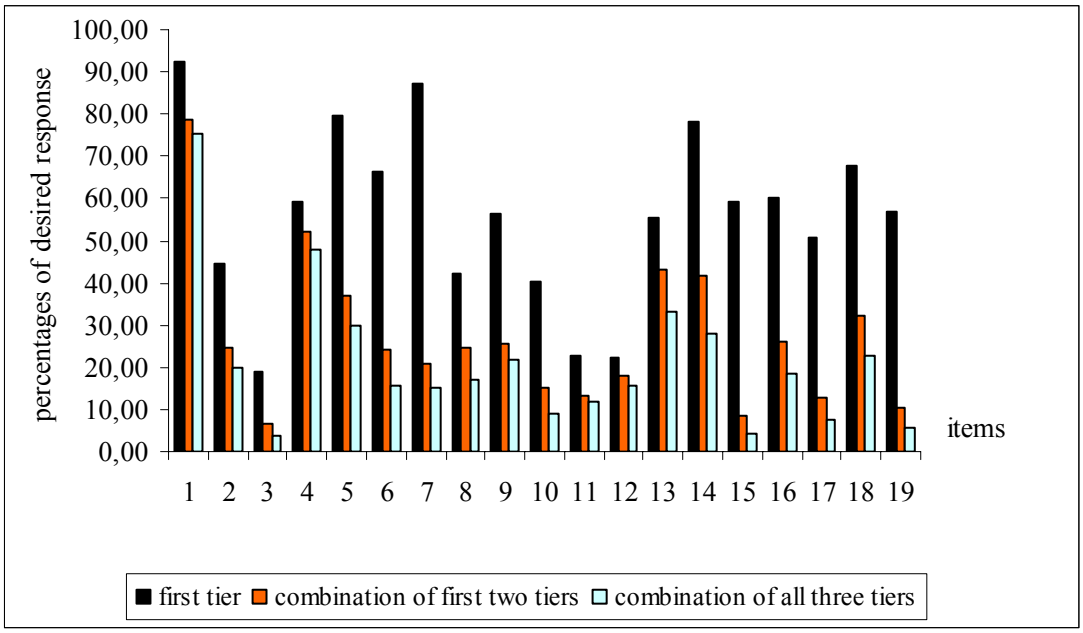


Figure 4.2 Distribution of the students' desired responses of the three tiers for all items

Table 4.4 shows the students' misconception identified through Test of Ecology Concepts and the percent of misconception. Only the misconceptions higher than 5% were listed in Table 4.4

Table 4.4 A list of students' misconceptions identified through test of ecology concepts

Misconception	Item Number	Percent
A. Basic Ecological terms		
1. The number of people in Turkey is an example of population because population is group of people in a certain area.	2	5
2. The number of people in Turkey is an example of population because population is the group of the member of species in a certain area.	2	5.3
3. Decomposers are important for ecosystem because they are found on dead animals.	7	5.7
4. Decomposers are important for ecosystem because they eat dead plants and animals to keep environment clean.	7	34.8
B. Energy Sources in Ecosystem		
1. The energy source for plants is soil because plants grow in soil.	4	13.2
2. The energy source for plants is air because they use the gases in air to get energy.	4	7.3
3. There is a relationship between plants and animals with respect to energy because animals eat plants.	5	19.5
4. There is relationship between plants and animals with respect to energy because both plants and animals have their own energy.	5	7.3
5. There is relationship between plants and animals with respect to energy because animals are stronger than plants and they have their own energy.	5	5.2
6. There is no relationship between plants and animals with respect to energy because both animals and plants have their own energy.	5	5

Table 4.4 Continued

Misconception	Item Number	Percent
C. Food Chain		
1. A bacterium inside the human body is a part of food chain because bacterium decomposes lifeless body, break into mineral.	6	12.3
2. A bacterium inside the human body is not a part of food chain because bacterium feed on our body.	6	5.3
3. Food chain is a kind of feeding including different food materials because it is consisted of proteins and vitamins found in foods.	8	15.2
4. Food chain is the transfer of energy from one living to another because food chain exists when an animal eats a plant.	8	5.5
5. Nectar, butterfly and bird are constituents of a food chain because a bird eats others due to being stronger than others.	10	7.8
6. Nectar, butterfly and bird are not constituents of a food chain because nectar is food of butterfly.	10	9.2
7. Nectar, butterfly and bird are not constituents of a food chain because nectar is not a plant.	10	14.8
8. Nectar, butterfly and bird are not constituents of a food chain because nonliving things are not in the food chain.	10	6.7
D. Notion of Energy		
1. In a food chain including plants, insect, chicken and man, energy does not pass from one living thing to another because every living thing has its own energy.	9	13.7
2. In a food chain including plants, insect, chicken and man, energy flows through man to plant because man has the greatest energy.	9	7.8
3. In a food chain including plants, insect, chicken and man, energy flows through plant to man because man does not give energy to anything.	9	8.2
4. In a food chain including grass , sheep and man, man has the greatest energy because man is stronger and has more energy	11	16

Table 4.4 Continued

Misconception	Item Number	Percent
5. In a food chain including grass, sheep, and man, man has the greatest energy because he gets his energy both from grass and sheep.	11	32.2
6. In a food chain including grass, sheep and man, man has the greatest energy because meat is a powerful energy source and nutritious food for man.	11	5.7
7. Among lion, rabbit and man, lion is the primary consumer because lion is the wild and strong animal.	12	8.7
8. Among lion, rabbit and man, lion is the primary consumer because lion is a carnivore.	12	8.7
9. Among lion, rabbit and man, man is the primary consumer because he consumes everything.	12	39.7
10. In an energy pyramid, man occupies the base because the number of man highest in nature.	13	6.3
11. In an energy pyramid, consumers occupy the base because they have the greatest energy.	13	7.8
E. Food Web		
1. In a food web, a change in one population will only effect another population if two population are directly related as predator and prey.	14	12.8
	16	7.1
	17	7.8
	18	5.8
	19	11.9
2. A population located higher on a given food chain within a food web is a predator of all populations located below it in the chain.	15	6.25
	18	10.8
3. A change in the size of a prey population has no affect on its predator population.	14	5.5
	16	6.7
	15	6.3
4. If the size of one population in a food web is altered, all other populations in the web will be altered in the same way.	15	19.3
	19	9

As a summary, students have many misconceptions about basic ecological concepts such as energy sources in ecosystem, notion of energy, food chain and food web. The highest misconception is related to primary consumer, students thought that among lion, rabbit and man, man is the primary consumer because man consumes everything (39.7%), which shows students can not differentiate consumers. Moreover, 34.8% of the students have problem about the role of decomposers in ecosystem because they consider that they eat dead plants and animals to keep environment clean. In item 11 related to energy, 32.2% of students chose that in a food chain including grass, sheep, and man, man has the greatest energy because he gets his energy both from grass and sheep. Students thought that energy is adding up so man has the greatest energy. Moreover, 19.5% of the students stated that there is a relationship between plants and animals with respect to energy but they assume that this relationship depends on food not energy. Most of the students fail to answer the question 14, 15, 16, 17, 18 and 19 concerning food web. They thought that in a food web, a change in one population would only effect another population if two populations were directly related as predator and prey. This shows that students do not understand prey, predator and the relationship between them clearly. Also, they assumed 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 and they thought that 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.

4.1.2 Descriptive Statistics of TOLT

The Test of Logical thinking (TOLT) was used to determine formal reasoning of students. The TOLT contains ten items measuring five reasoning modes. These are proportional reasoning (Items 1&2), controlling variables (items 3&4), probabilistic reasoning (Items 5&6), correlational reasoning (Items 7&8), and combinatorial reasoning (Items 9&10).

The frequencies and percentages of students with respect to five reasoning modes can be seen in the Table 4.5. Most of the students have high combinational reasoning ability (49.1%) but they have low correlational (8.3%) reasoning ability.

Table 4.5 Frequencies and percentages of students with respect to five reasoning modes

Reasoning mode	Item	f	%
Proportional	1	145	24.3
Proportional	2	80	13.3
Total		225	18.75
Controlling variables	3	103	17.7
Controlling variables	4	88	14.7
Total		191	15.9
Probabilistic	5	79	13.3
Probabilistic	6	41	6.8
Total		120	10
Correlational	7	50	8.3
Correlational	8	50	8.3
Total		100	8.3
Combinational	9	338	56.3
Combinational	10	252	42
Total		590	49.1

A clear picture can be seen in Figure 4.3 which shows the distribution of each item and their frequencies.

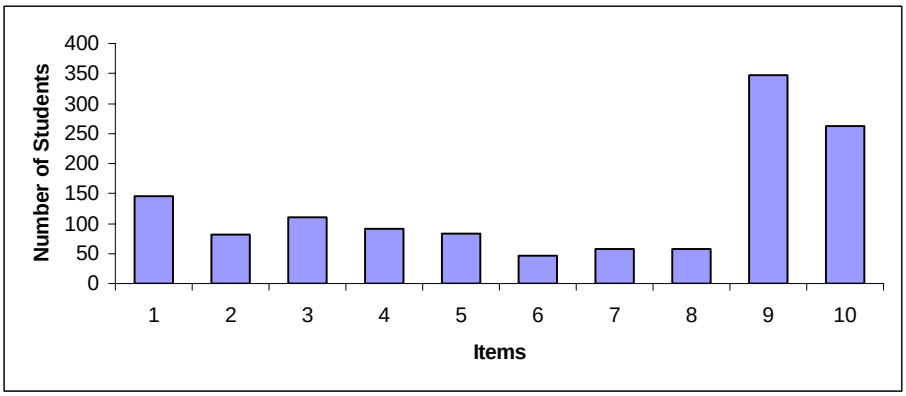


Figure 4.3 Distribution of students' TOLT scores

TOLT scores are also classified into three formal reasoning levels; low (scores from 0 to 3), medium (scores from 4 to 7) and high (scores from 7 to 10). Table 4.6 shows the distribution of students with respect to levels of formal thought. This table indicates that 533 students (88.8%) have low formal reasoning ability, 57 students (9.5%) have medium formal reasoning ability and 10 students (1.6%) have high formal reasoning ability. The majority of students have low formal reasoning ability.

Concerning gender difference, the number of the girls is slightly higher than boys at low formal reasoning ability, but the number of boys at medium formal reasoning ability is higher than girls at the medium formal reasoning ability and a few boys (4) and girls (6) have high level of formal reasoning level.

