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Determination of secondary school students' cognitive structure, and misconception in ecological concepts through word association test

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In this study, we determined cognitive structures and misconceptions about basic ecological concepts by using "word association" tests on secondary school students, age between 12-14 years. Eighty-nine students participated in this study. Before WAT was generated, basic ecological concepts that take place in the secondary science curriculum were determined. And then these concepts; "Environment", "species", "habitat", "population", "ecosystem", "food chain", "substance cycle", "biological diversity", "environmental pollution", "global warming", "acid rain" and "greenhouse effect" were determined as keywords. Also, students were asked to construct a related example sentence for each keyword. Analysis of data was done in four steps: Determination of the responses given for the keywords, calculation of the Relatedness Coefficient between the keywords, formation of concept web that put forward the relation for the given responses to keywords, and analysis of constructed sentences for each keyword. In conclusion, this study put forward that most of the students had weak cognitive structure about ecological concepts. The close relations among these concepts with each other could not be built in students' cognitive structure. Most of the students' responses were superficial knowledge acquired in daily life and contained many misconceptions. Although students were aware of environmental problems, they were deficient in scientific information about reasons and effects of these problems. This case shows that we are not sufficient in environmental education and training.

Key words: Cognitive structure, ecology, environmental education, misconception, word association test.

INTRODUCTION

Understanding how students acquire knowledge and how they construct this knowledge in their mind is always an important issue for science education researchers. Transferring and constructing knowledge to learners' mind have been tried to represent in terms of cognitive structure (Tsai, 2001; Tsai and Huang, 2001, 2002; Kurt, 2013, Nakiboğlu, 2008). "Cognitive structure is a hypothetical construct referring to the organization (relationships) of concepts in memory" (Shavelson, 1974b, p. 3).

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Cognitive structures that affect reconstruction of incoming stimuli contain students' knowledge, and organization of the knowledge (Tsai, 2001). Poor cognitive structures prevent the acquisition of new knowledge meaningfully, and thus students' academic achievement in the school and ability to apply knowledge to daily life might be influenced (Tsai and Huang, 2002). So it is important to determine students' cognitive structure about a specific subject or concept before instructional process. Determination of students' cognitive structure helps teacher to choose appropriate teaching strategies, and helps students to link past experience to new knowledge. Hence it can facilitate students' conceptual development and conceptual change (Tsai, 2001; Tsai and Huang, 2002).

It is known that students do not come to learn science as they are a tabula rasa; they get the knowledge and ideas in their cognitive structure by the help of their daily experiences related to the physical world (Vosniadou and Ioannides, 1998). These prior knowledge and ideas that students generate are often contradicted with scientific facts. These are called misconceptions (Alparslan et al., 2003; Bahar, 2003). Students have to associate a subject or concept to its implication in daily life and have to structure it using the prior knowledge for a meaningful learning (Bahar, 2003; Tsai and Huang, 2002). Incomplete or wrong prior information might prevent meaningful learning; hence it becomes important to study students' cognitive structure, and to study how to dissolve determined misconceptions in their cognitive structure (Alparslan et al., 2003; Bahar, 2003). Determination of students' cognitive structure can expose students' misconception, too (Tsai, 2001). Thus, it is also important in this respect.

Misconceptions can be classified as follows: preconceived notions, non-scientific beliefs, conceptual misunderstandings, vernacular misconceptions and factual misconceptions (Committee on Undergraduate Science Education, 1997). Preconceived notions are the outcomes of daily experiences. Misconceptions, for an instance, are like as many people believe that since groundwater apparently flows, the underground water must flow too (Brown and Clement, 1991). Non-scientific beliefs include views learned by students from sources other than scientific education such as myths that can cause conflicts with scientific education. Conceptual misunderstandings appear when students, during the scientific education, cannot confront their own preconceived notions and non-scientific beliefs, and fail to resolve conflicts between their beliefs and scientific reality. Some misconceptions such as "cold matter does not contain any heat" or "greenhouse gases exist in the atmosphere as a layer" can be mentioned in this case. Concepts that have different meanings, both in daily life and in science, as in the example of the concept of "work", are misconceptions caused by the language we use and they are called vernacular misconceptions. Factual misconceptions are learned at an early age and cannot be changed during the life-time. For example, the concept of the "setting and rising of the sun" can be the cause of a misconception by children who may think the sun is moving. However, children understand the reality of the earth's revolution around the sun when they grow older (Buluş and Güllü 2008; Committee on Undergraduate Science Education, 1997; Sheparson et al., 2011).

Cognitive structure research in the literature about ecological concepts

In various studies, students' poor cognitive structures related to ecology are determined, which are as follows: some students aged 13-15 years think that there is no interaction between living and non-living things in the ecosystem (Adeneyi, 1985). Some students, aged 11-12 years, perceive living things as major components in ecosystems and consider the role of abiotic factors less essential than living things (Prokop et al., 2007); whereas, some college students perceive that the ecosystem consists of only living organisms (Brehm et al., 1986). Also, they have some misconceptions related to population and habitat (Adeneyi, 1985; Özkan et al., 2004; Sander et al., 2006; Jordan et al., 2009).

Munson (1991) asserted that students are unable to comprehend any change in items of the ecosystem that affect the whole system, e.g. they believe that living organisms in the ecosystem can affect each other only if they have relation in food chain. Besides, most of high and secondary school students are not aware of the flow of energy among living organisms and they cannot comprehend the proper energy flow in the food chain (Griffiths and Grant, 1985; Hogan, 2000; Özkan et al., 2004; Yörek et al., 2010).

As remarked by Munson (1991), students are unable to comprehend that different species have different needs for themselves and each species has a different effect in the ecosystem. Palmer (1999) found that some students in age-groups of 11-12 years and 14-15 years have scientifically acceptable knowledge related to ecological role e.g. "one of the roles of tree is to produce oxygen that animals breathe", but some students also have misconceptions like "bacteria have no role because many animals get sick due to them", "butterflies have no role, and they only fly around". Özkan et al. (2004) determined that some 7th grade (aged 12 years) students have misconceptions related to ecological roles such as "decomposers eat dead plants and animals to keep the environment clean", and "decomposers have no effect on ecosystem because they are too small to be seen by the naked eyes". Also, Yörek et al. (2010) exhibited similar findings in their study conducted with 9th grade school students and biology teachers.

Besides the studies of basic ecological misconceptions, there have been various studies carried out on misconceptions in environmental problems. According to Marinopoulos, and Stavridou (2002), some of students aged 11-12 years are unaware that wastes that pollute the air cause both chemical and physical changes in the atmosphere. Further, they cannot comprehend: how acid rain is formed, how it harms the environment and humans both, and how it can have an effect not only in the polluted area but also in farther lands. Also, it has been observed that many secondary and high school students (aged 11-16) have lots of misconceptions, such as acid rain can cause the greenhouse effect and by that food may poison humans, ozone layer keeps the world warm or protects the planet from acid rains, ozone layer depletion causes greenhouse effect, and holes in the ozone layer would allow air to escape into space (Boyes and Stanisstreet, 1997, 2001; Boyes et al,. 1999; Bozkurt and Cansüngü, 2002; Selen et al., 2006). Aydın, and Coşkun (2010) asserted that some of 7th grade (aged 13 years) students define global warming as depletion or dilution of the ozone layer. Moreover, they think that the dilution of the ozone layer is because of the global warming.

There are various techniques to determine these cognitive structure and misconceptions. Extensive research has shown that cognitive structure and misconceptions related with ecology can be determined with various instruments such as open ended questions (Adeneyi, 1985; Brehm et al., 1986; Bishop and Anderson, 1990), multiple choice questions (Bishop and Anderson, 1990; Gallegos, Jerezano and Flores, 1994; Griffiths and Grant, 1985; Yörek et al., 2010), observations and interviews (Tekkaya, Çapa and Yılmaz, 2000; Tsai and Huang, 2001; Palmer, 1999; Yörek, et al., 2010), likert type scale (Bozkurt and Cansürgü, 2002). Besides these traditional assessment techniques, some alternative assessment techniques are also used such as word association tests, concept maps, concept webs, structured grids, estimation-observation-expression, diagnostic branched tree, drawings and explanations, flow map, two-tier diagnostic tests (Kurt, 2013; Shepardson, et al. 2011, Shavelson, 1974a; Shavelson, 1974b; Tsai, 2001; Tsai and Huang, 2002).

