academicJournals

Vol. 10(16), pp. 2207-2215, 23 August, 2015
DOI: 10.5897/ERR2015. 2386
Article Number: BE3174D54770
ISSN 1990-3839

http://www.academicjournals.org/ERR

Educational Research and Reviews

Full Length Research Paper

The effect of recycling education on high school students' conceptual understanding about ecology: A study on matter cycle

Ilker Ugulu, Nurettin Yorek*, and Suleyman Baslar

Faculty of Education, Dokuz Eylul University, Izmir, Turkey.

Received 4 July, 2015; Accepted 7 August, 2015

The objective of this study is to analyze and determine whether a developed recycling education program would lead to a positive change in the conceptual understanding of ecological concepts associated with matter cycles by high school students. The research was conducted on 68 high school 10th grade students (47 female and 21 male students). The research has been contextualized as a quasi-experimental design model with pretest-posttest control group and the EECUT Test was applied to the students in the research group prior to and after providing them with the respective courses with an aim to determine the effects of the Recycling Education Program (REP) on the conceptual understanding of ecological concepts by high school students. Based on the results a significant difference in the conceptual understanding of the students included in the respective experimental and control group was identified in the answers given to the EECUT WC and EECUT CC questions.

Key words: Recycling, education, ecology, matter cycle.

INTRODUCTION

Industry and technology that developed at an un-believable rate with the industrial revolution first changed the production and consumption understanding of the people, and negative changes in the cultural environment with the nature and natural events that occurred after this led to environmental problems and its much quicker increase (Ugulu et al., 2014). Although this process seems to increase the life quality and comfort of people on one hand, it started to show its real effect in the following years (Marshall and Toffel, 2005). The unconscious use of the resources, and throwing industrial waste as if the environment will never be polluted occurred as the real consequences of the process of industrialization that developed in an uncontrolled manner (Dogan et al., 2010). As a result of the decrease in the resources used as if it would never extinct, industrial institutions fell short of raw materials and started to consider ways of creating new sources although they are expensive (Akın, 2007). More importantly, it is believed that this is going to be worse in the next years. In short, a great majority of human beings have already started to discuss whether the benefit or harm of the developing technology is more (Ugulu et al., 2014).

Without a doubt, the real responsible for environmental

*Corresponding author. E-mail: nurettin.yorek@deu.edu.tr

problems and the great damage that occurs is not the process of industrialization. The fact that the process of industrialization takes place in an uncontrollable manner and individuals turn into consumption monsters constitutes the basis of the problems. Thus, environmental problems are actually educational problems as they result from the attitudes and behaviours of human beings. Education is the most important means of changing people's negative behaviours and gaining them terminal behaviours and ensuring that people as individuals get to know and develop themselves and their environment (Yorek et al., 2010). Thus, the environmental education that ensures the development of the science of environment in all segments of the society; gaining environmentally-sensitive, permanent and positive behavioural changes; protecting the natural, historical and cultural values; ensuring the active participation in the solution of environment-related problems; making people understand their mutual relations and interactions among themselves and their cultural and biological environments, and gaining appropriate behaviours for its protection is the primary and most important factors in preventing environmental problems (Republic of Turkey Ministry of Environment 1997).

In the light of all these data and the relevant literature, it was observed that there are problems in terms of the adequacy and sustainability of the practices applied in many institutions (schools, municipalities, government offices) with regard to sustainability. Considering the contributions of recycling in the protection and sustainability of environment resources, the inadequacy of this training is an important deficit in terms of our country that shows a great development potential. Furthermore, the lack of studies and findings carried out in Turkey with regard to the recycling education on which researches have been carried out for long years stand out. In this context, this research is important both in that it is experimental and contributes to the need for information on this subject. The purpose of this study is to investigate whether a positive change can be created in the conceptual understanding of high school students on matter cycles with a recycling education programme developed.