Table 4.6 Distribution of students with respect to level of formal thought

	Formal Reasoning Level (N)			
	Low	Medium	High	Total
Boys	249	34	4	287
Girls	284	23	6	313
Total	533	57	10	600

Descriptive statistics for the gender and reasoning ability with respect to understanding of the ecological concepts and attitude towards science are summarized in Table 4.7. As seen in the table, students at high level reasoning ability have higher mean understanding of the ecological concepts. Girls at the high, medium and low formal level have slightly higher mean of understanding of the ecological concepts than boys at the high, medium and low level reasoning ability as seen in the Figure 4.4. Mean of attitude scores of girls is higher than boys at low and medium level reasoning ability; thus, girls at low and medium level reasoning ability have more positive attitude towards science than boys at low and medium level reasoning ability but boys at high level reasoning ability have more positive attitude than girls at high level reasoning ability. Mean of attitude scores of girls is lower than boys at higher level reasoning ability. This pattern can be seen clearly in the Figure 4.5

Table 4.7 Descriptive statistics for the gender and reasoning ability with respect to understanding of ecological concepts and attitude

	Low		Medium		High		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Attitude								
Boys	53.9	8.24	58.4	8.88	65.7	4.3	54.6	8.48
Girls	56.1	8.6	59.5	6.5	61.2	8.4	56.4	8.5
Total	55.1	8.5	58.8	7.9	63.0	7.1	55.5	8.5
Understanding								
Boys	3.4	2.3	4.7	2.5	5.7	0.95	3.6	2.3
Girls	4.3	2.7	5.3	2.2	6.0	2.4	4.4	2.6
Total	3.8	2.5	4.9	2.4	5.9	1.9	4.0	2.5

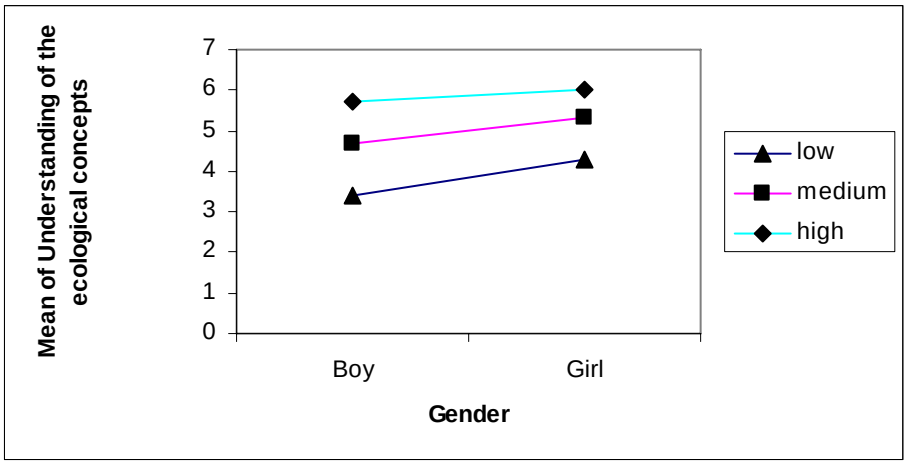


Figure 4.4 Understanding of the ecological concepts profiles of low, medium, high level students across gender

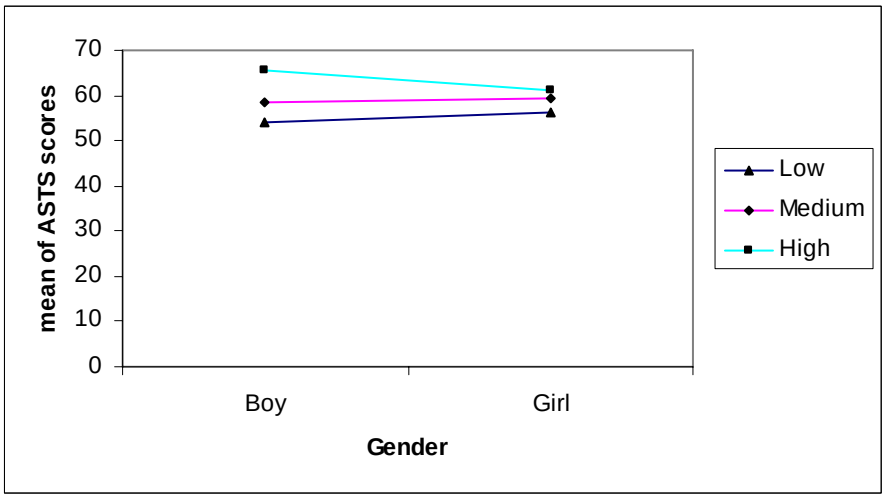


Figure 4.5 Attitude profiles of low, medium, high level students across gender

4.2 Inferential Statistics

Multivariate Analysis of Covariance (MANCOVA) performed to investigate the effect of gender on students' understanding ecological concepts and attitude toward science when the effect of reasoning ability is controlled. Statistical analysis was performed at .05 significance level using Statistical Package for Social Sciences (SPSS). Two dependent variables were used: scores of ecology concept test and attitude scale towards science. The independent variable was gender. Reasoning ability was used as covariate. As seen in Table 4.8 and Table 4.9, there were correlations among dependent variables and independent variables, and between independent variables.

Table 4.8 Significance test of correlation between independent variables and dependent variables

Variables	Correlation Coefficients	
	ATTITUDE	UNDERSTANDING
ATTITUDE		.215
UNDERSTANDING	.215	
GENDER	.106	.157
TOLT	.172	.278

*Correlation is significant at the 0.05 level (2-tailed).

Table 4.9 Significance test of correlation between independent variables

Variables	Correlation coefficients	
	GENDER	TOLT
GENDER		.39
TOLT	.39	

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

Assumptions were tested to check for normality, homogeneity of regression, equality of variances. For normality assumption, skewness and kurtosis values for the dependent variables were checked. The skewness and kurtosis values of the variables were approximately in an acceptable range for normal distribution as seen in descriptive statistics section.

Homogeneity of regression assumption means that the slope of the regression of a DV on a covariate must be constant over different values of group membership. Table 4.10 indicates the results of Multivariate Regression Correlation (MRC) analysis of homogeneity of regression. As seen in Table 4.8, homogeneity of regression assumption is validated for this model.

Table 4.10 Results of the MCR analysis of homogeneity of regression

Model	Change Statistics				
Understanding	R Square Change	F Change	df1	df2	Sig. F Change
TOLT	.077	50.199	1	598	.000
Attitude TOLT	.029	18.175	1	598	.000

Table 4.11 indicates the Box's M Test of Equality of Covariance Matrices. As seen from the table, the observed covariance matrices of the DVs were equal across groups.

Table 4.11 Box's M test of equality of covariance matrices

Box’s M	4.733
F	1.572
df1	3
df2	84437201
Sig	.194

Levene's Test of Equality was used to determine the equality variance assumption. Table 4.12 shows that the error variances of the selected DVs across groups were equal.

Table 4.12 Levene's test of equality of error variances

	F	Df1	Df2	Sig
Attitude	.048	1	598	.828
Understanding	6.03	1	598	.014

Hypothesis of the study:

There is no significant main effect of gender on the population means of understanding of ecological concepts and attitude towards science when the effect of TOLT scores is controlled.

This hypothesis was tested by MANCOVA. Table 4.13 shows that there was statistically significant gender difference in favor of girls with respect to collective dependent variables when the effect of TOLT scores controlled (Wilks' Lambda=0.97; p=.00). Eta squared represents the proportion of variance of the dependent variable. Values for eta squared can range from 0 to 1. Effect size (eta square) of gender is small, effect size of TOLT is high. Sample size of this study (N=600) is higher than 100 so power is not an issue.

Table 4.13 MANCOVA results

Source	Wilks' Lamda	Hypothesis df	F	Sig (p)	Eta-Squared	Observed Power
Intercept	.51	2	5566.99	.000	.949	1
GENDER	.971	2	8.893	.000	.029	.97
TOLT	.911	2	29.253	.000	.089	1

In order to test the effects of covariate on each dependent variable, a univariate analysis of covariance (ANCOVA) was conducted as follow-up tests to the MANCOVA. Table 4.14 shows gender difference is effective on both attitude towards science and understanding ecological concepts. Table 4.14 also indicates that TOLT has significant effect on understanding and attitude.

Table 4.14 Test of between subject effects

Source	Dependent Variable	df	F	Sig.	Eta Squared	Observed Power
Corrected Model	Attitude	2	12,239	.000	.039	.996
	Understanding	2	32.784	.000	.099	1.000
Intercept	Attitude	1	11130.297	.000	.949	1.000
	Understanding	1	481.124	.000	.446	1.000
TOLT	Attitude	1	17.485	.000	.028	.987
	Understanding	1	49.145	.000	.076	1.000
GENDER	Attitude	1	6.147	.013	.010	.697
	Understanding	1	14.256	.000	.023	.965
Error	Attitude	597				
	Understanding	597				
Total	Attitude	600				
	Understanding	600				

a Computed using alpha = .05

4.3 Result of interviews

Interview sessions were conducted individually with ten 8th grade students to reveal reasons behind the students' misconception. Interview questions covered environment, specious, populations, ecosystem, biosphere, producers, consumers, decomposers, energy pyramid, energy flow, food chain and food web topics.

1. Definition of environment and interpretation of the living and non living things

Most of the students define environment as a place where living and non-living things live. Some of the students said that environment is a place that people, animals and plants live, they do not consider non-living things in the environment. Most of the students differentiate living things from non-living things. While most of them explain the relationship between living and non-living things, some of them have misconception about how they are related, for example, two of the students said:

‘‘Living things take energy from non-living things like plant that takes water from soil.’’

They thought that soil is the energy source of plant. On the other hand, one student considered nonliving and living things relationship as a nutrient cycling, for instance, she said:

‘‘Living things die, decompose into minerals and plants take minerals, animals eat plants.’’

She did not consider energy relationship. Some of the students who have low grades have no idea about the relationship between the living things and non-living things.

It can be said that most of the students define the environment correctly. This result was consistent with the TEC scores. On the other hand, some of the students have misconceptions about the relationship between living and non-living things. While some of them know partially, some of them have no idea.

2. Definition of some ecological conceptions

When asked what the species is, two of the students said that they had no idea about species and seven of them said that it is a type. They remembered everyday language meaning of species not the scientific meaning. While only one of the students defined species as variety in living things, she said that she did not remember much more so she could not give an example for species. Moreover, when asked what the population is, students’ response showed that they have

misconception or lack of knowledge. Students confused population with the human population that is the popular saying; for example, three of the students stated:

‘‘Population is the number of people.’’

Also, most of the students said that they did not know what the population is. When asked whether the population and species are similar things, four students stated that they were not same and they explained this with different reasons whereas six of them said that they did not know; for instance,

‘‘Species is a kind whereas population is human population.’’

‘‘I do not know whether the population and species are similar things’’

Next question is about ecosystem. Except one student who said he did not know the definition of the ecosystem, all of the students gave response for this question. Five students out of ten defined ecosystem as ecologic balance and arrangement in nature. Only one student gave the desired response and he explained ecosystem is the interrelationship between living and non-living things. While one of the students remembered ecosystem as a food chain of the world like snake eats frog, others remembered pollution that affects balance of ecosystem or style of living as ecosystem. Some of the students’ responses;

‘‘Ecosystem is balance and arrangement in nature.’’

‘‘Ecosystem is the interrelationship between living and non-living things.’’

‘‘Ecosystem is the food chain of the world; snake eats frogs.’’

When students were asked what biosphere is and whether different ecosystems constitute biosphere, only two of the students gave answer that biosphere is earth and different ecosystem constitute biosphere. However, others could not give any response; thus, most of the students have no idea about biosphere.

3. Energy and Energy Source

When interviewer asked how you could describe energy, students gave different responses, for example, one student said that men get energy from food they

eat and another described energy as it is the thing that provides our movement. Also, some of the students defined energy as

‘‘Amount of materials in living and non-living things.’’

Moreover, some of the students explained that sun or soil are the source of energy in the nature while others stated that they did not know for the source of energy in the nature. For the question of how living things use sun as energy, three students failed to response this question and others explained that plants use energy by taking water from soil or photosynthesis and men use sun as heat. Moreover, two of the students explained that plants get energy from soil and animals eat plants so animals get energy. For the question about the relationship between animals and plants in terms of energy, one student replied:

‘‘There is no relationship between animals and plants since plants get energy from rain; animals get energy from what they eat.’’

As a summary, students’ responses to the questions revealed the presence of misconceptions among students concerning source of energy. Most of the students thought that foods eaten or soil were described as source of energy. Some of the students said that sun is the source of energy but men get this energy as heat. In addition, some explained that plants get energy from soil and rain and animals get energy from plants. As a result, students’ answers indicated that students had misconception about energy and energy source.

4. Food chain

When asked definition of food chain, students gave different responses. Students thought food chain as eating order or food. They confused food with the popular saying. Their response showed that they have misconception about food chain; for example, some of the students stated:

‘‘Different foods coming together constitute food chain.’’

‘‘Strong animals eat weak animals’’

‘‘Animals eating each other are called food chain.’’