Word Association

Word association, as asserted in various studies, is an effective technique that is used to determine cognitive structure, misconceptions and to reveal relations between the concepts (Bahar et al., 1999; Bahar and Özatlı, 2003; Ercan et al., 2010; Gunston, 1980; Kurt, 2013; Nakiboğlu, 2008; Shavelson, 1974a, Shavelson, 1974b; Tsai and Huang, 2002). Students recall one or two word responses about the given keyword in a specific length of time in a word association test (WAT). The diversity of responses given for a keyword is used to determine their understanding in any subject. An ordered response given for a keyword by a student asserts relations between the concepts in their cognitive structure, and this shows semantic proximity. The closeness between the two concepts in the cognitive structure can be revealed by the responses (Bahar and Özatlı, 2003; Tsai and Huang, 2002; Shevelson, 1974a). For example, suppose, if the word “school” is given to students as a key concept, in response to, “teacher, lesson, book, garden and friend” are the given words by the students. It can be inferred that the relation between the “school and teacher” is closer than the relation between “school and friend” in the student’s cognitive structure. The number of responses related with the key concept “school” is directly proportional to the conceptual relation in the student’s cognitive structure. Ayas (2005) emphasised that both the amount of the students’ responses and the relation of these responses with the keyword is high. This means the cognitive structure is better. However, the quality of responses and the level of association between the relations of two different concepts are more important than the number of responses.

Shavelson (1974a) determined that there are four features in the evaluation of the word association. These are as follows: the number of the responses given to the key concept, the kind of responses, order of responses, and same responses given to two different key concepts (overlapping). In order to understand the number of relations among the concepts scaled that a person relates, the number of responses given for a word is an important clue and sign to determine if the word is understood or not by the person (Bahar et al., 1999; Shavelson, 1974a). However, the kinds of given responses should be taken into consideration. For example, the other student may respond “friend, garden, fun, naughtiness, break time” when he is asked to make word associations with the concept of “school”. According to this, it can be observed that students’ responses are different even the number of responses is equal in the two examples. A variety of responses can be examined from the responses, as first student’s answers have a certain context about the school in which it has both educational and social function, but the second student does not have the same ideas about school’s educational function. The given responses to the keyword should be expected to be associated with the context. However, in the given example, the answer “naughtiness” is an unexpected response. Consequently, it would be better to keep it out of the evaluation. Besides this, Gunston (1980) determined that even word association indicates a relation between the two concepts, but it cannot be fully asserted what the relation is. Although the two different students give the same responses for a keyword, they may structure the relation between the two concepts

differently. In order to overcome this limitedness, Gunston (1980) reorganised Shavelson's technique, in which, students construct a sentence including keyword and responses after completing the word association. He also determined that this sentence can be used in evaluating cognitive relation (Gunston, 1980). In this way, responses can be evaluated by making correct connection.

Matching responses between two key concepts show level of association between the concepts in student's cognitive structure. Garskoff and Houston (1963) determined relation between two concepts, as "Relatedness Coefficient" (RC) (Shavelson, 1974b; Bahar et al., 1999). According to this, for example, if P, Q, R and S are responses given for "Concept A", and same responses are given for "Concept B" in the same order. This means that there is a perfect relation among these two concepts, and their relatedness concept parameter is 1. If there is no overlapping between the two concepts then there is no relation among two concepts, and their relatedness concept parameter is 0 (Shavelson, 1974b; Bahar et al., 1999). Calculation of RC is illustrated in the method.

Bahar et al. (1999) used the concept web which is prepared with the help of Cutting Point (CP) technique for the evaluation of WAT. In this technique, a frequency distribution table for the given responses is prepared for each keyword, then less than 3 or 5 numbers are accepted as CP, which is the number of most repeated response in the table. For example, the word "teacher" is the most frequent answer to the key concept "school". CP can be accepted as 20 if this response is given by 25 students. Responses that have the frequency above 20 constitute the first line of the concept web. Responses below this frequency number are recorded to the upper part of the concept web and the concept web is completed by decreasing CP periodically in the same way (Figure 1a, 1b, 1c and 1d). From the concept web, students' cognitive structure related with the keywords, relationship of the concept with other concepts and the responses, and misconceptions can be determined.

Purpose

An effective environmental education plays a big role in realising the human activities that are the underlying causes of the environmental problems. It is also essential to understand the environment as a whole by leaving the anthropocentric idea. Difficulties for students in comprehending the complexity and the intricate structure of the nature might be very crucial in order to understand, protect, and make the environment better. Thus, in this study, we determined cognitive structures and misconceptions about basic ecological concepts by using "word association" tests on secondary school students (ages 12-14 years).

METHODOLOGY

Working group, data collection tool and data collection: In Turkey, environmental education is taught in different units of biology, social studies, and science lessons. But, important ecological subjects are undertaken especially in the science lesson at secondary school level. Thus, eighty-nine secondary school students, age between 12-14 years, participated in this study at the City Centre of Kocaeli, in the North-west of Turkey. To determine students' cognitive structures and misconceptions about ecological concept, Word Association Test (WAT) was used. Before WAT was generated, basic ecological concepts that took place in the secondary science curriculum were determined. Then these concepts; "environment", "species", "habitat", "population", "ecosystem", "food chain", "substance cycle", "biological diversity", "environmental pollution", "global warming", "acid rains" and "greenhouse effect" were identified as keywords. Each individual key word was listed separately on each page where ten lines were left below for possible responses. In order to prevent confusion every keyword was written at the beginning of each line. Bahar et al. (1999) explained that repeating keywords in every line, the chain effect, in other words preceding response prevents recalling background of the keyword. Also, students were asked to construct a related example sentence related with the given keyword in order to lower WAT's limitedness to remark correctness of relations among the given responses after every key concept. An example page layout is given below.

Environment: ……
Environment: ……
Environment: ……
Environment: ……
Environment: ……
Environment: ……
Environment: ……
Environment: ……
Environment: ……
Environment: ……
An example sentence related with environment:……..

It was determined that 30 s should be given for each of the keyword (Bahar et al., 1999; Nakiboğlu, 2008; Timur, 2012). However it was suggested to be more appropriate for secondary school students that the duration should be 60 s (Ercan et al., 2010). In this study, students age-group 12-14 years were considered and duration of 60 s was considered. However, the students constructed the sentences related with the key concept almost in 30 s. This study was conducted in December 2011. Students were introduced with WAT before the commencement of the study and an example was conducted with word "school". Actual participation was performed after being sure that all the students have understood their role in the study.

Analysis of data: Analysis of data was done in four steps: (1) determination of the responses given for the keywords, (2) calculation of the Relatedness Coefficient between the keywords, (3) formation of concept web that put forward the relation for the given responses to keywords, (4) analysis of constructed sentences for each keyword.

Primarily, for each keyword, response of each student is listed. Then, the number of repetition is determined for every response given for each keyword in the research group.

Garskoff and Houston (1963) used Relatedness Coefficient (RC) to determine the relation among keywords with one another (Bahar et al., 1999; Shavelson, 1974b). In RC (Table 1)

formula, $RC = \frac{\sum(A \times B)}{n^2 - 1}$, both the general responses that will be displayed in two keywords and the rank order of these responses are taken into account. Calculation of RC is displayed in the example below.