Problem statement

The process of industrialization that developed in an uncontrolled manner since the nineteenth century and the orientation towards a consumer society have led to a very quick increase in the amount of the waste generated by the society. What to do with and how to use urban waste are still among today's most important environmental problems. Protecting natural resources through recycling projects, reducing the waste and making unusable substances that we already have or qualify as garbage undertakes an indispensable role in the solution of this problem by saving energy, money and time (Ugulu, 2012).

The question with which factors the behaviours of the individuals with regard to recycling are related after understanding the importance of recycling at international level has come to the fore both psychologically and sociologically in terms of both the environmental and recycling education. Consequently, the studies on why individuals do recycling or not, it was found that the behaviours of the individuals with regard to recycling are affected by such reasons as economical factors, the convenience of recycling, the fact that recycling makes the individual feel as a beneficial person to the society, the level of knowledge about recycling, indifference towards recycling, the lack of time and the inadequacy of physical conditions (Smeesters et al., 2001). It was determined that the other factors positively affecting recycling are the effects of recycling on protecting the energy resources and the contribution to preventing environment pollution (Brody, 1997).

The attitudes and behaviours of the individuals on the subject constitute the basis of all these factors positively or negatively affecting recycling (Smeesters et al., 2001). Thus, hypotheses on what the factors affecting the attitudes and behaviours on the subject were first put forth in investigating the actions aimed at environmental education and recycling. Attitudes, values and beliefs are characteristics that provide a person particular individual characteristics and exhibit a relatively stable establishment after they are gained (Smeesters et al., 2001). Thus, they were considered as central concepts in many studies aiming to explain and foresee individuals' behaviours on recycling. When the studies on recycling are generally assessed, it was observed that some of these studies are solely based on the data on recycling (Kok and Siero, 1985; McCarthy and Schrum, 1993), while such studies as the Theory of Reasoned Action, the Theory of Planned Behavior and Schwartz's Model of Altruistic Behaviour put forth more detailed theories on behavioural sciences in addition to investigating the data of recycling.

With the gaining weight of the views that the ecological information overload based on the traditional approach are not sufficient for environmental education, it was thought that the principles of the constructivist approach that associates learning with the past experiences and information accumulation of the individuals can be

applied to the environmental education (Ugulu, 2012). Munson (1994) examined the subject of conceptual change by reviewing the researches carried out on the constructivist learning approach, and also conducted researches on how to cope with misconceptions. According to Munson (1994), "misconceptions" are scientifically incorrect interpretations made by children when responding to a problem. Accordingly, the misconceptions of the students on ecological events and concepts will give environmental educators important clues as ecological knowledge has an important place in the structuring of ecological information environmental education. Starting from this point, it is thought that the recycling education designed in accordance with the principles of the constructivist approach will be more effective in the process that individuals exhibit the terminal behaviours on recycling. The fact that a recycling education programme prepared in accordance with how the principles of the constructivist approach affects individuals' conceptual understanding of ecology considering the effect of recycling in the natural cycle constitutes the main idea of this study.

METHOD

Research design

This study was designed in pretest-posttest control group quasi-experimental research design. There are two groups created with unbiased allocation. The group that is under the effect of the independent variable among these groups is the experiment group, and the group that is not under the effect of the independent variable is defined as the control group.

Sampling

In quasi-experimental research designs, the sample size is usually kept small due to the research's characterisitics (Balim, 2013; Ilter, 2014; Gutierez, 2015). This research was carried out on 68 tenth grade students studying in two different classes of a high school in Izmir province. One of these groups was determined as the experiment group, and the other one was determined as the control group through random selection. There are 32 students in the experiment group and 36 students in the control group. 21 of the students in the experiment group are female, and 11 of them are male. 26 of the students in the control group are females, and 10 of them are males (Table 1).

Table 1. Sampling.