In the second question, students were asked to draw a food chain and show the consumers on it. One of the students drew as figure 4.6 and stated first consumer is a cow that eats producers. Second consumer that eats first consumer is lion. When asked the reasons of the starting a plant to food chain and which one has the most energy, she explained that flowers are producers which produce their food by photosynthesis and flowers has the most energy. From her drawings, it is concluded that she thought food web as a simple of food chain and she drew a cyclic food chain. Other students drew a linear food chain as men→food→energy. They thought that man is the consumer and because of stating man first in their food chain drawings, they believed that food has the most energy so man eats food to get energy. Some of the students defined food chain as producer→ first consumer→ second consumer→ third consumer and stated that first consumer is herbivore, second consumer is carnivore and omnivore. They also said that plants give oxygen to air so it is producer.

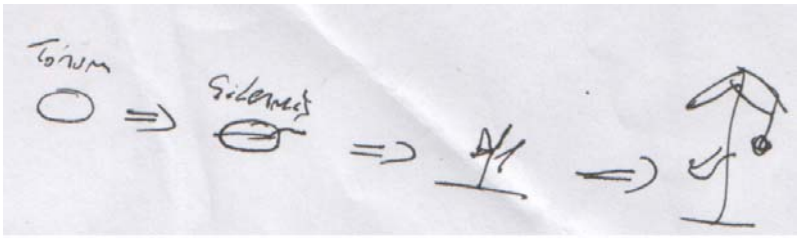


Figure 4.6 Food chain is a kind of germination of seed by student 4

As a result, students' responses to those questions indicated the presence of misconceptions among students concerning food chain. Students do not consider the food chain as a flow of energy through its members. Some students thought that food chain is a kind of feeding including different food material and also they thought that food has the most energy so they started with food. Some of them stated that energy

is transferred from weak animals to strong animals and man has the most energy. While most of the students started with a plant or producer to food chain, others started with animal or man. Whereas one of the students drew the food chain as a cycle (figure 4.7), others drew a linear chain. One of the students confused germination of seed with food chain as seen in the figure 4.6. To sum up, students have many misconceptions about food chain.

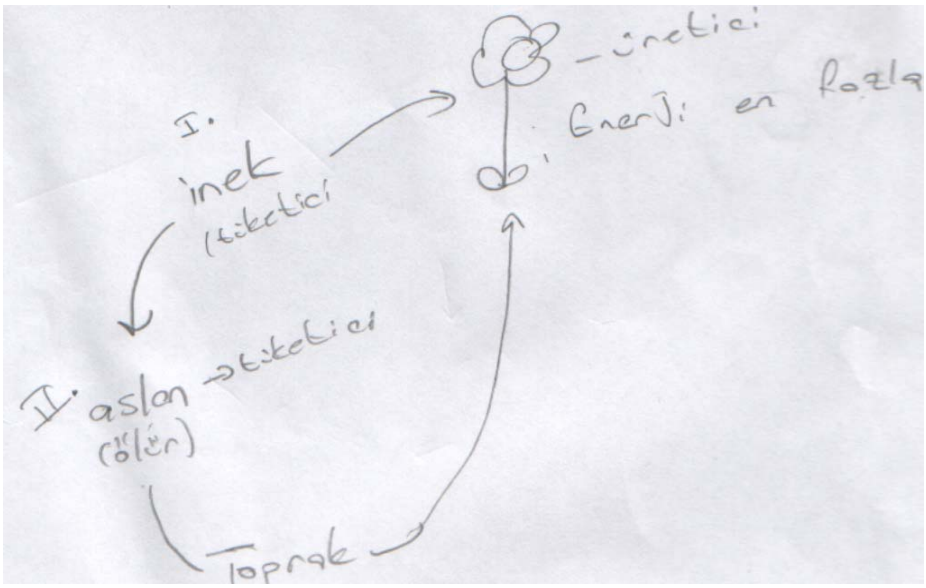


Figure 4.7 Food chain as a cyclic chain by student 1

In the next question about food chain, interviewer asked if nectar, butterfly and bird are constituents of a food chain and the reasons behind this. Most of the students said that they are not constituents of a food chain because of many reasons. For instance, one of the reason is that butterfly can not eat nectar. Another reason is that nectar is not a producer; it is the part of the flower. Other reason is that there is no food for butterfly. Answers to this question revealed the some of students' misconception concerning food chain. Some thought that nectar could not act as a

producer because nectar is only the part of plant. Some of them do not know what the nectar is so they thought there is no food for butterfly.

In the last question students were asked whether a bacterium inside the human body is a part of food chain or not and what could be the reasons of this. One of the students responded ‘‘a bacterium inside the human body is a part of food chain because a bacterium eats other organisms’’ but other students said that a bacterium inside the human body is not a part of food chain since it decomposes organic materials into inorganic materials in the ecosystem. Other students explained the reason is that there is no producer. These answers indicated that students held many misconceptions concerning functions of bacteria in food chain. Most of the students thought bacteria as decomposer and they thought that food chain should be started with producers. Two students stated that food chain starts with a plant and there was no producer in our body so a bacterium inside the human body is not a part of food chain.

5. Energy pyramid

When asked about the Energy Pyramid, students gave different responses like:

‘‘A group of energy.’’

‘‘Order of energy.’’

‘‘A group of living things that constitutes energy pyramid.’’

Students do not have accurate meaning of energy pyramid. Although some of the students could not draw energy pyramids, most of the students drew energy pyramids correctly but labeled wrongly as seen in the figure 4.8, figure 4.9, and figure 4.10.

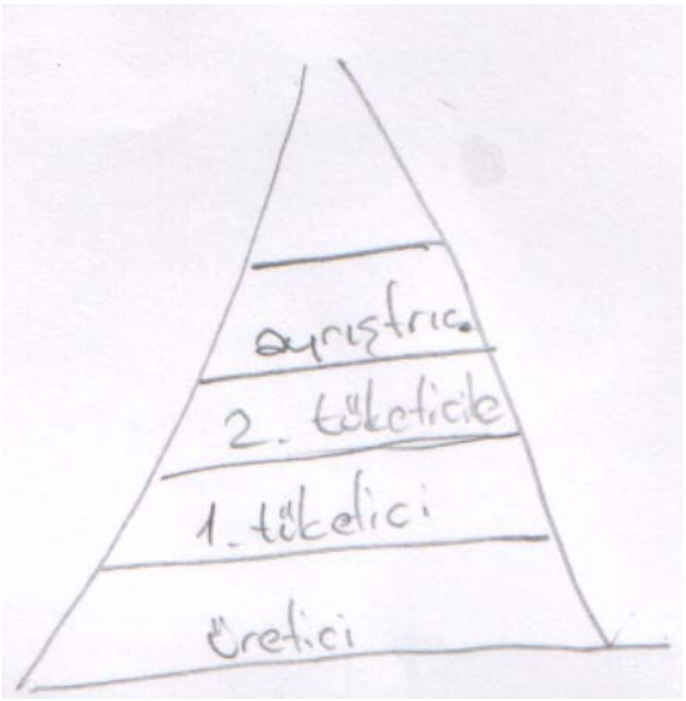


Figure 4.8 Drawing about energy pyramid indicating the producer, first consumer and decomposer by student 1

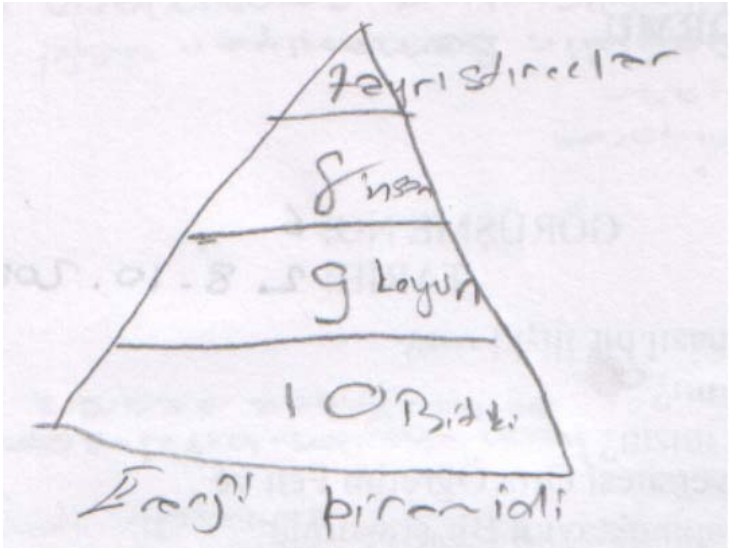


Figure 4.9 Drawing of energy pyramid indicating the number of organism by student 5

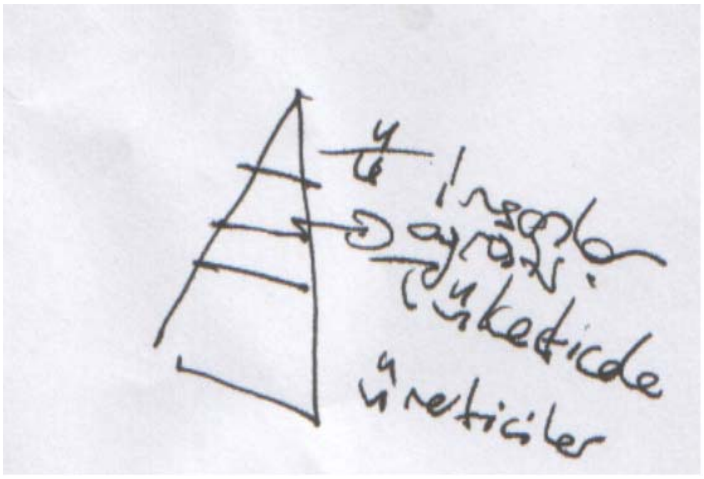


Figure 4.10 Drawing of energy pyramid by student 9

After energy pyramid was drawn, they were asked why they gave place for decomposers in the top of the energy pyramid. Only one student explained that they decompose all of them. Other students said ‘‘decomposers are very small and have very little energy so they located top of the energy pyramid’’. Others have no idea about this. Next question is that why the base of energy pyramid is larger than the top of energy pyramid or why the top of the energy pyramid is smaller than the base. Most of the students stated that the number of plants is very high so the base of the energy pyramid is larger than the top of the energy pyramid. They did not mention the amount of energy in their explanations.

To sum up, students’ responses to those questions indicated the presence of misconceptions among students regarding energy pyramid. Most of the students defined energy pyramid as group of energy or order of energy. While some of them could not draw an energy pyramid correctly, other drew it but identify its parts wrongly. They put decomposer at the top of the energy pyramid. They stated that the number of organism decreases from the base of the energy pyramid to the top so the base of the energy pyramid is larger than the top of the energy pyramid. As a result, all of these revealed that students had misconceptions about energy pyramid.

6. Food web

When asked about food web, one of the students expressed the circulation of materials. He thought that water evaporates from sea and ocean, condense in the atmosphere and rain to earth (Figure 4.11). On the other hand, only one student could draw food web in the land and water ecosystem but her drawings indicated food web as a simple cyclic food chain (Figure 4.12 and Figure 4.13). Other students, however, defined food web as the group of many foods. Students confused food web with food chain or materials cycling. However, most of the students failed to draw food web.