The rank orders of responses are sequenced according to the increased frequency, so lower one is considered as 1. According to the Table 1, there are five different responses to the keyword "greenhouse effect" and six different responses to the keyword "global warming". The responses: greenhouse gases, carbon dioxide and temperature rise are present in both the lists. 'A' is the rank order of common response in the first list; 'B' is the rank order in the second list. 'n' is the number of responses in the list containing several keywords. RC in keywords of "greenhouse effect" and "global warming" is calculated as shown in the example:

$$RC = \frac{\sum(A \times B)}{\sum n^2 - 1} = \frac{(4 \times 5) + (2 \times 6) + (1 \times 3)}{(6^2 + 5^2 + 4^2 + 3^2 + 2^2 + 1^2) - 1} = 0.39$$

Students' responses that have the misconception are excluded from the study during the calculation of RC for the concepts. Students' sentences related with the key concepts are analysed.

In forming concept web, Cut-off Point (CP) technique of Bahar et al. (1999) is used.

Finally, students' sentences about the keyword are subjected to content analysis. Sentences constructed by students are separated into different themes like: correct scientific knowledge (CSK), affective knowledge (AK), examples from daily life and/or smattering (EDL), misconception (MC) and vain/irrelevant/meaningless (VIM).

Validity and reliability: The keywords used in WAT have a key role in understanding the environmental subjects, and are part of the secondary science curriculum. After that, opinions of a biology professor and a teacher who had ten years experiences in science teaching were obtained to check the content validity.

All keywords were placed on separate pages. Also, responses to be given for a keyword were set to be written in different lines. Thus, it was aimed to be highly reliable that the given responses do not affect each other and the other keywords.

During the listing process of the given responses to the keywords, written sentences were inspected; and irrelevant responses were left out from the analysis. For example, for the keyword "population", a student answered: bicycle, pumping and air, and the example sentence was: "My friend's bicycle tire got flat and we pumped air". Therefore, the given response was not added to the analysis about population, and also this sentence was considered as in the theme of vain/ irrelevant/meaningless (VIM).To protect reliability two researchers encoded data independently about the sentences of responses. Data were classified according to their relation with each other; and sketch themes were determined. Then, the real themes were constructed after getting a consensus among the researchers.

And inter-rater reliability value was 97.5 %. Based on Miles and Huberman's criterion, which is a consistency value above 0.70, is acceptable, our inter-rater reliability is quite high. Also, some examples from the students' sentences are presented.

RESULTS AND DISCUSSION

Analysis of the number of given responses to the keywords: When student's responses to the keyword analysed, it was observed that the number of responses given to the keywords is 163 (Table 2). Given responses for the keywords "environmental pollution" and "global warming" were observed more than others. Understanding the relation between the concepts scale what the person relates; the number of responses given for a word is an important clue and sign that the meaning of that word understood by that person (Shavelson, 1974a; Shavelson, 1974b; Bahar et al., 1999). Thus, it can be said that students can structure the concepts of environmental pollution and global warming better. It is observed that these two issues have always remained on the agenda with recently increasing environmental problems.

However, the number of responses given to the keywords "biological diversity" and "population" were lower than others.

In word association test, not only number of responses but also accuracy of these responses is also important for determination of students' cognitive structure. When the responses for the keyword were inspected, it was seen that 23 of total responses were misconception (Table 2). Most of the misconception emerged keywords "substance cycle" and "greenhouse effect".

This means that these concepts were not constructed properly in students' cognitive structure.

Analysis of the relatedness coefficients between keywords: While determining students' cognitive structure, besides the number of students' responses, it is also important to put forward the relations between concepts in the students' cognitive structures (Bahar et al., 1999; Kurt et al., 2013; Shavelson, 1974a). In a WAT, number of overlapping responses, and rank order of these responses are indicators of the semantic proximity of the keywords (Shavelson, 1974a; Bahar et al., 1999).

In this study, the semantic proximity of the keywords was determined through Garskoff and Houston's relatedness coefficients (RC) which is calculated based on overlapping responses and rank order of these responses (Table 3).

Calculated RC regarding the responses of the students indicated that keywords in cognitive structures related to each other were very limited (Table 3). According to Table 3, the relationships between keywords Population-Biological Diversity were most close in the students' cognitive structure (RC=0.37). A relation though not strong (RC=0.22) was observed in the concept: Habitat–Environment and Species-Greenhouse Effect. Weaker relations ($0.10 < RC < 0.20$) were observed between: Species–Habitat, Species–Population,, Species–Biological Diversity and Acid Rain–Substance Cycle. After considering other RCs (≤ 0.10), it is possible to say that students almost could not bring in any relation between these concepts. Kurt et al. (2013) asserted that conceptual understanding is not only to know definition of

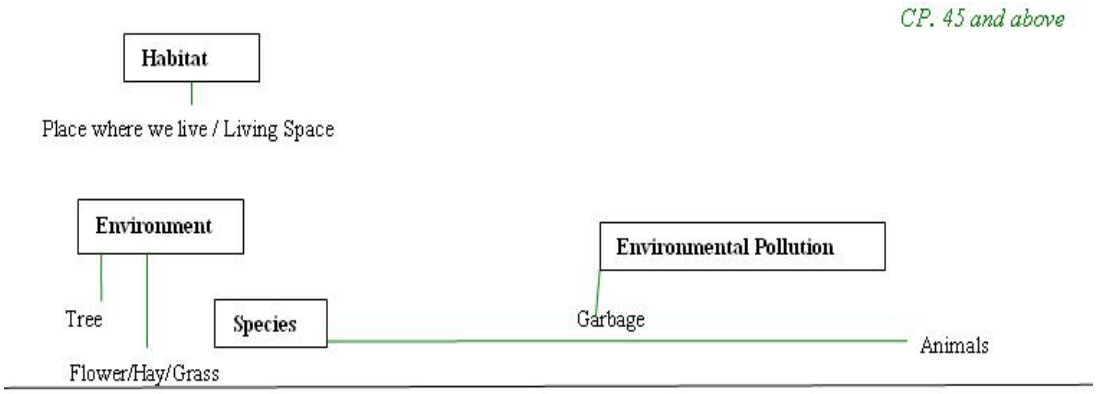

Figure 1a. Keyword concept web formed according to frequencies (CP 45 and above).

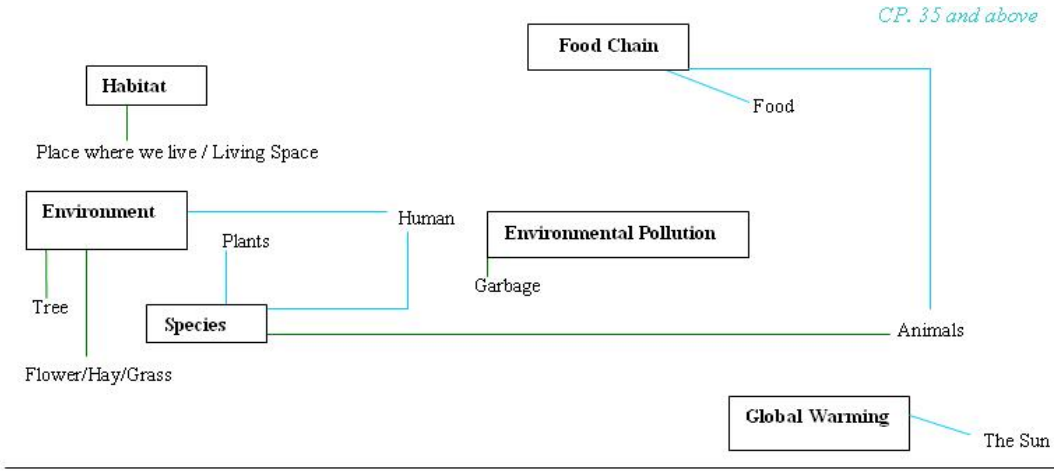

Figure 1b. Keyword concept web formed according to frequencies (CP 35-44).