Group	Female	Male	Total
Experiment	21	11	32
Control	26	10	36

Data collection tools

EECUT prepared in order to understand the extent that high school students structure the concepts about ecology contains open-ended questions for matter cycles prepared by considering the mis-conceptions of the students on these subjects through literature review. A concept analysis on "Ecosystem Ecology" which is included in the curriculum of the 10th grade of the high school was prepared for the content validity of the conceptual understanding test. The content analysis created has been a lodestar in order for the questions in the conceptual understanding test in parallel to the subjects and concepts. The content validity of the concept analysis was ensured by interviewing two biology instructors and two teachers in the field. The trial form prepared after making the necessary regulations about the content validity was applied to a student group of 30 people studying in their first year at the university, the students were asked for the parts that they had difficulty in understanding throughout the practice and corrections were made accordingly. A pilot study was carried out by applying the questions to 80 students studying in the 10th grade of two high schools in order to test the reliability, and it was made clear whether the questions are understandable as expressions and the time given is sufficient. EECUT took its final shape as a result of the data obtained from the pilot study (Table 2).

The semi-structured interview was conducted with 9 students each for the experiment and control groups (3 students each from the low, middle and top groups in terms of their levels of conceptual learning) after the experimental application. It was carried out for the purpose of revealing the misconceptions observed in the answers of the students to EECUT with their reasons. A voice recorder was used during the interviews after taking the consent of the students interviewed, and non-verbal behaviours were written on paper. Then this interview recorded was put on paper and coded, and it was classified and interpreted by determining categories. In semi-structured interview technique, an interview protocol containing the questions that are aimed to be asked is prepared. In line with the course of the interview, the course of the interview can be affected by side or sub-questions and people may be asked to clarify and detail their answers. If an individual answered certain questions in other questions during the interview, the researcher might not ask these questions (Türnüklü, 2000). The concept validity and reliability are used in association with the researcher in an interview, one of the qualitative methods of research (Türnüklü, 2000). Care was taken in asking the same question with the same words and in the same manner to everyone participating in the study. A pilot practice was carried out by interviewing individuals with similar properties with the real interviewees before applying the semi-structured interview form to experiment and control groups, and whether the interview questions are clear and intelligible and the period that must be allocated for the interview were determined.

Implementation

EECUT, used as the data collection tool of the research, was applied to the students in the experiment and control groups as pretest and posttest before and after the practice.

Table 2. Ecosystem ecology conceptual understanding test contents.

Question	Target
EECUT WC (Water Cycle)	Determining students' conceptual understanding levels with regard to water cycle
EECUT CC (Carbon Cycle)	Determining students' conceptual understanding levels with regard to carbon cycle
EECUT NC (Nitrogen Cycle)	Determining students' conceptual understanding levels with regard to nitrogen cycle

During the experimental practice, the group that is provided training in the framework of high school biology teaching program adopted with the decision No. 137 of 03.06.2008 of Turkish Education Board affiliated to Ministry of Education was considered as the control group, and the group that were applied Recycling Education Program (REP) to biology education program was considered as the experiment group. REP was prepared in a way that it constitutes a whole with the subject "Ecosystem Ecology" included in the curriculum of the 10th grade in the context of REP high school biology teaching program. Its period of the application was limited to 10-course hours determined in the curriculum for the subject "Ecosystem Ecology".

Recycling education program

The concepts that are aimed to primarily gain the students of the experiment group in the context of the program during the process of forming the REP were analyzed based on the 3R (Reduce, Reuse, Recycle) model. After the concept analysis was prepared, target concepts were placed in the subject in a way that they do not disrupt the integrity of the expression of the subject "Ecosystem Ecology". The theoretical part of the program was created this way. In the second stage, recycling activities were prepared in order to ensure that the concept related to recycling are conceptually structured in the students and that they are understood in a way that they will change their behaviours. These activities were also placed in the subject in a way that they do not disrupt the course and unity of the expression. Consequently, a "Recycling Education Program" that is integrated with the subject "Ecosystem Ecology" was created. An example of the activities applied in the context of the program is shown below.