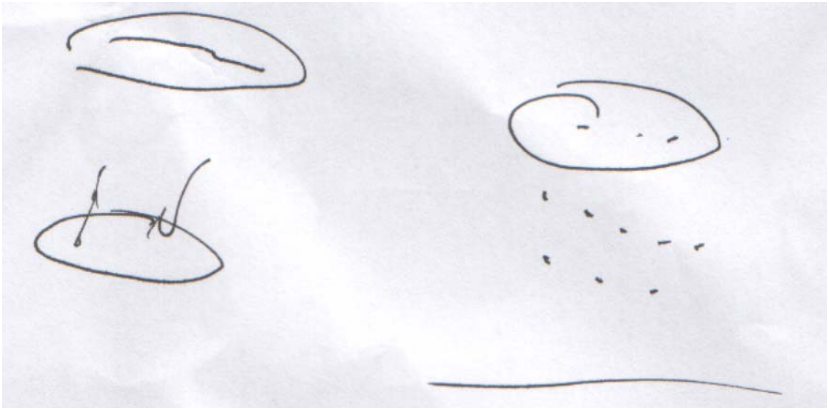


Figure 4.11 Drawing of food web by student 2

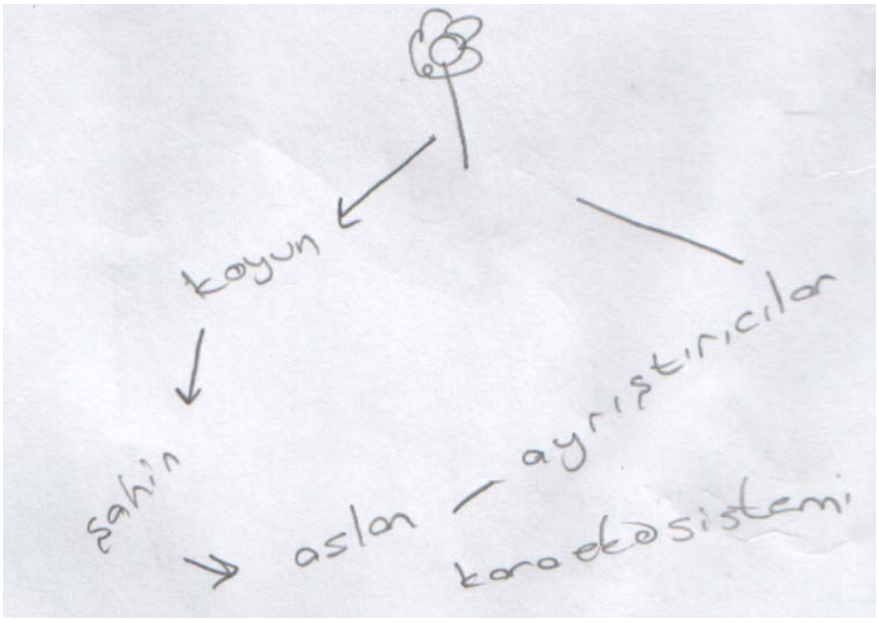


Figure 4.12 Drawing of food web in land ecosystem by student 1

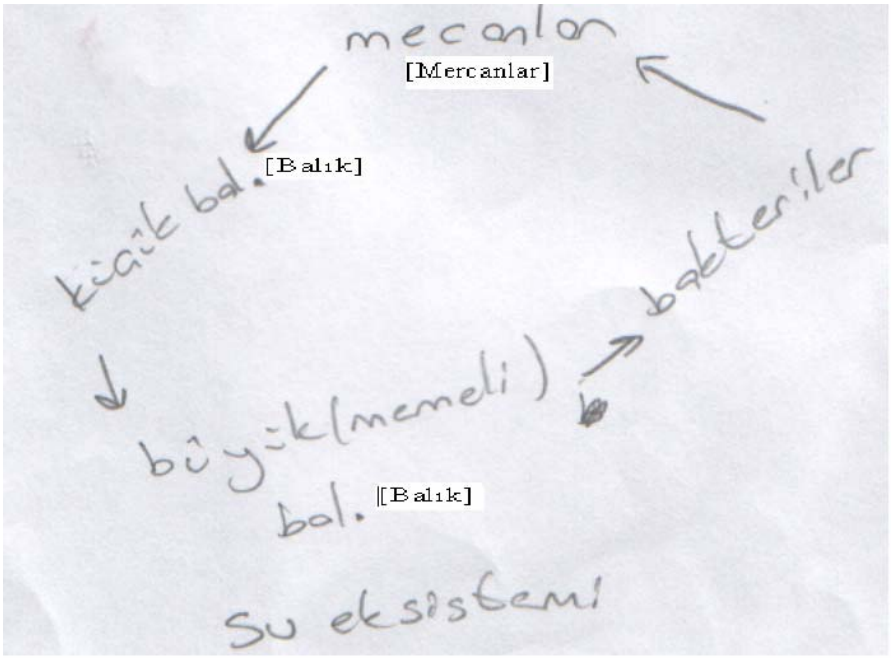


Figure 4.13 Drawing of food web in the water ecosystem by student 1

As seen in the drawings and students' responses, most of the students had no idea about food web or they had misconceptions about food web. Some students stated circulation of materials as food web; others had difficulty in differentiating the food chain from food web in construction of the food web.

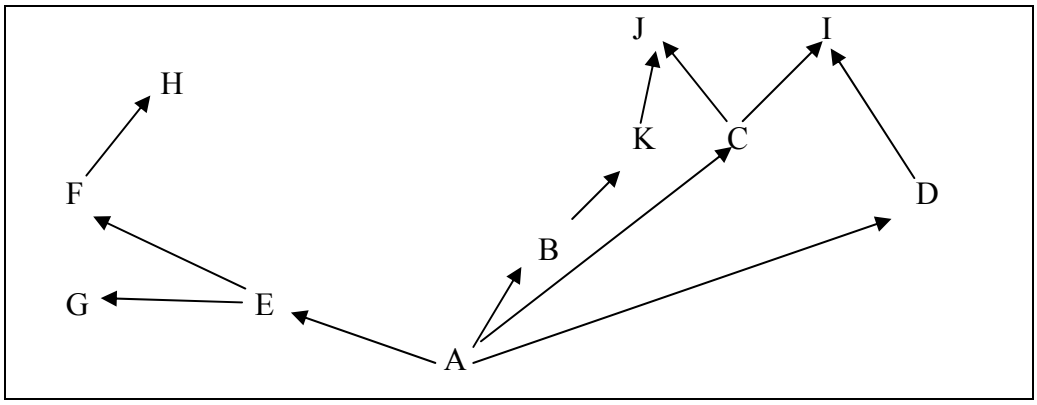


Figure 4.14 A sample of food web (Webb & Boltt, 1990)

When interviewer showed a sample of food web diagram (figure 4.14) and asked about the meaning and importance of direction of arrows, most of the students said that arrows indicate that big animals eats small animals and the direction of the arrows is not important. In addition, one of the students responded that direction of the arrows is not important and arrows show the food. On the other hand, some of the students said that they revealed the relationship; they thought that direction is important; for example, they said ''arrows show prey and predator''. Although most of the students described A as a producer, some of the students said that A is a plant or A is a soil when asked what A is.

Next question is about the effects of changing the environmental conditions in this food web (Figure 4.14). They were asked what happens to population **H** in figure 4.14 if there is a sudden decrease in population **F**. Some of the students explained

their answers as while **F** decreases, **H** increases whereas others responded that when **H** decreases, **F** decreases because **F** is the food of **H**. In the other question, students were asked whether sudden decrease in population **E** affects the population **H** or not (Figure 4.14) and how this happens. Some of the students stated that when **E** decreases, **H** does not change since population **E** affects **F** but it does not affect **H** though others answered that it does not affect **H** since there is no direct relationship. Similarly, they were asked if a sudden increase in population **G** affects the population **F** or not (Figure 4.14). One of the students said that **G** does not increase. Others stated that it does not affect since there is no relationship between them. In the last question, students were asked whether a sudden size change in population **A** affect the population **J** in Figure 4.14 and how, some of the students mentioned that a size change in population **A** does not affect **B**, **K** and **J**. Some other students stated that it does not affect because there is no direct relations. Other students said that when population **A** increases, population **B** decreases so population **K** increases and population **C** decreases because population **A** eats population **B**.

As a result, students' answers show that they had many misconceptions about food web. They could not differentiate prey population and predator population. They considered food chain inverted. Furthermore, they do not have ability to determine the effect of sudden size change in one population on prey and predator and non-adjacent population.

To sum up, results of interview are consistent with the results of TEC. Moreover, interview results show that students have many misconceptions and reasons of these misconceptions.

4.4 Summary of the Results

1. Based on the TEC results, students' responses were categorized as complete understanding, partial understanding, lack of understanding and misconceptions were examined. For example, in item 7 related to

decomposers, 14.7% of the students have complete understanding, 6% of the students have partial understanding, 36.2% of the students have lack of understanding and 43.1% of the students have misconceptions.

2. About 55.8% of the students have complete understanding in the first tier. 27% of the students have complete understanding in the combination of first two tiers and 21.2% of the students have complete understanding in the combination of the all three tiers.

3. The results of this study indicated that students have many misconceptions about basic ecological terms, food chain, food web, energy flow and source of energy according to results of TEC and interviews. For instance, according to TEC results, in item 7 related to decomposers, about 34.8% of the students have misconceptions the role of decomposers in ecosystem because they consider that they eat dead plants and animals to keep environment clean. In the interview, students located decomposers at the top of the energy pyramid and they explained reason of this that decomposers decompose all of the organisms below in the energy pyramid.

4. In item 11 related to energy flow, about 32.2% of students chose that in a food chain including grass, sheep, and man, and man has the greatest energy because he gets his energy both from grass and from sheep. In the interview, students stated reason that energy is adding up so man has the greatest energy.

5. In item 12 related to primary consumer, 39.7% of the students chose that among lion, rabbit, and man, man is the primary consumer because he consumes everything.

6. In item 5 related to energy, about 19.5% of the students stated that there is a relationship between plants and animals with respect to energy but they assume that this relationship depends on food but not energy.

7. During interview, new misconceptions were found; for example, students confused germination of seed or circulation of material with food web. Moreover, students drew food chain as cyclic chain not linear. Furthermore, students thought that energy pyramids show the number of organisms.

8. The mean of the TOLT score is 1.1 which indicates very low reasoning ability, the mean of the ASTS scores is 55.5 which implies that most students have positive attitude towards science and the mean score of TEC is 4.03 which shows very low understanding of the ecological concepts.

9. Most of the students have high combinational reasoning ability (49.1%) but they have low correlational (8.3%) reasoning ability.

10. There was statistically significant gender difference in favor of girls with respect to collective dependent variables when the effect of TOLT scores controlled (Wilks' Lambda=0.97; p=.00).

11. Female students had higher understanding of ecological concepts and more positive attitude towards science than male students when the effect of TOLT scores controlled.

CHAPTER 5

CONCLUSION, DISCUSSION AND IMPLICATIONS

This chapter of the study includes overview of the study, conclusions and discussion of the results, internal and external validity, implications of the study, and recommendations for further research.

5.1 Overview of the study

The main purpose of the study was to investigate students' understandings of ecological concepts and the effect of gender and reasoning ability on 8th grade students' understanding ecological terms and attitude towards science. In this study, Test of Ecology Concepts (TEC), Test of Logical Thinking (TOLT) and Attitude Scale towards Science (ASTS) were used to measure misconceptions related to ecological concepts, reasoning ability and attitude towards science respectively. TEC, TOLT, ASTS were administered to all 8th grade students in Tosya , the biggest district of Kastamonu.

TEC, three-tier tests, was developed based on the previous studies and administered in order to asses students' misconceptions related to ecological concepts. Statistical analyses were presented in chapter 4.

5.2 Conclusions and Discussion of the Results

The results of this study indicated that students have many misconceptions about basic ecological terms, food chain, food web, energy flow and source of energy according to results of TEC and interviews. Most of the students have

misconception about food web since students thought food web as a simple food chain. This can be seen easily in the students' drawings during the interview. Webb and Bolt (1990) reported that students aged 15-17 have difficulty in progressing from food chain to food web and had many misconception about food web than first year university students since food chain is thought as a simple set of isolated organisms so students have difficulty to understand food web. Another most common misconception about food web in this study is that a change in one population will only affect another population if the two populations are directly related as predator and prey. During interview, when asked the effect a change in one population on a second population in other part of the food web, students said ''if two population are too far apart, there is no effect'' or ''it does not affect since there is no direct relationship between population''. Gallegos (1994), Adeniyi (1985), Griffiths and Grant (1985) revealed the similar result and claimed that students overcome this difficulty in food web concept if food chains are thought as interactive population embedded in an ecological context. Moreover, students could not differentiate first consumer from second or third consumer; for example, when asked students to order lion, rabbit and man, most of them chose that man is the primary consumer because he consumes everything and man has the greatest energy. They thought that organisms higher in a food web eat everything that is lower in the food web and have more energy than lower in the food web. Griffiths and Grant (1985) supported our findings. Moreover, Adeniyi (1985) found the similar results and reported that Nigerian students aged 13-15 years believed that energy is adding up so man gets his energy from both cows and plants and has more energy. Adeniyi revealed that some of this misconception may have existed before instruction but a few of them appeared result from instruction. Our findings from interview was consistent with Adeniyi's results.