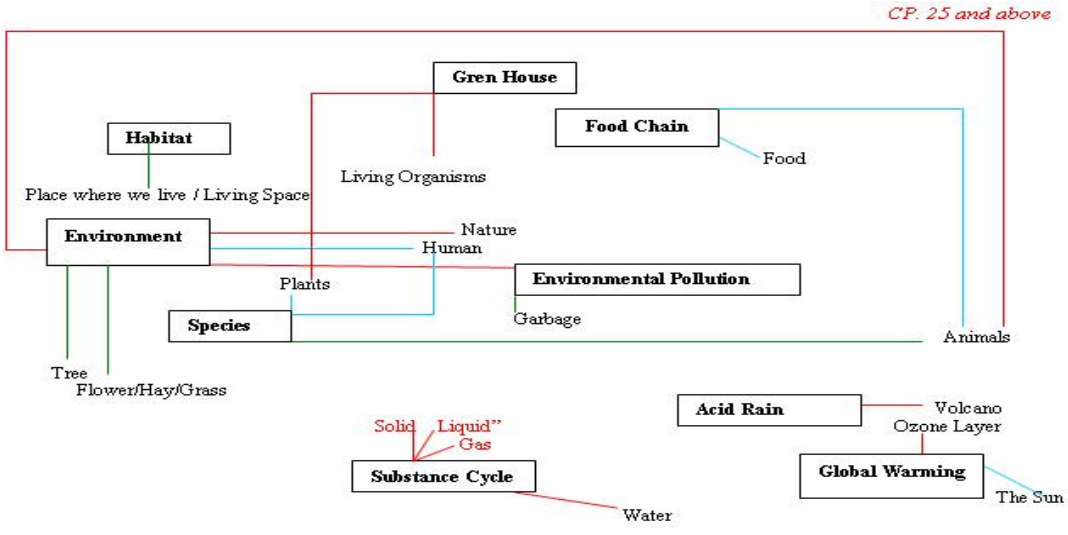

Figure 1c. Keyword concept web formed according to frequencies (CP 25-34).

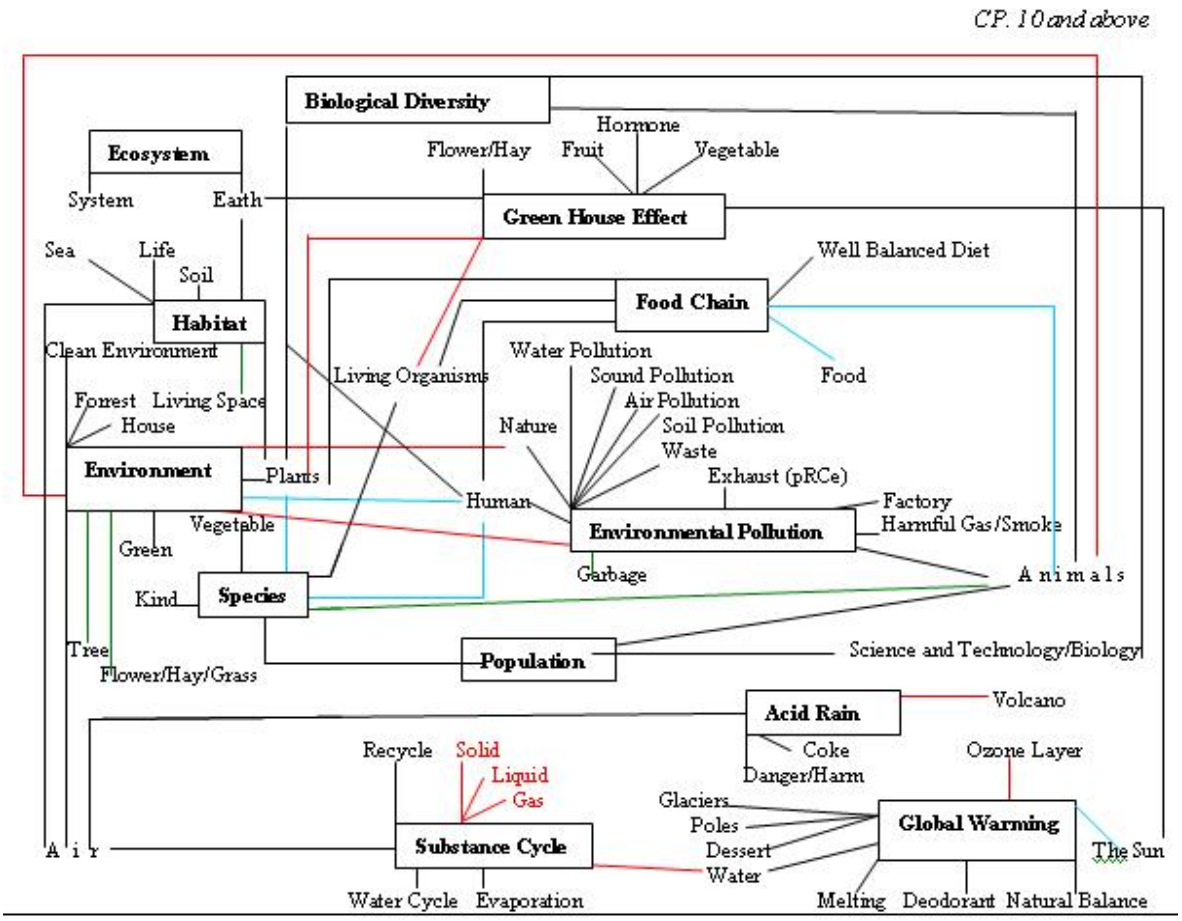

Figure 1d. Keyword concept web formed according to frequencies (CP 10-24).

Table 1. An example table for the frequency and rank order of the given answers.

Response	f	Rank order	Response	f	Rank order
Global Warming	20	5	Carbon dioxide **	20	6
Greenhouse Gases*	17	4	Greenhouse Gases *	18	5
Fossil Fuels	10	3	Atmosphere	12	4
Carbon dioxide**	8	2	Temperature rise ***	10	3
Temperature rise ***	3	1	Water vapour	5	2
			Melting of Poles	2	1

Key word = Greenhouse Effect; Keyword = Global Warming. */**/*** common response for the two keywords.

the concept, but also to be aware of relations between concepts especially in biology courses which contain the micro and macro relations among concepts. Ecological concepts have a close relation with each other, inability to relate them correctly, as a consequence, prevents students from understanding the environment holistically.

Analysis of the concept web: For a better understanding of students' cognitive structure about ecological concepts, the concept web was prepared (in Figure 1.a, 1.b, 1.c, and 1.d). It was figured out according to the students' responses to the keywords from higher to lower frequency. Thus, Figure 1.a is the strongest level of the web and Figure 1.d is the weakest level of the web.

Responses of CP 45 and above were given to "environment", "environmental pollution", "habitat" and "species" (Figure 1.a), and the number of these responses was

Table 2. The number of responses given to the keywords

The keyword	Number of responses	Number of misconceptions
Environmental Pollution	25	-
Global Warming	24	2
Environment	21	-
Habitat	20	-
Food Chain	20	1-
Substance Cycle	17	6
Greenhouse Effect	16	6
Species	14	3
Ecosystem	14	3
Acid Rain	13	1
Biological Diversity	7	-
Population	7	1
Total	163	23

restricted. For example tree and flower/hay/grass, which are only the living component of the environment, are given as responses related to "environment". When the responses of CP 35–44 were analysed, it was observed that responses added about keywords as "global warming" and "food chain", and the number of responses increased even less (Figure 1.b).

CP 25–34 for keywords "greenhouse effect", "substance cycle" and "acid rain" was added. The relation among keywords was formed only in "environment" and "environmental pollution". The students were not able to form a relation among other keywords yet. Responses as solid, liquid, gas about the "substance cycle" showed that students were confused between the substance cycle and the change of state (Figure 1.c).

While all of the keywords appeared only at a weakest level of the concept web (CP 10-24), the number of indicated responses was increased. In addition to the relation among the environment-environmental pollution appeared in the previous step, relation among the keywords as species-population and habitat-biological diversity could also be observed (Figure 1.d).

It was observed that students confused the concepts of the greenhouse effect and the greenhouse cultivation. While the responses of animals and plants were given for the keyword "biological diversity", micro-organisms could not be observed (Figure 1.d).