Example of activity

WHAT IS HAPPENING HERE – 1 Targets?

It is aimed to make the students understand the concept of organic fertilizer. The concepts of organic and inorganic matters are discussed for this purpose. Furthermore, the states of the matters in nature and matter cycles are examined.

Activity materials

(1) A large plastic bag and a node, (2) A buckle of wet sand, (3) 3 grapes, (4) 5 plastic containers, (5) A handful of chopped herbs, (6) 3 lettuce leaves, (7) 2 nails, (8) A roll of white toilet paper, (9) A slice of wheat bread, (10) A sieve

Practice

(1) The teacher defines the concepts organic and inorganic matters. (2) The materials required for the activity are placed in the bag and kept in an appropriate environment for a period of one month. (3) What kind of changes can occur in the bag during this process is discussed with the students. (4) Assessments based on ecosystem elements are made in the discussion. (5) The bag is opened at the end of the process, and the latest state of the materials placed in the bag is evaluated.

Data analysis

The content analysis method was used in order to analyze the data obtained through EECUT in the framework of the research. The process carried out in the content analysis method that ensures the detailed examination of the data is to bring together similar data in the framework of certain concepts and themes and interpret them by organizing in a way that the reader can understand (Yıldırım and Şimşek, 2005). Data obtained from the data collection tool are separately coded by a researcher and another experienced faculty member. The coding made by both researchers was compared for reliability, and the necessary corrections were made by deeming a correspondence percentage of 70% and above as adequate (Yüksel 2011).

FINDINGS

In this section, the analysis of the answers given by the students to Ecosystem Ecology Conceptual Understanding Test (EECUT) prepared in order to investigate the effect of the Recycling Education Program (REP) on the level of understanding of ecological concepts related to matter cycles of the students is presented. For this reason, the analyses on EECUT WC that aims to determine the conceptual understanding of the students on water cycle, EECUT CC that aims to determine the conceptual understanding of the students on carbon cycle and EECUT NC that aims to determine the

Table 3. EECUT Water Cycle (WC) question pre- and post-test categories.

	Answers by the students	Pretest				Posttest			
		EG		CG		EG		CG	
		f	%	f	%	f	%	f	%
CD	There is a water shortage as a result of the insufficiency of groundwater resources.	2	6	3	8	-	-	-	-
	A number of usable water resources is significant.	10	31	8	22	20	63	15	42
	The reason for the water shortage is unconscious water consumption.	7	22	11	31	3	9	3	8
	The reason for the water shortage is the pollution of water resources.	1	3	8	22	-	-	3	8
	Total	20	62	30	83	23	72	21	58
ID	Global warming reduces water resources.	8	25	2	6	6	19	11	31
	The perforation of the ozone layer leads to drought.	4	13	4	11	3	9	4	11
	Total	12	38	6	17	9	28	15	42

conceptual understanding of the students on nitrogen cycle are given respectively.

With EECUT WC question, it was aimed to understand the level that the importance of the water resources is structured by the students in the framework of the water cycle. Answers given to this questions by the students in the pretests and posttests are presented in tables (Table 3). In the table, the answers of the students who made correct definitions (CD) and incorrect definitions (ID) are assessed in the table according to the question.

EECUT WC:

Approximately 70% of the world is covered with water. This water in the earth exists in the living beings with such water sources as oceans, seas, lakes and streams and is in the form of a cycle among these elements.

Accordingly, what do you think is the reason that a lot of countries in the world (including Turkey surrounded by the sea on three sides) suffer from water shortage although there is a significant amount of water in the world?

When the answers given by the students to the question EECUT WC are assessed primarily by the correct definition scale, it is observed that the correct definition percentage which was 62% before the practice in the experiment group reached 72% after the practice, and the correct definition percentage which was 83% in the control group decreased up to 58% after the practice (Table 3).