Results of TEC and interview also showed that students have many misconceptions about food chain; for instance, during interview students stated ''strong animals eat weak animals'', ''food chain is a kind of germination of seed'' and they drew food chain as a cyclic or linear. They considered part of plant like

flower, leaves is not producer and producer must be green; for example, nectar, butterfly and bird do not constitute food chain since student thought that there is no producer. They assumed that nectar is part of flower and green plants are only producers of carbohydrates in ecosystems. Moreover, a bacterium inside the human body is a part of food chain because a bacterium eats other organisms but other students said that a bacterium inside the human body is not a part of food chain since it decomposes organic materials into inorganic materials in the ecosystem. Students considered bacteria as the microscopic-sized bacteria to diseases when asked whether bacteria in the human body constitute a food chain as indicated by Eilam (2002). Eliam concluded that students' prior knowledge affects further learning as seen in the function of bacteria.

Findings of this study showed that students have difficulty to understand energy pyramid and energy source; for instance, most of the students believed that the source of energy for plants is soil since plant grow in soil. Bell (1985); Adeniyi, (1985); Smith and Anderson (1984) were reported the similar findings. Interview results supported TEC findings that students stated source of energy as ''soil since plants take water and mineral from soil ''. Moreover, students thought that the number of plants is very high so the base of the energy pyramid is larger than the top of the energy pyramid. Students' drawings indicated that decreasing numbers of organisms from the base to the apex of the energy pyramid since energy is abstract concepts so students could not see energy but they see organisms. Therefore, students labeled number of organism in the energy pyramid. Moreover, they believed that number of producers is higher than the consumers. On the other hand, Leach et al. (1996) found that the number of producers is high to satisfy consumers and there are more herbivores because people keep and breed them and humans provide food for other organisms.

Furthermore, most of the students have misconception about decomposers. They thought as decomposers that eat dead animals and plants to keep environment clean. Çığırgan (2000) reported reason of this that science textbook introduce

decomposers as garbage collector (as cited in Özkan et al., 2004). Also, most of the students gave place decomposers at the top of the energy pyramid during the interview since they believed that decomposers decompose everything and decomposers are very small and have very little energy so they located top of the energy pyramid. Moreover, Adeniyi (1985) found that students located decomposers at the top of the energy pyramid due to teacher's placement of decomposers in the top rung of the energy pyramid and maintained that one of the sources of students' misconceptions is teachers' misconceptions.

These results suggest that students brought their misconceptions to the class and most of the students only memorize scientific facts. They do not try to understand facts with reasons. Therefore, teachers ought to realize and identify students' misconceptions. Also, they should design their lesson to remediate these misconceptions.

The result of this study revealed that as a three-tier test, TEC provides us to categorize students' responses as complete understanding, partial understanding, lack of understanding and misconception; for example, in item 7 related to decomposers, 14.7% of the students have complete understanding, 6% of the students have partial understanding, 36.2% of the students have lack of understanding and 43.1% of the students have misconception. Furthermore, mean percentages of the first and combination of first two tiers are higher than the combination of all three tiers since third tier measures confidence of students for their response. About 55.8% of the students have complete understanding in the first tier. 27% of the students have complete understanding in the combination of first two tiers and 21.2% of the students have complete understanding in the combination of the all three tiers. Percentages of desired responses decrease when tier increases. Therefore, TEC, three-tier diagnostic test, is useful to identify students' misconceptions since misconceptions can be differentiated from lack of understanding, partial understanding and complete understanding. Also, TEC, three-tier diagnostic test, does not overestimate misconception.

Result of this study showed that there was statistically significant gender difference in favor of girls with respect to understanding ecological concepts and attitude toward science (Wilks' Lambda=0.97; p=0.00). This result is consistent with the previous studies (Alparsan, Tekkaya & Geban, 2003; Sungur & Tekkaya, 2003). For example, Sungur and Tekkaya (2003) found that girls have higher achievement and more positive attitude than boys. Moreover, Alparsan, Tekkaya & Geban (2003) indicated that a significant difference between performance of girls and that of boys in the favour of girls. On the other hand, this result is inconsistent with some of the previous studies (Clarke, 1972; Clark & Nelson, 1972; Kotte, 1992). They reported that boys have possessed more positive attitude in studying science than girls . According to Catsambis (1995), girls have less positive attitudes although they performed better than boys and got higher grades in science classes. Jones (2000) reported that girls have different experiences outside the school and this affects their attitude. However, Keeves and Kotte (1992) reported that there were no significant differences between males and females for biology. Osborne (2003) found reasons of gender difference as teacher, curricula, cultural and other variables; for example, in society there is a general silent belief that girls do not do science which affects students to determine the choice of science course. Therefore, teacher should pay attention not to introduce gender bias during instruction and there should not be gender bias in the design of the classroom environment. Curriculum and textbook should be examined whether gender difference present or not (Sungur & Tekkaya, 2003).

Beside gender difference, reasoning ability effects students' understanding ecological concepts and attitude towards science.This result is consistent with the previous studies (Lawson & Renner, 1975; Lawson & Thompson, 1988; Panizzon, 2003; Sungur & Tekkaya, 2003). For example, Panizzon (2003) found the similar result that there is a significant relationship between conceptual knowledge and reasoning ability in science students. Moreover, Lawson and Renner (1975) found that while high level formal reasoners were able to understand both concrete and formal concepts, low level reasoners were able to understand only concrete concepts.

Sungur and Tekkaya (2003) revealed a significant mean difference between concrete and formal students with respect to achievement and attitude toward biology. Moreover, Lawson and Thompson (1988) found that better reasoning ability means larger mental capacity and higher achievement. Therefore, teachers should be aware of students' reasoning ability levels in order to promote meaningful learning and also teachers ought to design their lesson and classroom environment according to students reasoning levels; for example, teachers can use concrete problems or materials in order to foster understanding. In addition, teachers should ask questions which require analyzing, critical thinking to increase reasoning level (Mwamwenda, 1993). Different instructional methods like learning cycle (Bitner, 1991) or inquiry (Johnson & Lawson, 1998) should be used to foster scientific reasoning.

In summary, students have many misconceptions. These misconceptions should be identified before instruction. TEC-three tier diagnostic test- is very useful tool to identify misconceptions since it does not overestimate misconceptions and misconceptions can be differentiated from lack of knowledge, partial understanding and complete understanding by means of TEC. Moreover, result of this study shows that there was statistically significant gender difference in favor of girls with respect to understanding ecological concepts and attitude toward science. Furthermore, results of this study show that there was statistically significant gender difference with respect to understanding ecological concepts and attitude toward science when the effect of reasoning ability was controlled.

5.3 Internal and External Validity

There are several important threats to internal validity of survey research; mortality, location, instrumentation (Fraenkel & Wallen, 1996, p: 383). To control location threat, same room was used for interview and comfortable conditions were supported for all interviewees. All schools' classrooms generally were similar condition as heating, lightening, wideness, etc for administration of the three-tier test. Data collector bias and data collector characteristics could not be threat to internal

validity since the interviews were conducted by only the researcher. Confidentially was not a threat because all the interviewees were informed about their answers used only the purposes of this study.

External validity is the degree to which results are generalizable, or applicable to groups and environments outside the research setting. There are two types of external validity: population validity and ecological validity. Population validity is to degree to which a sample represents the population of interest. Ecological validity refers to the degree to which results of a study can be extended to other settings or conditions (Fraenkel & Wallen, 1996 p: 106-109). Our sample is all eighth grade students in Tosya. So, the outcomes of this study were the accessible population. TEC, TOLT and ATSS were administered in ordinary classrooms. There were not many differences among them. However, there were difference among subject characteristics such as socioeconomic status, education facilities etc which can affect the results of the study.

5.4 Implications of the Study

There are several important implications according to results of this study and findings of the previous studies:

1. Results of the previous studies and this study showed that students have misconceptions and these misconceptions are obstacles for students to learn new concepts. Teacher should pay attention to students' misconceptions that was found in this study or previous studies while planning their learning activities and learning materials.

2. By means of three-tier diagnostic test, complete understanding, partial understanding, lack of knowledge can be differentiated from misconception so three-tier diagnostic test ought to be used to identify misconception.

3. Students' reasoning ability is important for understanding of ecological concepts that are abstract. It is very difficult for students to understand abstract ecological concepts like energy flow or notion of energy. In order to increase understanding, teachers should use more concrete materials like models, diagrams, simulations to make abstract concepts understandable to students (Postner, Strike, Hewson, & Gertzog, 1982)

4. Teachers should determine whether they introduce gender bias during instruction or interaction with their students. In addition, textbooks and curriculum materials ought to be examined to identify whether they reflect gender difference or not.

5.5 Recommendations for Further Research

There are several recommendations for the further studies. They can be listed as the followings:

1. The other biology topics can be investigated by using a three-tier test to identify students' misconceptions.

2. The sample can be chosen from different city and sample size can be increased to get more accurate results for further studies.

3. Eight grade students' misconception concerning some ecological concept was investigated in this study. Similar research studies can be conducted for different grade levels.

4. The effect of reasoning ability and gender on students' understanding and attitude regarding other biology topics or other subject areas such as physics, chemistry can be investigated.

REFERENCES

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

Anderson, C., Sheldon, T., & Dubay, J. (1986). The effects of instruction on college nonmajors' conceptions of respiration and photosynthesis, Research Series No. 164. East Lansing, MI: Institute for Research on Teaching. *ERIC Document Reproduction Service No. ED 2703*

Arnaudin, M. N.,& Mintzes, J. J., (1985). Students alternative conceptions of the human circulatory system: a cross-age study. *Science Education*, 69 (5), 721-733.

Aşcı, Z., Özkan, Ö. & Tekkaya, C., (2001). Students' misconceptions about respiration. Retrieved March 10, 2005 from www.fedu.metu.edu.tr/ufbmek-5/b_kitabi/PDF/Fen/Bildiri/t72d.pdf

Ausubel, D.P., (1968). *Educational Psychology, A cognitive view*, New York, Holt, Ripehart, Winston.

Bar, V., Zinn, B., Goldmuntz, R., & Sneider, C., (1994). Children's concepts about weight and free fall. *Science Education*, 78, 149–169.

Barrass, R., (1984). Some Misconception and misunderstanding perpetuated by teachers and textbooks of biology. *Journal of Biology Education*, 18, 201-235.

Bell, B., (1985). Students' ideas about plant nutrition: what are they? *Journal of Biological Education,* 19, 213-218.

Bishop. B. A., & Anderson, C. W., (1990). Student conceptions of natural selection and its role in evolution. *Journal of Research in Science Teaching*, 27(5), 415-417.

Bitner, B., (1991). Formal operational reasoning modes: Predictors for critical thinking abilities and grades assigned by teachers in science and mathematics for students in Grades nine through twelve. *Journal of Research in Science Teaching*, 28, 265–274.

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

Brehm, S., Anderson, C. W., & DuBay, J., (1986). Ecology: A teaching module. Occasional Paper No. 94. East Lansing, MI: Institute for Research on Teaching, Michigan State University.

Browning, M. E., & Lehman, J.D., (1988). Identification of student misconceptions in genetics problem solving via computer programs. *Journal of Research in Science Teaching*, 25(9), 747-761.

Brumby, M. N., (1984). Misconceptions about the concept of natural selection by medical biology students. *Science Education*, 68, 493–503.

Campbell, J.R., Voelkl, K.E, & Donohue, P.L., (1998). Report in brief: NAEP 1996 trends in academic progress.

Canal, P., (1999). Photosynthesis and inverse respiration in plants: an inevitable misconception. International Journal of. *Science Education*, 21, 363-371.