In responses given for the keyword "environment", non-living items except air and micro-organisms from the living components were included at all. The keyword "food chain" was confused with the balanced diet. This outcome shows parallelism with the studies of Griffiths and Grant (1985), and Munson (1991). Besides this, the responses sun, energy, carnivore, herbivore, etc. were not given to the keyword "food chain". Gallegos et al. (1994) determined that students thought that while the food chain consists of prey and predators, it does not include producers. In contrast, in our study, it was observed in the concept webs that students gave "plants" as response for the keyword "food chain", but they were not aware of "prey" and "predator" (Figure 1.d).

"Volcanoes" as natural reasons of "acid rain" were given as a response, but there were no examples given about the reasons of human origin by the students. Besides, a relation was suggested between the acid rain and fizzy drinks. In this step, another misconception appeared about the substance cycle indicating that there was confusion between the substance cycle and recycling. The responses about the variety of environmental pollution and reasons given were in CP range of 10–24. As associating environmental pollution with human, they also associated it with animals. The keyword "environmental pollution" was not associated with the keywords "acid rains", "greenhouse effect" and "global warming" (Figure 1.d).

The student's responses, even drawn in concept webs (Figure 1.a, 1.b, 1.c, and 1.d) proved that there was a weak relation among the ecological concepts displayed in Table 3. First conceptual relation Environment-Environmental Pollution only appeared in 3rd step (Figure 1.c). However, these two concepts' RC was only 0.13 (Table 2). Other relations that appeared in the concept web was in 4th step (Figure 1.d) that was observed between the Species-Population (RC=0.19) and Habitat-Biological Diversity (RC=0.03). These findings showed that students could not conceive any relation between these concepts. If ecological concepts do not relate in students' mind in the early grades, it might be difficult to repair this cognitive lack and develop cognitive structure.

Upon inspection of the concept webs (Figure 1.a, 1.b, 1.c, and 1.d), another issue appeared that most of the students' responses were not scientific information, but

Table 3. Relatedness coefficients of keywords.

	Species	Habitat	Population	Ecosystem	Biological Diversity	Environ. Pollution	Global Warming	Acid Rains	G. House Effect	Food Chain	Substance Cycle
Environment	0.01	0.26	0.03	0.05	0.03	0.13	0.03	0.03	0.06	0.10	0.01
Species	-	0.13	0.19	0.22	0.19	0.03	0.03	0.01	0.22	0.10	0.00
Habitat	-	-	0.04	0.08	0.03	0.06	0.08	0.04	0.04	0.04	0.02
Population	-	-	-	0.08	0.37	0.01	0.02	0.02	0.02	0.03	0.00
Ecosystem	-	-	-	-	0.06	0.02	0.05	0.02	0.06	0.03	0.00
Biological Diversity	-	-	-	-	-	0.01	0.01	0.00	0.05	0.04	0.00
Environmental Poll.	-	-	-	-	-	-	0.04	0.05	0.01	0.03	0.02
Global Warming	-	-	-	-	-	-	-	0.04	0.03	0.02	0.03
Acid Rain	-	-	-	-	-	-	-	-	0.02	0.02	0.12
Greenhouse effect	-	-	-	-	-	-	-	-	-	0.02	0.04
Food Chain	-	-	-	-	-	-	-	-	-	-	0,00

came from instances occurring in the daily life. Responses about ecosystem, biological diversity, population and the greenhouse effect were rare. It means that students did not have a deep understanding about these subjects in their cognitive structure (Shavelson, 1974a; Shavelson, 1974b; Bahar et al., 1999; Nakiboğlu, 2008; Gunston, 1980). For example “Science and technology/biology” related responses which were given to the keywords "population" and "greenhouse effect" showed that there were deficiencies in students’ cognitive structure even though they were aware of these concepts related with science.

It was found, upon analyses of keywords “food chain” and “acid rain” that students were not able to figure out the theoretical structure in their minds when the responses were given for these words. It was seen that studies of Marinopoulos and Stavridou (2002), Özkan et. al. (2004); Boyes and Stanisstreet (2001), Selen Darçın et. al. (2006) are support by this result, too.

The given responses related with the keyword “environment” were as follows: cigarette butt, mathematics, freedom, etc.; responses related with the keyword “species” were computer, jewellers, sport, etc.; responses related with the keyword “habitat” were sound and paper; responses related with the keyword “greenhouse effect” were space and wind; all of these examples showed that students could not relate the ecological concepts in their mind correctly.

Analysis of the sentences: Deficiency in cognitive structure can be observed in students’ sentences about the keywords. 32.1% of sentences that students constructed about the keywords were evaluated as vain/irrelevant/meaningless. For example, “I did not understand the meaning of population” (KW=population), “Science course is fun” (KW=population), “I like milk and dairy products” (KW=biological diversity); sentence like these were placed in this category (Table 4).

It seems that most of the sentences (26.3%) constructed were from daily life or smattering (EDL), for example, “I saw many flowers” (KW=species); “We are taught the substance cycle in the science lesson” (KW=substance cycle), “World is trying to cope with global warming” (KW=global warming), etc. Connel et al. (1999) indicated that some young people (aged 16-17 years) think personal experiences are most trusted source of environmental information. Our findings concluded that most of the students used their knowledge gained from daily life experiences, not based on scientific information, in their sentences. Only 10.3% of the sentences contained correct scientific knowledge (CSK) (Table 3). Maximum sentences that contain CSK were for keyword “Habitat” (34.8 %); fewer sentences that contain CSK were for “Biological Diversity” (3.4 %), “Environment” (4.5 %) and “Acid Rain” (4.5 %). It is remarkable that students’ sentences about “population” contained no CSK. Sentences containing CSK are given in Table 5. The term “habitat” is not used in daily life (in Turkish). Thus, the students knew it only in scientific context, so number of sentences which included CSK was highest for this keyword. However, the terms “diversity”, “environment”, etc. might be used in different meaning in daily life and science. So this might cause conflicts in students’ cognitive structure. As well, vernacular misconceptions might also be a problem. Similarly, Jegede and Aikenhead (1999) determined that clashes between students’ life-words and science prevent them from learninh science effectively and meaningfully.

12% of the students made sentences containing affective knowledge (AK) such as “I like environment”

Table 4. Frequencies according to category of sentences related with keywords

The keyword (KW)	CSK		AK		EDL		MC		VIM	
	f	%	f	%	F	%	f	%	f	%
Environment	4	4.5	49	55.1	24	27.0	10	11.2	2	2.2
Species	11	12.4	4	4.5	51	57.3	15	16.9	8	9.0
Population	0	0	0	0	9	10.1	11	12.4	69	77.5
Habitat	31	34.8	3	3.4	26	29.2	11	12.4	18	20.2
Ecosystem	5	5.6	4	4.5	9	10.1	16	18.0	55	61.8
Food Chain	18	20.2	7	7.9	19	21.3	28	31.5	17	19.1
Substance Cycle	5	5.6	5	5.6	20	22.5	19	21.3	40	44.9
Biological Diversity	3	3.4	8	9.0	10	11.2	9	10.1	59	66.3
Environmental Pollution	14	15.7	30	33.7	34	38.2	7	7.9	4	4.5
Global Warming	10	11.2	12	13.5	30	33.7	26	29.2	1	12.4
Greenhouse Effect	5	5.6	2	2.2	4	4.5	42	47.2	36	40.4
Acid rains	4	4.5	1	1.1	44	49.4	16	18.0	24	27.0
Total	110	10.3	128	12.0	281	26.3	190	17.8	343	32,1

CSK, Correct Scientific Knowledge; AK, Affective Knowledge; EDL, Examples from Daily Life or Smattering; MC, Misconception; VIM, vain/ irrelevant /meaningless.

Table 5. Examples containing correct scientific knowledge that students made.