When the reasons for the decrease in the percentage of making correct definitions of the control group students with semi-structured interviews are investigated, it was observed that the students especially associate the concept global warming with water cycle incorrectly. After the practice, 19% of the students in the experiment group and 31% of the students in the control group made the explanation *"Global warming reduces water resources."* The students who made this explanation developed such a mistake that water resources will evaporate as a result of global warming and thus, water resources will decrease. This mistake shows that the students who made the explanation could not structure the water cycle as a whole. Below is the explanation of one of the students who commented this way.

Researcher: You indicated that water resources decreased as a result of global warming? What is the reason for this opinion?
Student: Water resources evaporate as the temperature in the world rises. Consequently, water resources also decrease.

With EECUT WC question, it was aimed to understand to which degree that carbon in the composition of organic molecules which are the basic molecules added into the structure of the living beings is structured in the framework of the carbon cycle by the students. The answers given by the students to this question in pretests and posttests are shown in tables (Table 4). In the table, the answers of the students who made correct definitions (CD) and incorrect definitions (ID) for the question were evaluated.

EECUT CC:

The carbon atom in a CO_2 molecule in the air is marked using the radioactive isotopes method. After some time,

Table 4. EECUT Carbon Cycle (CC) question pre- and post-test categories.

	Answers of the students	Pretest				Posttest			
		EG		CG		EG		CG	
		f	%	f	%	f	%	f	%
CD	It reaches the human beings with the transmission of the carbon into the food by the producers and then by means of nutrition.	1	3	3	8	19	59	13	36
	Total	1	3	3	8	19	59	13	36
	It reaches the liver cell through respiration.	19	60	16	44	8	25	17	47
	It reaches the human cell with the help of the enzymes.	-	-	-	-	1	3	-	-
	It reaches the human cell by steam.	-	-	-	-	1	3	-	-
ID	It reaches the human cell by means of the genes.	1	3	-	-	-	-	-	-
	It reaches the human cell with radioactive rays.	1	3	-	-	-	-	1	3
	It reaches the human cell through technological devices.	-	-	1	3	-	-	-	-
	It reaches the liver cell through the nitrogen cycle.	-	-	1	3	3	9	4	11
	Total	21	66	18	50	13	41	22	61
B	I don't have any knowledge and thought.	10	31	15	42	-	-	1	3
	Total	10	31	15	42	-	-	1	3

the marked carbon atom is seen in a human liver cell.

Accordingly, how did the carbon atom reach the human cell?

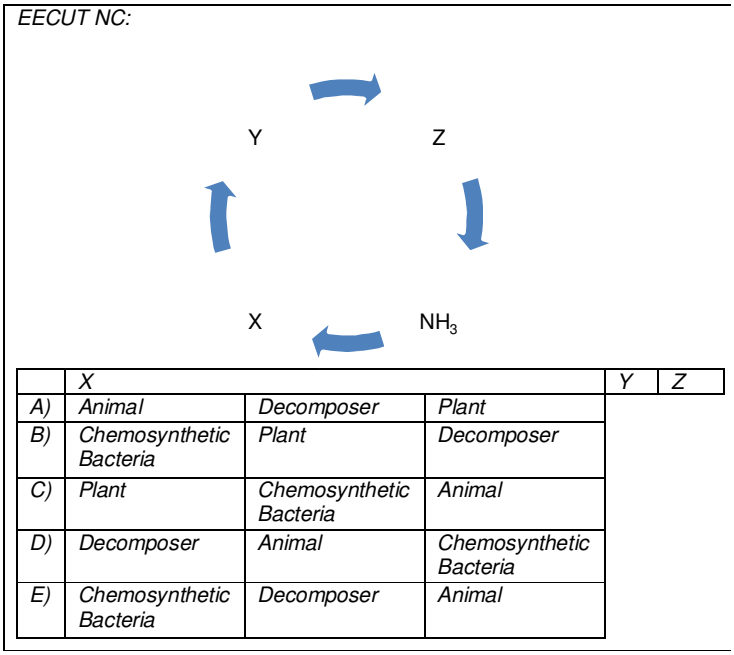
When the answers of the students to EECUT CC question are assessed primarily by the correct definition criterion, it is observed that the correct definition percentage which was 3% before the practice in the experiment group reached 59% after the practice, and the correct definition percentage which was 8% before in the control group reached 36% after the practice (Table 4). This shows that both of the programs applied to the experiment and control group students are effective in the learning of the carbon cycle event.