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

Carey, S., (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.

Çataloğlu, E., (2002). Development and validation of an achievement test in introductory quantum mechanics: The quantum mechanics visualization instrument (QMVI) Online. Retrieved July 30, 2005 from http://etda.libraries.psu.edu/thesis/approved/WorldWideIndex/ETD-145/

Catsambis, S., (1995). Gender,race,ethnicity, and science education in middle grades. *Journal of Research in Science Teaching*, 32, 243-257.

Cavallo, A.M.L., (1996). Meaningful learning, reasoning ability and students' understanding and problems solving topics in genetics. *Journal of Research in Science Education*, 33, 625- 656.

Çetin, G. (2003). *Developing and implementing an instructional Technology aided conceptual change in Teaching Ecology Concepts at nine grade*, Unpublished Master Thesis, The Middle East Technical University, Ankara.

Champagne, A. B., & Klopfer, L. E. (1983,January). Naive knowledge and science learning. *American Association of Physics Teachers*, New York.

Cherrett, J. M., (1989). *Key concepts: The results of a survey of our members' opinions.* Oxford: Blackwell Scientific Publications.

Chi, M.T.H., & Slotta, J. D., (1993). The ontological coherence of intuitive physics. *Cognition and Instruction*, 19, 249–260.

Clement, J., (1982). Students' preconceptions in introductory mechanics. *American Journal of Physics*, 50, 1, 66-71.

Engel Clough, E., & Wood-Robinson, C., (1985). Children's understanding of inheritance. *Journal of Biological Education*, 19, 304–310.

D'Avanzo, C. (2003). Application of research on learning to college teaching: ecological examples. *Bioscience*, 53, 1121-1128.

Driver,R. & Easley, J.A., (1978). Pupils and paradigms: A review of literature related to concept development in adolescent science students. *Studies in Science Education* 5, 61-84.

Driver, R., Guesne, E., & Tiberghien, A. (1985). *Children's ideas in science*. Philadelphia: Open University Press.

Ehindore, O. J. (1979). Formal operational precocity and achievement in biology among some Nijerian high school students. *Science Education*, 63, 231-236.

Eilam, R., (2002). Strata comprehending ecology: Looking through the prism of feeding relations. *Science Education*, 86(5), 645-671.

Eisen, Y., Stavy, R. (1992). Material cycles in nature: a new approach to teaching photosynthesis in junior high school. *The American Biology Teacher*, 54, 339-342.

Eryılmaz, A. & Sürmeli, E. (2002). *Üç-aşamalı sorularla öğrencilerin ısı ve sıcaklık konularındaki kavram yanılgılarının ölçülmesi.* Retrieved May 29, 2004, from
http://www.fedu.metu.edu.tr/ufbmek-5

Eyidoğan, F. & Guneysu, S. (2001).*İlköğretim 8. sınıf fen bilgisi kitaplarındaki kavram yanılgıları*, Retrieved May 30, 2004, from
http://www.fedu.metu.edu.tr/ufbmek-5

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

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

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

Gallegos, L, Jerezano, M.E. & Flores, F. (1994). Preconceptions and relations used by children in the construction of food chains. *Journal of Research in Science Teaching*, 31(3), 259- 272.

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

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

Germann, P. J. (1994). Testing a model of science process skills acquisition: An interaction with parents' education, preferred language, gender, science attitudes, cognitive development, academic ability, and biology knowledge. *Journal of Research in Science Teaching*, 31, 749-783.

Griffard, P. B. & Wandersee, J. H (2001). The two-tier instrument on photosysnthesis: What does it diagnose? *International Journal of Science Education*, 23(10), 1039-1052.

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

Gtiffiths, A. K., Thomey, K., Cooke, B., & Normore, G., (1988). Remedation of students-specific misconceptions relating three science concepts. *Journal of Research in Science Teaching*, 25(9), 709-719.

Gunstone, Champagne, & Klopfer, 1981; Gunstone, R.F., Champgane, A.B., Klopfer, L.E. (1981). Instruction for understanding: A case study. *The Australian Science Teachers Journal,* 27(3), 27-32.

Haidar, A. H., (1997). Prospective chemistry teachers' conceptions of the conservation of matter and related concepts. *Journal of Research in Science Teaching*, 34, 181–197.

Halloun, I. A., & Hestenes, D., (1985). Common sense concepts about motion. *American Journal of Physics*, 53, 1056–1065.

Haslam, F., & Treagust, D.F., (1987). Diagnosing secondary students' misconceptions of photosynthesis and respiration in plants using a two-tier multiple choice instrument. *Journal of Biological Education*, 21(3), 203-211.

Hawkins, J., & Pea, R. D., (1987). Tools for bridging the cultures of everyday and scientific thinking. *Journal of Research in Science Tea*ching, 24, 291–307.

Helm, H. (1980). Misconceptions in physics amongst South African students. *Physics Education*, 15, 92-97.

Hestenes, D., Wells, M. & Swackhamer, G. (1992). Force concept Inventory. *The Physics Teacher,* 30, 141-158.

Hewson, P.& Hewson, M. (1988). An appropriate conception of teaching science: a view from studies of science learning. *Science Education*, 72(5), 597-614.

Ivowi, U.M.O. (1983). *Misconceptions in physics amongst Nigerian secondary school students*. In: Helm, H., Novak, J.D.: Proceedings of the International Seminar "Misconceptions in Science and Mathematics". Ithaca, N.Y.: Cornell University, 356-361.

Johnson, M. A. & Lawson, A.E. (1998). What are the relative effects of reasoning ability and prior knowledge on biology achievement in expository and inquiry classes. Journal of Research in Science Education, 35, 89-103.

Kargbo, D.B., Hobbs, E.D., Erickson, G.L (1980). Children's beliefs about inherited characteristics. *Journal of Biological Education*, 14(2), 137-146.

Korkmaz, O. (2004) *The relationship among reasoning ability, gender and students' understanding of diffusion and osmosis*. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Kutluay, Y. (2005). *Diagnosis of eleventh grade students' misconception about geometric optic by a three-tier test*. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Lavoie, D.R. (1997). *Using a modified concept mapping strategy to identify students' alternative scientific understandings of biology*. Paper presentation at National Association for Research in Science Teaching, Annual meeting at Chicago, IL, March 21-24.

Lawson, A.E., Thompson, L.D., (1988). Formal reasoning ability and misconceptions concerning genetics and natural selection. *Journal of Research in Science Teaching*, 25, 733-746.

Lawson, A., & Renner, J. (1975). Piagetian theory and biology teaching. *The American Biology Teacher*, 37, 336–343.

Leach, J., Driver, R., Scott, P., Wood-Robinson, C., (1996). Children's ideas about ecology 3: ideas found in children aged 5-16 about the interdependency of organisms. *International Journal of Science Education*, 18, 129-141.

Mintzes, J. J., (1984). Naïve theories in biology: Children's concepts of the human body. *School Science and Mathematics*, 84(7), 548-555.

Munson, B. H., (1994). Ecological misconceptions. *Journal of Environmental Education*, 25(4), 30-34.

Nakhleh & Krajcik (1994) Influence levels of information as presented by different tehnologies on students' understanding of acid, base, and ph concepts. *Journal of Research in Science Teaching*, 34(10), 1077-1096

Niaz, M., & Lawson, A. (1985). Balancing chemical equations: The role of developmental level and mental capacity. *Journal of Research in Science Teaching*, 22, 41–51.

Novak, J., & Gowin, D., (1984). *Learning how to learn.* New York: Cambridge University Press.

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

Novak, J.D. (1993). How do we learn our lesson?. *The Science Teacher*, 50(3), 50-55.

Odom, A. L., & Kelly, P. V., (2001). Integrating concept mapping and the learning cycle to teach diffusion and osmosis concepts to high school biology students. *Science Education*, 85 (6), 615-635.

Odom, L.A., & Borrow, H.L., (1985). Development and application of a two tier diagnostic test measuring collage biology students' understanding of diffusion and osmosis after a course of instruction. *Journal of Research in Science Teaching*, 27(5), 493-504.

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

Osborne, R. J., & Freyberg, P.S., (1985). *Learning in Science: The implications of children's science*. London: Heinemann.

Osborne, R., Wittrock, M.C. (1983). Learning science: A generative process. *Science Education*, 67, 4, 489-508.

Osborne, R. (1983). Towards modifying children's ideas about electric current. *Research in Science and Technological Education*,1(1), 73-82

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

Panizzon, D., (2003). Using a cognitive structural model to provide new insights into students' understandings of diffusion. *International Journal of Science*, 25(12), 1427-1450.

Peşman, H., (2005). *Development of a three-tier test to asses ninth grade students' misconception about simple electric circuits*. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Pfundt, H., & Duit, R. (1991). *Bibliography of students' alternative frameworks in science education*, 3rd ed. Kiel, Germany: IPN.

Pines, L., West, L., (1986). Conceptual understanding and science learning: An interpretation of research within a sources of knowledge framework. *Science Education*,70(5) 583-604.

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

Reiner, M., & Eilam, B., (2001). Conceptual classroom environment—a system view of learning. *International Journal of Science Education*, 23(6),551- 568.

Rollnick, M., & Mahooana, P.P., (1999). A quick and effective way of diagnosing student difficulties: Two tier from simple multiple-choice questions. *South African Journal of Chemistry*, 52(4), 161-165.

Sanders, M., (1993). Erroneous ideas about respiration: The teacher factor. *Journal of Research in Science Teaching*, 30(8) 919-934.

Simpson, M,. Arnold, B. (1982). Educational psychology and the teaching of specialist subjects. *Scottish Educational Review*, 14 (2), 109-117.

Smith, E.L., Anderson, C.W. (1984). Plants as producers: A case study of elementary science teaching. *Journal of Research in Science Teaching*, 21(7), 685-698.

Soyibo, K., (1999). Gender differences in Caribbean students' performance on a test of errors in biological labelling, *Research in Science and Technological Education*, 17, 75–82.

Stavy, R., Wax, N., (1989). Children's conceptions of plants as living things. *Human Development,* 32, 635.

Steinkamp,M.W., & Maehr, M.L. (1983). Affect, ability and science achievement: Aquantitative synthesis of correlational research. *Review of Educational Research*, 53, 369-396.

Strike, K. A. and Posner, G. J. (1982). Conceptual change and science teaching. *European Journal of Science Education*, 4(3), 231-240.

Sungur, S., & Tekkaya, C., (2003). Students' achievement in human circulatory system unit: the effect of reasoning ability and gender, *Journal of Science Education and Technology*, 12, 59–64.

Sungur, S., (2004). *An implementation of problem based learning in high school biology courses*. Unpublished Master Thesis, The Middle East Technical University, Ankara.

Thijs, G. D. (1992). Evaluation of an introductory course on "force" considering students' preconceptions. *Science Education*, 76, 155–174.

Tobin, K. G. & Capie, W. (1981). The development ad validation of a group test of logical thinking. *Educational and Psychological Measurement*, 41, 413–423.

Tamir, P., (1990). Justifying the selection of answers in multiple-choice items. *International Journal of Science Education*, 12(5), 563-573.

Valanides, N. C. (1997) Cognitive abilities among twelfth-grade students: implications for science teaching*, Educational Research and Evaluation*, 3, 160–186.

Wandersee, J.H. (1994). *Making high-tech micrographs meaningful to the biology student*. The content of science. London: The Falmer Press, 161-176.

Webb, P., & Boltt, G., (1990). Food chain and food web: A natural progression? *Journal of Biological Education*, 24(3), 187-191.

Weinburgh, M.(1995). Gender differences in student attitudes toward science: A metaanalysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching,* 20, 839-850.

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

Westbrook, S.L., & Marek, E.A. (1992). A cross-age study of student understanding of the concept of homeostasis. *Journal of Research in Science Teaching*, 29, 51–61.

Willson, V.L., (1983). A meta-analysis of the relationship between science achievement and science attitude: Kindergarten through college. *Journal of Research in Science Teaching*, 20, 839-850.