The keyword	Example sentence
Environment	There are lots of animal species in our environment.
	Environment is a place in which there are natural items such as rose, bird, tree, rock.
Species	Diversity in species makes us different.
	Different species increase biological diversity.
	Species breed simply in class of their own.
Habitat	Habitat means living space.
	Every living organism has its own living space.
Ecosystem	Polar bears live in polar ecosystem.
	The Earth comes to my mind on the count of ecosystem.
Food Chain	Lions are on the top of the food chain.
	Food chain means; creatures' eating each other in order to feed.
Substance Cycle	It rains thanks to substance cycle.
	Substance cycle does not exist in all substances.
Biological Diversity	Biological diversity occurs thanks to adaptation.
Environmental Pollution	If the environmental pollution cannot be prevented our living space dies out.
	Unplanned urbanisation causes environmental pollution.
Global Warming	Icebergs are melting because of global warming.
Greenhouse Effect	Greenhouse effect causes global warming.
Acid Rain	Acid rains may occur, after the eruption of a volcano.

(KW=environment), "protect ecosystem" (KW=ecosystem)", "biological diversity is crucial" (KW=biological diversity) (Table 4). The sentences containing misconceptions were 17.8%. The sentences containing the highest misconception were related with the keywords "greenhouse effect" (47.2%), "food chain" (31.5%), "global warming" (29.2%), and "substance cycle" (21.3%). Less misconception appeared in sentences related with "environmental pollution" (7.9%), "biological diversity" (10.1%) and "environment" (11.2%) (Table 4).

When the sentences were inspected extensively, it was observed that students had many misconceptions about keywords (Table 6). It is inferred that students could not comprehend the complex structure of the environment. By the study of Özkan et al. (2004), it has been observed that there are similar misconceptions as the environment

is formed only from living organisms and plants. Besides, remarking the occurrence of the sun in the environment is confused with the concept of ecosystem.

When the misconceptions about species were inspected, it was observed that students confused the concept of species with subspecies, kingdom, phylum and genus. They thought species means gender. Besides, they have confusion about the concept "species" with the vernacular word "kind". Also, Munson (1991) remarked that students cannot understand the relation that different species have their own needs and each species has different effects on ecosystem.

Another misconception is remarked in the concepts of population and inhabitants. Students could not notice that population is a biome formed from the same species inhabiting in an area. They had the misconception that all the plants and animals together is the population. This output is in agreement with the findings of Adeneyi (1985) and Tekkaya et al. (2000).

It is also remarked that students had misconceptions related with the habitat such as: it is a place that animals live; it means struggle for life; it is only a forest, and it is a place that only fish and animals live. Besides, it was observed that the concept of ecosystem was confused with habitat, biological diversity and food chain in the sentences. Also, studies performed by Adeneyi (1985), Sander et al. (2006), and Jordan et al. (2009) determined that students have misconceptions like confusing habitat with the ecosystem, and it belongs only to terrestrial/aquatic animals.

In the sentences formed about the keyword "ecosystem", emphasis on systems that formed organs of living organisms and space showed that boundaries of the ecosystem could not be recognised. Students had a misconception like: ecosystem is formed only by living organisms. This outcome displays parallelism with the studies of Brehm et al. (1986), and Prokop et al. (2007). Another outcome is that micro-organisms as living organisms and non-living members of the ecosystem could not be recognised. Similarly, Adeneyi (1985) put forward that students are not aware of the relation among living and non-living things of ecosystem. Also, Palmer (1999), and Yörek et al. (2010) put forward that students cannot realise the role of bacteria and decomposers.

Students have confusion about concepts of food chain, food web and healthy diet. Also, a number of articles on this subject state that concept of food chain and food web is confused (Griffiths and Grant, 1985; Munson, 1991). In this study, when sentences were inspected it was observed that students did not notice food chain is formed by producers, consumers, decomposers and a flow of energy that starts from the sun. Also, Griffiths and Grant (1985), Hogan (2000), Özkan et al. (2004) and Yörek et al. (2010) determined that students could not comprehend that energy follows in the food chain.

The change of state of substance cycle in the ecosystem and substance cycle related to water cycle was also confused. Furthermore, following misconceptions were observed too: substance cycle is change of state; biological diversity occurs only in animals and plants, and human beings are entirely different from these creatures.

Misconception that students related to the environmental pollution was "only garbage that is thrown away causes environmental pollution", and they had no information about other kinds of pollutants that cause serious issues. It was also observed students had inadequate information about the kinds of environmental pollution. When their sentences were analysed, it was apparent that they had misconceptions like: global warming causes depletion of the ozone layer, melting of icebergs causes global warming, or global warming is effective only in a certain area, and it is relevant to seasons. Similar outputs are remarked in studies of Aydın and Coşkun (2010) and Selen Darçın et al. (2006). Most observed misconception about the greenhouse effect is its confusion with green housing. Study of Shepardson et al. (2011) supports these findings. According to the same study, most of the students explain greenhouse effect as solar rays or heat that come from the sun. They also thought that greenhouse is a layer of gas that is not venting to atmosphere and this layer is sending these solar rays back to the earth which consequently causes heating. Besides, other misconceptions were also observed, e.g. it is the depletion of the ozone layer or the cause of the depletion of the ozone layer. This outcome is similar with the studies of Boyes and Stanisstreet (1997, 2001), Boyes et al. (1999), Bozkurt and Cansüngü (2002) and Selen Darçın et al. (2006).

Misconceptions among students for both, in the formation of acid rain and its effects, were observed. They believed that acid rain is formed only because of volcanoes and it burns and poisons the things it touches. In their studies, Marinopoulos and Stavridou (2002) put forward that students could not comprehend that acid rain is formed because of contaminators that can be both physical and chemical, and effective above the polluted areas. These misconceptions show that students confuse environmental problems with one another. For example, they think "greenhouse effect is the same thing as acid rain" as determined in the studies of Bozkurt and Cansüngü (2002) and Selen Darçın et al. (2006).

Conclusion

In conclusion, this study, which was held by using word associations, put forward that most of the students had weak cognitive structure and lots of misconceptions about ecological concepts. The close relations among these subjects with each other could not be built in students' cognitive structure. Although students were

Table 6. Students' sample sentences containing misconceptions

The keyword	Sample sentences
Environment	A place where trees and creatures live.
	Laws of nature come to mind on the count of environment.
	Groups of plants are formed by forests.
	Composed of human, nature and flowers.
	A healthy place formed of plants, tress and the sun.
Species	Every species has its own species.
	There are different species of animals. For example, reptiles, mammals.
	Three kinds of species: humans, animals, plants.
	There are many genera of creatures on earth.
	Man and woman are species
	There are many plants, animals and human on the Earth.
Population	Population is increasing gradually.
	All creatures are in a population.
	Population forms society.
	Animals are population.
Habitat	It is a place that creatures live.
	Habitat is a cave and bears live in there.
	Place that animals live.
	Habitat is a forest.
	Animals and fishes live in a habitat.
Ecosystem	Ecosystems are not intertwined.
	Ecosystem is made by planets.
	Humans form an ecosystem.
	Ecosystem is living organism's diversity.
	Ecosystem is a living space
Food Chain	Living organisms form ecosystem by eating each other.
	We should have a regular diet to be healthy.
	If the food chain disappears, life becomes difficult.
	Most of the animals are carnivore.
	Food chain is formed by animals and human beings.
	Human beings and animals' food chain is different.
	Food chain is a cycle in which one living organism eats the other.
Substance Cycle	Substance cycle occurs by melting, freezing and evaporation.
	Paper and plastic recycling is made by machines.
Biological Diversity	Animals and plants form the biological diversity.
	Human beings are very different from others.
Environmental Pollution	Throwing butchered animals' organs away causes environmental pollution.
	Pollution is separated into three parts; environmental, water and air pollution.
	Environmental pollution means there is garbage everywhere.
Global Warming	Global warming may increase in summer.
	Global warming occurs because of melting icebergs.
	There is global warming in America.
Greenhouse Effect	Greenhouse effect is the absence of the ozone layer.
	Greenhouse effect depletes the ozone layer.
	We can grow some of the fruits and vegetables faster thanks to the greenhouse effect
Acid Rain	Acid rain is poisoned.
	Acid rain burns things that they touch.
	Volcanoes erupt, then mixed with rain and this make people ill.
	Acid rains would not happen if there were no volcanoes.

aware of environmental problems, they were deficient in scientific information about reasons and effects of these problems. They were not conscious of environmental problems whose effects are far and wide. This case shows that we are not sufficient in environmental education and training.