60% of the students in the experiment group and 44% of the students in the control group before the practice, and 25% of the students in the experiment group and 47% of the students in the control group after the practice made the explanation *"The marked carbon atom reached the liver cell through respiration"* (Table 4). This explanation shows that the students cannot structure the carbon cycle well. It is believed that this mistake can only be eliminated by increasing the emphasis during the lectures that the carbon in the air can be added to the structure of organic materials only when they are taken by the producer creatures.

After the practice, 9% of the students in the experiment group and 11% of the students in the control group made the explanation "The marked nitrogen reaches the liver cell with through nitrogen cycle. This explanation shows that the students cannot structure the carbon cycle well as well as they have problems in understanding the nitrogen cycle. It is thought that this mistake can be eliminated by increasing the emphasis that the carbon in the air can only be taken by the producer organisms and added into the structure of organic molecules, and thus creatures.

With EECUT NC question, it was aimed to understand to what extent the nitrogen cycle, one of the matter cycles, and its properties are known and structured by the students. The answers given by the students to this question in pretests and posttests are presented in tables (Figure 1). The answers of the students who made correct marking (CM) about the creatures in the cycle and the answers of the students who made incorrect marking (IM) are assessed separately on the figure.

When the answers given by the students to question EECUT NC are primarily evaluated by the correct marking criterion, it is seen that the percentage of correct marking which was 47% in the experiment group before the application reached 69% after the application, and the correct marking percentage which was 22% in the control group reached 67% after the application (Table 5). When the answers given to the question EECUT NC by the



	X			Y	Z
A)	Animal	Decomposer	Plant		
B)	Chemosynthetic Bacteria	Plant	Decomposer		
C)	Plant	Chemosynthetic Bacteria	Animal		
D)	Decomposer	Animal	Chemosynthetic Bacteria		
E)	Chemosynthetic Bacteria	Decomposer	Animal		

Figure 1. EECUT NC:

Table 5. EECUT nitrogen cycle (NC) question pre- and post-test categories.

	Answers given by the students	Pretest				Posttest			
		EG		CG		EG		CG	
		f	%	f	%	f	%	f	%
CM	Chemosynthetic bacteria turn ammonia produced by the decomposers into nitrite and nitrate. Plants can also use these salt.	15	47	8	22	22	69	24	67
	Total	15	47	8	22	22	69	24	67
IM	The reason for the formation of ammonia is bacteria.	11	35	20	58	10	31	8	22
	Plants use the ammonia they take from the soil.	3	9	4	11	-	-	4	11
	Total	14	44	24	67	10	31	12	33
B	I have no knowledge and thoughts.	3	9	4	11	-	-	-	-
	Total	3	9	4	11	-	-	-	-

students are first assessed by the correct marking criterion, it is observed that the correct marking percentage which was 47% before the practice reached 69% after the practice in the experiment group, and the correct marking percentage which was 22% in the control group reached 67% after the practice (Table 5). This shows that the programmes implemented in the experiment and control group students are effective in the learning of the nitrogen cycle event.

35% of the students in the experiment group and 58% Of the students in the control group before the practice, and 31% of the students in the experiment group and 22% of the students in the control group made the explanation *"The reason for the formation of ammonia is chemosynthetic bacteria* "after the practice (Table 5). This explanation shows that these students cannot structure the nitrogen cycle well.

It is believed that this mistake can be eliminated by increasing the emphasis on the activities of the decomposers during the practice. Below is the explanation of

one of the students who makes such a remark.