Yenilmez, A. (2006). *Exploring relationship among students' prior knowledge, meaningful learning orientation, reasoning ability, mode of instruction and understanding of photosynthesis and respiration in plants.* Unpublished Master Thesis, The Middle East Technical University, Ankara.

Young, D. J. & Fraser, B. J. (1994) Gender differences in science achievement: do school effects make a difference? *Journal of Research in Science Teaching*, 31, 857–871.

APPENDIX A

INTERVIEW SCHEDULE

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?
Çevrende canlı ve cansız varlıklar arasında bir ilişki var mı?
“Evet” derse, çevrede canlı ve cansız varlıklar arasında nasıl bir ilişki var?

TEMEL EKOLOJİK KAVRAMLAR

Tür nedir?
“Popülasyon” sözünden ne anlıyorsun?
Popülasyona bir örnek verebilir misin?
“Tür” ile “Populasyon” aynı şeyler mi?Açıklar mısın?
Sana “Ekosistem” nedir diye sorsam,bana neler söyleyebilirsin?
“Biyosfer” nedir? Farklı Ekosistemler biyosferi oluşturur mu?

ENERJİ

Enerjiyi nasıl tanımlarsın?
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 var mıdır?
Var derse, nasıl? Biraz açıklayabilir misin.

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

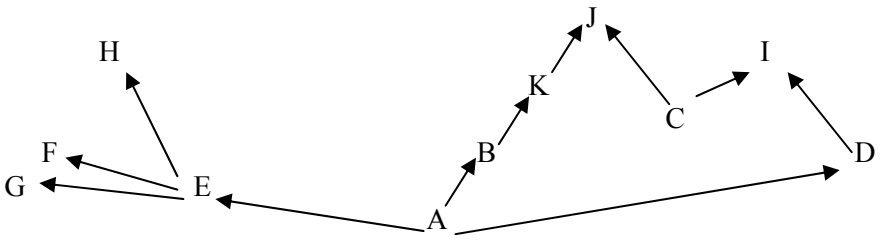
BESİN ZİNCİRİ

“Besin zinciri”ni nasıl tanımlayabilirsin?
Bana bir besin zinciri çizebilir misin?
Çizmiş olduğun besin zincirinde bana tüketiciyi gösterebilir misin?Tüketicileri birbirinden nasıl ayırt edebilirsin?
“Bitki ile başlarsa”, besin zincirine neden bitki ile başladın?
“Hayvan ile başlarsa”, besin zincirine neden hayvan ile başladın?
Peki enerji miktarı hakkında ne söyleyebilirsin?Verdiğin örnekte, hangi canlı en fazla enerjiye sahiptir?
Kelebek, kuş ve nektar bir besin zinciri oluşturur mu? Neden?
İnsan vücudundaki bakteri besin zincirinin bir parçası mı? Neden?

ENERJİ PİRAMİDİ

“Enerji piramidi”nden ne anlıyorsun?
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? Neden piramidin üst kısmı alt kısmından daha küçük?

BESİN AĞI
“Besin ağı” nı nasıl tanımlayabilirsin?
Bize şematik bir besin ağı çizebilir misin?
Bu besin ağını anlatır mısın?
Eğer su ekosisteminde çizerse, kara ekosisteminde besin ağı çizebilir misin?
“Bu bir besin ağını gösteren şekildir.Bu harflerin her biri belli bir popülasyonun bir üyesini simgelemektedir.Buna göre şu sorulara cevap verir misin?”



Oklar neyi ifade ediyor olabilir? Okların yönü önemli midir ?
"A" ne olabilir?

Şimdi bazı çevresel faktörler yüzünden yukarıdaki besin ağında bulunan popülasyonda ani değişikliklerin olduğunu düşünelim. Buna göre, bu değişikliklerin diğer popülasyonlar üzerindeki etkisini bulmaya çalışalım.

F popülasyonundaki ani azalma H popülasyonunu etkiler mi?
Etkiler derse, nasıl etkiler, 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?

A popülasyonunda olan ani bir değişiklikten J popülasyonu etkilenir mi?
Etkilenir derse, nasıl ve hangi yoldan, harfleri işaretler misin?
Etkilemez derse, neden?

APPENDIX B

CANLILAR VE ETKİLEŞİM' KAVRAM TESTİ

Sevgili Öğrenciler;

Bu testteki sorular, 'Canlılar ve Etkileşim' konusunda öğrencilerin sahip olduğu kavram yanlışlarını ölçmek için hazırlanmıştır.Test, 19 tane çoktan seçmeli soru içermektedir Her soru üç bölümden oluşmaktadır. Birinci bölüm, konu bilgisini içeren çoktan seçmeli soruyu; ikinci bölüm olası nedenleri, üçüncü bölüm ise bu cevaplarınızdan ne kadar emin olduğunuzu içeren soruyu içermektedir. Her soru için bir cevap ve her cevap için bir neden ve ne kadar emin olduğunuzu işaretlemeniz gerekmektedir. Sebep sorularında cevabınız 'Hiçbiri' ise yandaki boşluğa kendi cevabınızı yazınız. Lütfen hiçbir bölümü ve soruyu boş bırakmayınız.

Vereceğiniz bilgiler kesinlikle gizli tutulacaktır.Yardımlarınız için sizlere teşekkür ederim.

Hacer Soylu
ODTÜ - Eğitim Fakültesi

1. Okulunuzun adı :

2. Cinsiyet : ❑ Kız ❑ Erkek

3. Doğum tarihiniz :

4.Fen Bilgisi dersinizin geçen dönemki karne notu nedir?

5. Annenizin Eğitim Durumu	6. Babanızın Eğitim Durumu
❑Hiç okula gitmemiş	❑Hiç okula gitmemiş
❑ İlkokul	❑ İlkokul
❑ Ortaokul	❑ Ortaokul
❑ Lise	❑ Lise
❑Üniversite	❑Üniversite
❑Yüksek lisans (Mastır/Doktora)	❑Yüksek lisans (Mastır/Doktora)

1a.Çevre nedir?

a) Canlıların yaşadığı ortamdır.
b) Canlı ve cansız varlıkların bulunduğu ortamdır.
c) İnsanların yaşadığı yerdir.

1b.Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

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

1c.Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

2a.Aşağıdakilerin hangisi popülasyona bir örnektir?

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

2b.Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

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

2c.Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

3a. Ekoloji ile ilgili sıralamalardan hangisi doğrudur?

a) Tür< Populasyon<Ekosistem<Biyosfer
b) Populasyon < Tür <Ekosistem<Biyosfer
c) Tür <Ekosistem< Populasyon< Biyosfer
d) Tür< Populasyon< Biyosfer <Ekosistem

3b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

a) Popülasyon bir çok türü içine alır.
b) Popülasyonlar bir araya gelerek türleri oluşturur
c) Belirli bir çevrede yaşayan canlılarla cansızlar ekosistemi oluşturur.
d) Biyosferler bir araya gelerek ekosistemleri oluşturur.
e) Hiçbiri(.....)

3c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

4a. Bitkilerin enerji kaynağı nedir?

a) Toprak
b) Hava
c) Güneş

4b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

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.
e) Hiçbiri(.....)

4c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

5a. Bitkilerle hayvanlar arasında enerji bakımından bir ilişki var mıdır?

a) Vardır
b) Yoktur

5b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

a) Hayvanlar bitkileri yer.
b) Hayvanların ve bitkilerin kendi ayrı besinleri vardır.
c) Hayvanlar bitkilerden daha güçlüdür ve kendi enerjileri vardır.
d) Bitkilerden alınan enerjinin bir kısmı hayvanlar tarafından kullanılır. Hiçbiri(.....)

5c.Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

6a. İnsan vücudundaki bakteri besin zincirinin bir parçası mıdır?

a) Evet
b) Hayır

6b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

a) Büyük canlılar küçük canlılarla beslenir.
b) Bakteriler vücudumuzdaki besinlerle beslenirler.
c) Bakteriler bazı organizmalar tarafından parçalanır.
d) Bakteri ölü canlıları parçalar, minerallere ayırır.
e) Hiçbiri(.....)

6c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

7a. Ayrıştırıcılar doğa için önemli midir?

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

7b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

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.
e) Hiçbiri(.....)

7c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

8a. Besin zinciri nedir?

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

8b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

a) Besin zinciri,besinlerin içinde olan proteinler ve vitaminlerden oluşur.
b) Bir bitkinin yada 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.
e) Hiçbiri(.....)

8c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

9a. Bitki, böcek, insan ve tavuktan 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.

9b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

a) Her canlının kendi enerjisi vardır.
b) Bitkiler enerji akışının temelini oluşturur.
c) En çok enerji insandadır.
d) İnsan hiçbir şeye enerji vermez.
e) Hiçbiri(.....)

9c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

10a. Nektar, kelebek, kuş bir besin zincirini oluşturabilir mi?

a) Evet
b) Hayır

10b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

a) Nectar bir bitki değildir.
b) Cansız elementler zincirde yoktur.
c) Kuş daha güçlü olduğu için diğerlerini yer.
d) Nektar kelebeğin besinidir.
e) Hiçbiri(.....)

10c.Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

11a. Ot, koyun ve insandan oluşabilecek besin zincirinde <u>en çok</u> enerji hangi canlıdadır?

a) Ot
b) Koyun
c) İnsan

11b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

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.
e) Hiçbiri(.....)

11c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

12a..Aşağıdaki canlılardan hangisi birinci derecede tüketicidir ?

a) Aslan
b) Tavşan
c) İnsan

12b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir ?

a) İnsan her şeyi tüketir.
b) Tavşan otçuldur.
c) Aslan vahşi ve güçlüdür.
d) Aslan etçildir.
e) Hiçbiri(.....)

12c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz ?

a) Eminim
b) Emin değilim

13a. Enerji piramidinin tabanını hangi canlılar oluşturur ?

a) İnsanlar
b) Tüketiciler
c) Üreticiler

13b .Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir ?

a) En fazla enerji üreticilerdedir.
b) Tüketiciler enerji bakımından daha zengindir.
c) Doğada en çok insan bulunur.
d) İnsanlar hem bitkileri hem de hayvanları yer.
e) Hiçbiri(.....)

13c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz ?

a) Eminim
b) Emin değilim

14a. F popülasyonundaki ani bir azalma H popülasyonunu etkiler mi ?

a) Etkiler.
b) Etkilemez.

14b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir ?

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.
e) Hiçbiri(.....)

14c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

15a. E popülasyonundaki ani bir azalma H popülasyonunu etkiler mi ?

a) Etkiler.
b) Etkilemez.

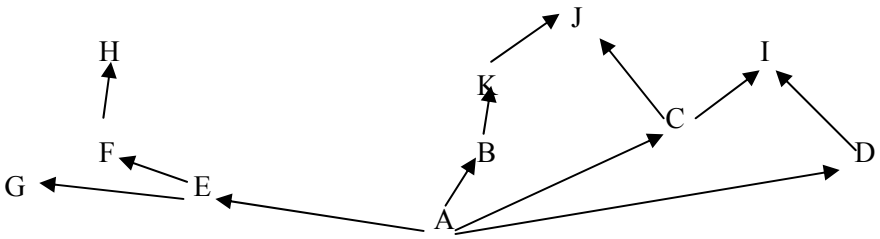
15b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

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.
e) Hiçbiri(.....)

15c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

14-19 arasındaki soruları aşağıdaki şekle göre cevaplayınız.
“Bu bir besin ağını gösteren şekildir.Bu harflerin her biri belli bir popülasyonun bir üyesini simgelemektedir.Buna göre aşağıdaki sorulara cevap verir misin ?



16a. G popülasyonundaki ani bir artış F popülasyonunu etkiler mi?
a) Etkiler.
b) Etkilemez.

16b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?
a) F popülasyonunu azalır.
b) Aralarında av-avcı ilişkisi yok.
c) Sadece E popülasyonu etkilenir
d) Yanyana değiller
e) Hiçbiri(.....)