Difficulties in environmental education may emerge because of the quality and content of the curriculum and course books, which does not comply with the goals and objectives of environmental education, and gives importance to the theoretical and rote learning rather than practical education (Atasoy and Ertürk, 2008). Some difficulties in the way of an effective environmental education can be summarised as follows: explanation inconsistency of goals and principles in preparing curriculum; environmental activities are not practiced because of the need for equipment, and lack of expert teachers in environmental education (Gökdere, 2005). The other problem in the environmental education is school active-ties. There are various, but not adequate for effective environmental education. These are also important factors in environmental education: teachers as the implementers of the curriculum, their level of pedagogical content knowledge regarding the environment, guidance from teachers and parents, and news regarding the environment in the media (Erdoğan and Uşak, 2009). Hudson (2001) determined that today's adult had more opportunities than today's children to interact with nature directly in their childhood, but today's children can access more information about the environment through TV (documentaries, nature shows, etc.), online resources, CD-ROM, etc. However, this new information sources are not considered in the environmental education curricula. Curricula must provide a continuum of opportunities from online to hands-on (Hudson, 2001).

Most of the misconceptions determined in this study were in the "conceptual misunderstandings" category, for instance, confusions about substance cycle with the change of state, incomprehension of boundaries of the ecosystem, confusion about the concept of species, subspecies, kingdom, phylum and genus. In addition, "factual misconceptions" were frequently observed in the study. Factual misconceptions of the students, such as global warming affects only a region, environmental pollution is formed of only litter, environment consists of only animals, plants, and trees, often arise in early age because of the conversation of daily life, misinterpretation of news and what they heard, etc. Finally, in this study, several vernacular misconceptions, such as population means inhabitants, greenhouse effect means greenhouse cultivation, species means sort in colloquial language, were observed. In order to restructure their knowledge with scientific information, firstly, students' misconceptions should be determined and classified. After that, these students should be made aware of the misconceptions (Committee on Undergraduate Science Education, 1997). In this way, the students can be questioned for information and restructure their knowledge under the control of their teachers.

IMPLICATIONS

1. This study shows that students had a week cognitive structure and had no scientific knowledge about ecological concepts. Most of the students' responses were superficial knowledge acquired in daily life and contained many misconceptions. To work things out, teachers should consider existence of such misconceptions and reinforce students' daily knowledge with scientific knowledge during the learning period.
2. Teachers' should keep misconceptions in mind, not only before the education but also during the education period. It is important to correct misconceptions and prevent new ones to occur. Hence, it is important for teachers to have pedagogic infrastructure on determination and elimination of misconceptions during the pre-service and in-service training.
3. Priority should be given to studies that determine effective teaching methods for improving students' cognitive structure, and break down the misconceptions. Developing effective teaching materials by various activities and experiments is also essential to provide rich teaching material to teachers.
4. It was observed that students' level of affective knowledge about the environment and environmental problems was high. This sensibility should be used for removing students' deficiencies about scientific fundamentals.
5. Environmental subjects and concepts have a close relation with each other. In elementary curricula, this close relation must be taught correctly, and subjects must be organised according to students' comprehensive environments' holistic structure. During the organisation of environmental subjects in curriculum importance of extra-curricular activities should also be kept in mind. Such extra-curricular elements can include, but are not limited to, visuals; such as documentaries, posters; real life items such as magazines, newspapers, news. They should be used to reinforce the students' knowledge about the subject.
6. Studies determining cognitive structures, and misconceptions in biological diversity, and substance cycle are extremely restricted in the literature. More studies should be carried out for these subjects to make students' problems clearer.
7. In this study, it has been observed that word association is an effective method to determine cognitive structures and misconceptions. Word association technique can be used in different concepts, subjects and fields.

LIMITATIONS

This study aimed to put forward that students' conceptualization of basic ecological concepts. Word association could not exhibit the whole understanding of ecology and ecological consciousness. For example we could not determine that students are aware of the cause and effect relationship in the ecosystem or not. This was not the aim of this study, but following studies should focus on this aspect.

Conflict of Interests

The author has not declared any conflict of interest.

REFERENCES

Adeniyi EO (1985). Misconceptions of selected ecological concepts held by some Nigerian students. *J. Biological Educ.* 19(4):311–316. doi: 10.1080/00219266.1985.9654758E

Alparslan C, Tekkaya C, Geban Ö (2003). Using the conceptual change instruction to improve learning*, J. Biological Educ*. 37(3):133-137. doi: 10.1080/00219266.2003.9655868.

Atasoy E, Ertürk H (2008). İlköğretim öğrencilerinin çevresel tutum ve çevre bilgisi üzerine bir alan araştırması. *Erzincan Eğitim Fakültesi Dergisi*, 10(1):105-122. Retrieved from http://eefdergi.erzincan.edu.tr/article/view/1006000671

Ayas A (2005). Kavram öğrenimi [Learning Concept]. In Çepni, S. (Ed). *Fen ve teknoloji öğretimi* [Teaching Science and Technol. (pp.65-90). Ankara: PegemA Yayıncılık.

Aydın F, Coşkun M (2010). Global warming perceptions of primary education 7th grade students in Turkey. *World Appl. Sci. J.* 10 (4):426–432. Retrieved from http://idosi.org/wasj/wasj10%284%29/9.pdf

Bahar M (2003). Misconceptions in biology education and conceptual change strategies. *Educ. Sci. Theory Practice* 3(1):55-64. Retrieved from https://edam.com.tr/kuyeb/en

Bahar M, Özatlı NS (2003). Kelime iletişim test yöntemi ile lise 1. sınıf öğrencilerinin canlıların temel bileşenleri konusundaki bilişsel yapılarının araştırılması. *Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Dergisi.* 5(2):75–85. Retrieved from http://fbe.balikesir.edu.tr/dergi/

Bahar M, Johnstone AH, Sutcliffe RG (1999). Investigation of students' cognitive structure in elementary genetics through word association tests. *J. Biological Educ.* 33(3):134–141. doi: 10.1080/00219266.1999.9655653

Bishop, B. A. & Anderson, C. W. (1990). Student conceptions of natural selection and its role in evolution. *J. Res. Sci. Teach.* 27(5):415–427. doi: 10.1002/tea.3660270503

Boyes E, Stanisstreet M (1997). Children's models of understanding of two major global environmental issues (ozone layer and greenhouse effect). *Res. Sci. Technol. Educ*. 15(1):19-28. doi: 10.1080/0263514970150102

Boyes E, Stanisstreet M (2001). School students' ideas about the "greenhouse effect". *Canadian J. Environ. Educ*. 6(1):77-101. Retrieved from http://cjee.lakeheadu.ca/index.php/cjee/article/view/289

Boyes E, Stanisstreet M, Papantoniou VS (1999). The ideas of Greek high school students about the "ozone layer". *Sci. Educ*. 83(6):724–737. doi: 10.1002/(SICI)1098-237X(199911)83:6<724::AID-SCE5>3.0.CO;2-P

Bozkurt O, Cansüngü Ö (2002). İlköğretim öğrencilerinin çevre eğitiminde sera etkisi ile ilgili kavram yanılgıları. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi* 23:67-73. Retrieved from http://www.efdergi.hacettepe.edu.tr/

Brehm S, Anderson CW, DuBay J (1986, June). *Ecology: A teaching module* (Occasional Paper no. 94). Retrieved from http://www.eric.ed.gov/PDFS/ED273445.pdf

Brown D, Clement J (1991). Classroom teaching experiments in mechanics. In Committee on Undergraduate Science Education (1997). *Science teaching reconsidered a handbook.* National Washington, D.C.: Academy Pres