Researchers: What is the duty of the decomposers in the ecosystem?
Student: They decompose dead organisms.

Researcher: How do you explain the decomposition event?
Student: So decay… (not sure). Big molecules are torn into small molecules.

Researcher: Can you given an example of these molecules?
Student: Yes… (thinks). Ammonia produced by chemosynthetic bacteria is an example to this. I mean in the nitrogen cycle...

DISCUSSION AND CONCLUSION

Recycling has always been one of the first strategies that come to mind when individuals and institutions want to perform a positive behaviour towards the environment, however the necessary determination and stability could not be achieved apart from a few examples when it comes to certain practices. Except for the activities of certain private institutions and foundations, there are scarcely any comprehensive examples of the recycling education within the curriculum of the institutions affiliated to Ministry of Education or universities (Ugulu et al. 2014). When the place of the recycling education in the international area is examined, a multi-dimensional development stands out in this area in parallel with the environmental education. While most of the practices in our country still cannot go beyond a few definitions about the recycling education, international practices consist of complicated curriculum programs created in a way that they include high and higher education starting from pre-school education. Again in parallel with the development process of environmental education, demographic and sociological factors affecting recycling and its education have been subject that have been investigated for long years (Allen et al. 1993; Goldenhar and Connell 1993; Jones 1990; McCarthy and Schrum 1993; Pieters 1991; Thøgersen 1994). In this study developed upon seeing the deficiency about the recycling education in Turkey, how the conceptual understanding regarding the ecological subjects related to matter cycles through REP prepared by examining the main concepts and international examples regarding recycling was investigated.

When the answers given by the students in the study group to EECUT questions in pretests and posttests were examined, it is observed that the success of the experiment group for EECUT WC increased to 72% from 62%, the success of the control group decreased to 58% from 83%; the success of the experiment group increased to 59% from 3% for EECUT CC question, and the success of the control group increased to 36% from 8%; and the success of the experiment group increased to 69% from 15%, and the success of the control group increased to 67% from 8%.

According to the results obtained by assessing the EECUT findings in terms of the effectiveness of REP, a significant difference is observed in EECUT WC and EECUT CC questions between the conceptual understanding of the experiment and control groups. It can be said that the success shown by the experiment group with regard to these questions results from REP as these questions aim to determine the conceptual understanding levels regarding the matter cycles and emphasise the production derived matter cycle in the nature of REP.

As a result of the study, it was observed that high school students have many misconceptions towards basic ecological concepts. In their study, Boyes and Stanisstrect (1999) put forth that a great majority of the students developed the thought that the world heats up as one of the negative consequences of global warming, and consequently they developed such a misconception as “the desertification areas in the world will increase as global warming increases”. When the answers given to EECUT WC question by the students in our study are examined, it is observed that a great majority of the students developed such a misconception that global warming will reduce the water sources. Thus, this misconception overlaps with the misconception indicated in the study of Boyes and Stanisstrect (1999).

Munson (1994) conducted researches on how the students cope with misconceptions about ecology by examining the subject change of concept after reviewing the researches carried out on the constructivist learning hypothesis. In his study, Munson (1994) determined that the studies carried out on science teaching in the framework of the constructivist approach are related to the fact that “the learning of the new concepts by the students are related to their previous knowledge (Carey 1985; Driver et al. 1985; Osborne and Freyberg 1985).” Thus, he mentioned the importance of misconceptions in the structuring of the new of information. Starting from this theoretical substructure and assessing the importance of misconceptions in environmental education, Munson (1994) summarized the main ecological concepts and the misconceptions related to these concepts. As a result of the study, it was determined that the misconceptions on this subject are quite important in terms of environmental education and instructors.

Consequently, it can be said that REP that includes concepts and activities related to recycling as well as including all concepts of the ecosystem ecology in the biology teaching program is an effective and useful tool in line with the targets of the environmental education with the success it creates in the conceptual understanding of the students.

Conflict of Interests

The authors have not declared any conflict of interests.

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