16c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?
a) Eminim
b) Emin değilim

17a. H popülasyonundaki ani bir azalma E popülasyonunu etkiler mi?
a) Etkiler.
b) Etkilemez.

17b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?
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.
e) Hiçbiri(.....)

17c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?
a) Eminim
b) Emin değilim

18a.A popülasyonunda olan ani bir değişiklikten J popülasyonu etkilenir mi?

a) Etkilenir.
b) Etkilenmez.

18b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

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.
e) Hiçbiri(.....)

18c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

19a. I popülasyonundaki ani bir artış K popülasyonunu etkiler mi?

a) Etkiler.
b) Etkilemez.

19b. Bir önceki soruya verdiğiniz cevabın sebebi aşağıdakilerden hangisidir?

a) Aralarında hiçbir bağ yok.
b) Birbirlerinden çok uzaklar.
c) Besin ağındaki bir değişiklik bütün besin ağını aynı şekilde etkiler
d) Aynı besin ağı içinde olduklarından etkiler.
e) Hiçbiri(.....)

19c. Bir önceki soruya verdiğiniz yanıttan ne kadar eminsiniz?

a) Eminim
b) Emin değilim

APPENDIX C

FEN BİLGİSİ DERSİ TUTUM ÖLÇEĞİ

Bu ölçek, Fen Bilgisi dersine ilişkin tutum cümleleri ve her cümlenin karşısında sizin düşüncenizi ölçen beş seçenek içermektedir. Lütfen her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

		Tamamen katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç katılmıyorum
1)	Fen Bilgisi çok sevdiğim bir alandır.	☐	☐	☐	☐	☐
2)	Fen Bilgisi ile ilgili kitapları okumaktan hoşlanırım.	☐	☐	☐	☐	☐
3)	Fen Bilgisinin günlük yaşantıda çok önemli yeri yoktur.	☐	☐	☐	☐	☐
4)	Fen Bilgisi ile ilgili ders problemlerini çözmekten hoşlanırım.	☐	☐	☐	☐	☐
5)	Fen Bilgisi konuları ile ilgili daha çok şey öğrenmek isterim.	☐	☐	☐	☐	☐
6)	Fen Bilgisi dersine girerken sıkıntı duyarım.	☐	☐	☐	☐	☐
7)	Fen Bilgisi derslerine zevkle girerim.	☐	☐	☐	☐	☐
8)	Fen Bilgisi dersine ayrılan ders saatinin daha fazla olmasını isterim.	☐	☐	☐	☐	☐
9)	Fen Bilgisi dersine çalışırken canım sıkılır.	☐	☐	☐	☐	☐
10)	Fen Bilgisi konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim.	☐	☐	☐	☐	☐
11)	Düşünce sistemimizi geliştirmede Fen Bilgisi öğrenimi önemlidir.	☐	☐	☐	☐	☐
12)	Fen Bilgisi çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir.	☐	☐	☐	☐	☐
13)	Dersler içinde Fen Bilgisi dersi sevimsiz gelir.	☐	☐	☐	☐	☐
14)	Fen Bilgisi konuları ile ilgili tartışmalara katılmak bana cazip gelmez.	☐	☐	☐	☐	☐
15)	Çalışma zamanımın önemli bir kısmını Fen Bilgisi dersine ayırmak isterim.	☐	☐	☐	☐	☐

APPENDIX D

MANTIKSAL DÜŞÜNME YETENEK TESTİ

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

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

12. [b] AÇIKLAMASI [2]

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

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

a. 7 oda

b. 8 oda

c. 9 oda

d. 10 oda

e. Hiçbiri

Açıklaması:

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

2. Daha fazla boya kutusu ile fark azalabilir.

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

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

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

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

a. 5 kutu

b. 7 kutu

c. 8 kutu

d. 9 kutu

e. Hiçbiri

Açıklaması:

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

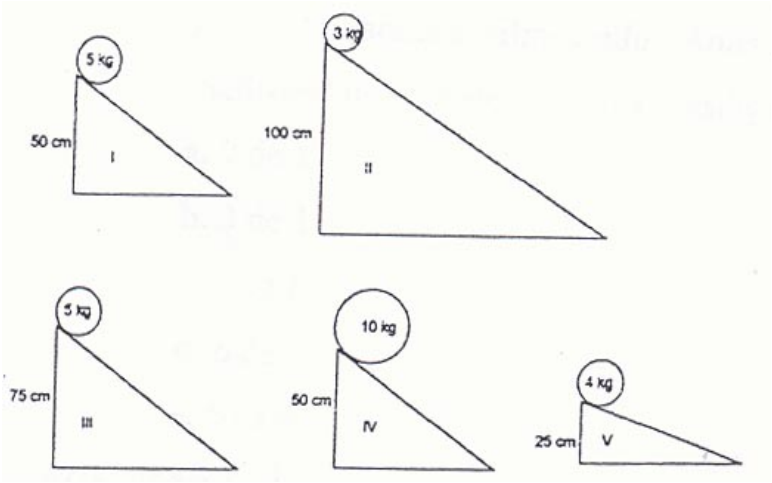
2. Eğer beş oda daha olsaydı, üç kutu boya daha gerekecekti.

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

4. Boya kutusu sayısı oda sayısının yarısı olacaktır.

5. Boya miktarını tahmin etmek mümkün değildir.

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

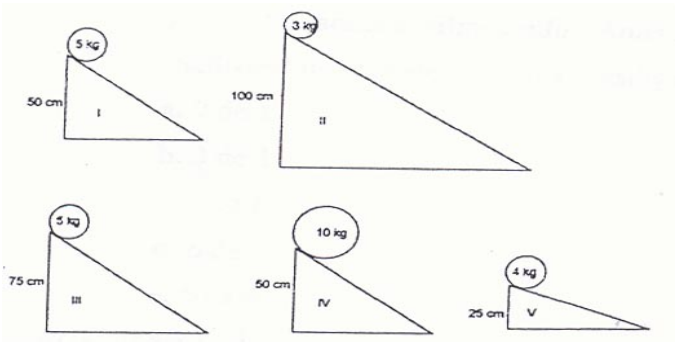


a. I ve IV
b. II ve IV
c. I ve III
d. II ve V
e. Hepsi

Açıklaması:

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

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



a. I ve IV
b. II ve IV
c. I ve III
d. II ve V
e. Hepsi

Açıklaması:

a. En ağır olan top en hafif olanla kıyaslanmalıdır.

b. Tüm eğik düzlem setleri birbiriyle karşılaştırılmalıdır.

c. Topun ağırlığı arttıkça, yükseklik azaltılmalıdır.

d. Ağırlıklar farklı fakat yükseklikler aynı olmalıdır.

e. Ağırlıklar aynı fakat yükseklikler farklı olmalıdır.

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

a. 2 de 1

b. 3 de 1

c. 4 de 1

d. 6 da 1

e. 6 da 4

Açıklaması:

1. Ardarda üç Fransızca bilen kişi çıkabildiği için dört seçim yapmak gerekir.

2. Mevcut altı kişi arasından İngilizce bilen bir kişi seçilmelidir.

3. Toplam üç İngilizce bilen kişiden sadece birinin seçilmesi yeterlidir.

4. Kompartımandakilerin yarısı İngilizce konuşur.

5. Altı kişi arasından, bir İngilizce bilen kişinin yanısıra, üç tanede Fransızca bilen kişi seçilebilir.

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

a. 2 de 1

b. 3 de 1

c. 7 de 1

d. 21 de 1

e. Yukarıdakilerden hiçbiri

Açıklaması:

1. Altın, gümüş ve bakırdan yapılan nesneler arasından bir altın nesne seçilmelidir.
2. Paraların $\frac{1}{4}$ ü ve yüzüklerin $\frac{4}{9}$ u altından yapılmıştır.
3. Torbadan çekilen nesnenin para ve yüzük olması önemli olmadığı için toplam 7 altın nesneden bir tanesinin seçilmesi yeterlidir.
4. Toplam yirmi bir nesneden bir altın nesne seçilmelidir.
5. Torbadaki 21 nesnenin 7 si altından yapılmıştır.

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

a. Evet

b. Hayır

Açıklaması:

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

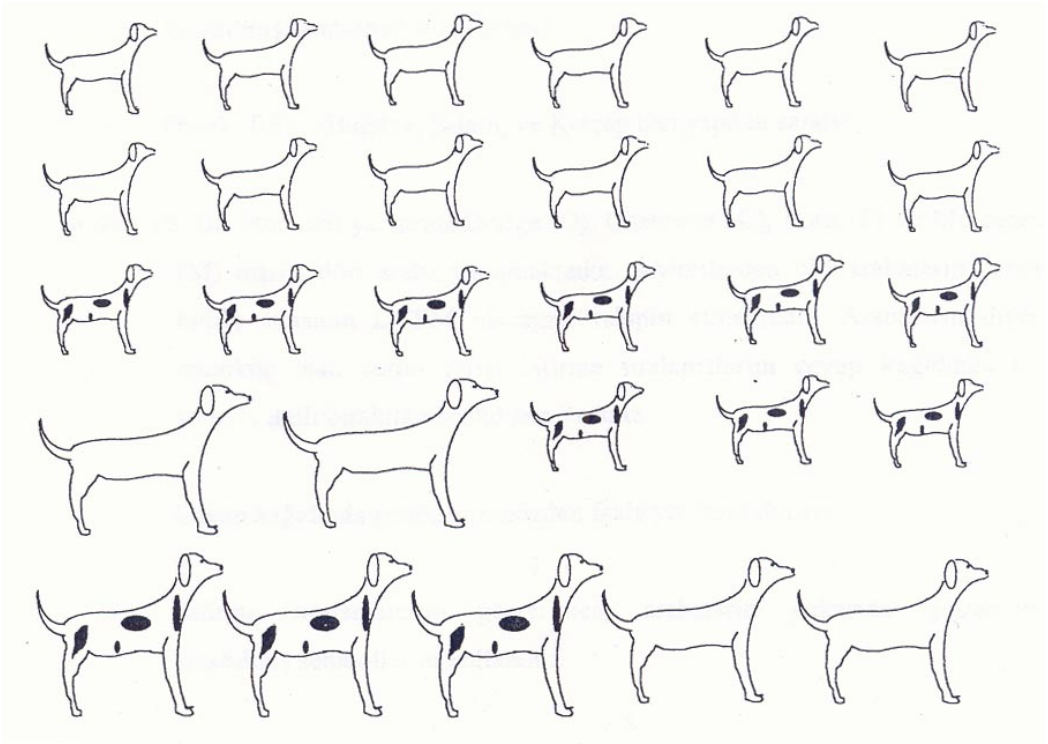
SORU 8: 7 büyük ve 21 tane küçük köpek şekli aşağıda verilmiştir. Bazı köpekler benekli bazıları ise beneksizdir. Büyük köpeklerin benekli olma olasılıkları küçük köpeklerden daha fazla mıdır?

a. Evet

b. Hayır

Açıklaması:

1. Bazı küçük köpeklerin ve bazı büyük köpeklerin benekleri vardır.
2. Dokuz tane küçük köpeğin ve yalnızca üç tane büyük köpeğin benekleri vardır.
3. 28 köpekten 12 tanesi benekli ve geriye kalan 16 tanesi beneksizdir.
4. Büyük köpeklerin $\frac{3}{7}$ si ve küçük köpeklerin $\frac{9}{21}$ i beneklidir.
5. Küçük köpeklerden 12 sinin, fakat büyük köpeklerden ise sadece 4ünün beneği yoktur.



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

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

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

Cevap kağıdı üzerinde bu soruyla ilgili bırakılan boşluklara bütün olası sandviç çeşitlerinin listesini çıkarın.

Cevap kağıdında gereksiniminizden fazla yer bırakılmıştır.

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

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

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

Cevap kağıdında gereksiniminizden fazla yer bırakılmıştır.

Bitirme sıralamalarını gösterirken, arabaların yukarıda gösterilen kısaltılmış sembollerini kulanınız.

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