Buluş Kırıkkaya E, Güllü D (2008). Fifth grade students' misconceptions about heat-temperature and evaporation – boiling. *Elementary Educ. Online*, 7(1):15-27. Retrieved from http://ilkogretim-online.org.tr/vol7say1/v7s1m2.pdf

Committee on Undergraduate Science Education (1997). *Science teaching reconsidered a handbook*. National Washington, D.C.: Academy Pres

Connel S, Fien J, Lee J, Sykes H, Yencken D (1999). If it doesn't directly affect you, you don't think about it': A qualitative study of young people's environmental attitudes in two Australian cities. *Environ. Educ. Res. 5*(1):95-113. doi: 10.1080/1350462990050106

Ercan F, Taşdere A, Ercan N (2010). Kelime ilişkilendirme aracılığıyla bilişsel yapının ve kavramsal değişimin gözlenmesi. *J. Turk. Sci. Educ. 7(2)*:136–154. Retrieved from http://www.tused.org/internet/tused/default13.asp

Erdoğan M, Uşak M (2009). Curricular and extra-curricular activities to develop the environmental awareness of young students: A case from Turkey. *Educ. Sci*. 11(1):73-86. Retrieved from http://hrcak.srce.hr/

Gallegos L, Jerezano M, Flores F (1994). Preconceptions and relations used by children in the construction of food chains. *J. Res. Sci. Teach.* 31(3):259–272. doi: 10.1002/tea.3660310306

Garskoff BE, Houston JP (1963). Measurement of verbal relatedness: an idiographic approach. *Psychological* Review 70(3):277-288. in Bahar, M.; Johnstone, A. H. and Sutcliffe, R. G. 1999. Investigation of students' cognitive structure in elementary genetics through word association tests. *J. Biological Educ. 33(3)*:134–141. doi: 10.1080/00219266.1999.9655648

Griffiths AK, Grant BAC (1985). High school students' understanding of food webs: Identification of a learning hierarchy and related misconceptions. *J. Res. Sci. Teach*. 22(5):421–436. doi: 10.1002/tea.3660220505

Gökdere M (2005). A study on environmental knowledge level of primary students in science education. *Asia-Pacific Forum on Sci. Learn. Teach*. 6(2). artical 5. Retrieved from http://www.ied.edu.hk/apfslt/v6_issue2/gokdere/

Gunston RF (1980). Word association and the description of cognitive structure. *Res. Sci. Educ.* 10:45-53.

Hogan K (2000). Assessing students' systems reasoning in ecology. *J. Biological Educ.* 35(1):22-28. doi: 10.1080/00219266.2000.9655731

Hudson SJ (2001). Challenges for environmental education: Issues and ideas for the 21st century. *BioScience,* 51(4): 283-288. doi: 10.1641/00063568(2001)051[0283:CFEEIA]2.0.CO;2

Jegede OJ, Aikenhead GS (1999). Transcending cultural borders: Implications for science teaching. *J. Sci. Technol. Educ*. 17(1):45-66. doi:10.1080/0263514990170104

Jordan R, Steven G, Demeter M, Lui L, Hmelo-Silver CE (2009). An Assessment of students' understanding of ecosystem concepts: Conflating ecological systems and cycles. *Appl. Environ. Educ. Commun*. 8(1):40-48. doi: 10.1080/15330150902953472

Kurt H (2013). Biology student teachers' cognitive structure about "Living thing". *Educ. Res. Rev*. 8(12):871-880. doi: 10.5897/ERR2013.1408

Kurt H, Ekici G, Aksu Ö, Aktaş M (2013). Determining cognitive structures and alternative conceptions on the concept of reproduction (The Case of Pre-Service Biology Teachers). *Creative Education*, 4(9), 572-587. doi: 10.4236/ce.2013.49083

Marinopoulos D, Stavridou H (2002). The influence of a collaborative learning environment on primary students' conceptions about acid rain. *J. Biological Educ.* 37(1):18-25. doi:10.1080/00219266.2002.9655841

Miles MB, Huberman AM (1994).Qualitative data analysis. USA: Sage Publication.

Munson HB (1991). Relationships between an individual's conceptual

ecology and the individual's conceptions of ecology. PhD diss., University of Minnesota, Minneapolis. In Munson, H. B. (1994). Ecological misconceptions. *J. Environ. Educ.* 25(4):30–34. doi: 10.1080/00958964.1994.9941962

Nakiboğlu C (2008). Using word associations for assessing non major science students' knowledge structure before and after general chemistry instruction: the case of atomic structure. *Chemistry Educ. Res. Practice* 9:309-322. doi: 10.1039/B818466F

Özkan Ö, Tekkaya C, Geban Ö (2004). Facilitating conceptual change in students' understanding of ecological concepts. *J. Sci. Educ. Technol*. 13(1):95-105. doi: 1059-0145/04/0400-0095/0

Palmer DH (1999). Exploring the link between students' scientific and nonscientific conceptions. *Sci. Educ.* 83(6):639-653. doi: 10.1002/(SICI)1098-237X(199911)83:6<639::AID-SCE1>3.0.CO;2-O

Prokop P, Tuncer G, Kvasnicak R (2007). Short-term effects of field programme on students' knowledge and attitude toward Biology: a Slovak experience. *J. Sci. Educ. Technol*. 16(3):247-255. doi: 10.1007/s10956-007-9044-8

Sander E, Jelemenská P, Kattmann U (2006). Towards a better understanding of ecology. *J. Biological Educ*. 40(3):119-123, doi:10.1080/00219266.2006.9656028

Selen Darçın E, Bozkurt O, Hamalosmanoğlu M, Köse S (2006). Misconceptions about greenhouse effect. *Int. J. Environ. Sci. Educ.* 1(2):104 – 115. Retrieved from http://www.ijese.com/Darcin.pdf

Shavelson RJ (1974a). Methods for examining representations of a subject matter structure in a student's memory. *J. Res. Sci. Teach.* 11(3):231-249.

Shavelson RJ (April, 1974b). Some methods for. examining content structure and cognitive structure in mathematics instruction. Paper presented at the annual meeting of the American Educational Research Association. ED 090 035 Retrieved from http://files.eric.ed.gov/fulltext/ED090035.pdf on 10.30.2014

Shepardson DP, Choi S, Niyogi D, Charusombat U (2011). Seventh grade students' mental models of the greenhouse effect. *Environ. Educ. Res*. 17(1):1-17. doi: 10.1080/13504620903564549

Tekkaya C, Çapa Y, Yılmaz Ö (2000). Biyoloji öğretmen adaylarının genel biyoloji konularındaki kavram yanılgıları. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi* 18:140-147. Retrieved from http://www.efdergi.hacettepe.edu.tr/

Timur S (2012). Examining cognitive structures of prospective preschool teachers concerning the subject "force and motion". *Educational Sciences: Theory and Practice*. (Special Issue, Autumn), 3039-3049. Retrieved from http://www.edam.com.tr/kuyeb/en/

Tsai CC (2001). Probing students' cognitive structures in science: the use of a flow map method coupled with a meta-listening technique. *Stud. Educ. Evalua.* 27(3):257-268. doi: 10.1016/S0191-491X(01)00029-3

Tsai CC, Huang CM (2001) Development of cognitive structures and information processing strategies of elementary school students learning about biological reproduction. *J. Biological Educ*. 36(1):21-26. doi: 10.1080/00219266.2001.9655791

Tsai CC, Huang CM (2002). Exploring students' cognitive structures in learning science: a review of relevant methods. *J. Biological Educ*. 36(4):163-169. doi: 10.1080/00219266.2002.9655827

Vosniadou S, Ioannides C (1998). From conceptual development to science education: A psychological point of view. *Int. J. Sci. Educ*. 20(10):1213–1230. doi: 10.1080/0950069980201004

Yörek N, Uğurlu İ, Şahin M, Doğan A (2010). Qualitative investigation of Students' understanding about ecosystem and its components. *Natura Montenegrina*, 9(3):973-981. Retrived from http://www.pmcg.co.me/NM9/Yorek%20et%20al%20ISEM4.pdf