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RESEARCH ARTICLE

The Awareness of Turkish High School Students About Carbon Footprint and The Effects of The High School Biology Curriculum on This Awareness

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Abstract

Carbon emissions which are one of the most important human sourced causes of global climate change continue to rise rapidly despite all efforts to minimize these emissions. Carbon footprint (CF) education is significant in terms of changing the present situation. The aim of this study is to determine the awareness of high school students about the CF issue which takes place in the 9th grade level teaching program and to determine the effects of students' awareness on teaching. Hence, a research-based exploratory mixed study design was conducted with 140 9th and 10th high school students. A special data collection instrument was developed for CF. Qualitative data that was collected was firstly subjected to the document analysis method. Then, an SPSS program was utilized in order to ascertain the percentage of students in different grade levels who were aware of the problem and to determine quantitatively the differences between them. As a result, it was found that the awareness of the students about the problems involving household and transportation components of CF were higher when compared to their awareness about lifestyles. However, the students do not hold a holistic approach about the relationship between CF and global climate change. When this case is evaluated, it appears that teaching of the concept of CF and the objectives related to that concept in the program were not achieved. A reevaluation of the teaching program and enrichment of teaching methods are crucial for teaching his issue. Besides, the test utilized in this study might also contribute to the enrichment of teaching by using it as a course material in CF teaching.

Key words: Global climate change, corbon footprint (CF) education, Turkish high school 9th grade biology curriculum.

Introduction

Global competition in production and consumption among countries, as well as the production and consumption habits of the population exert a great deal of pressure on natural resources and bring about many environmental problems (Galli et al., 2012). One of the most important problems is global climate change. Greenhouse gases (GHGs) cause global climate change. Carbon dioxide which is one of the GHGs is reported to be responsible for 80% of global warming and this proportion is expected to have risen by 57% after the 1980s (Lashof and Ahuja, 1990). This rise increases the significance of the impact of CO_2 emissions on the global climate change issue (Wiedmann and Minx, 2008). More than one third of carbon emissions in developed countries are personal transportation and household energy (Whitmarsh et al., 2011). Besides industrial processes, changes in individuals' lifestyles play an important role in the solution of this problem by having a population with low carbon emissions (Fusco et al., 2012; Whitmarsh, 2009; Whitmarsh et al., 2011; Whitmarsh et al., 2013). This situation demonstrates the preferences for lifestyles that are effective in reducing

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carbon emissions in the environment. As indicated by Lynas and Kutluğ, the reduction of carbon dioxide gas emissions can also be solved with the help of various details in daily life, not related to the politics of the countries (Lynas and Kutluğ, 2009). At first, individuals should be aware of this problem in order to care for details in their daily lives. The instruction of this issue should be conducted with proper methods and strategies in order to make people gain this awareness. Thus, transformation of the awareness, knowledge and attitudes of the individuals into behavior can be achieved. The awareness about the concept of CF increases with carbon footprint calculators however it is not sufficiently widespread, thus it is reported that the education needs to be conducted and expanded (Whitmarsh et al., 2011).

Based on this respect, the concepts of Ecological Footprint (EF) and Carbon Footprint (CF) have been added to the National Ministry of Education high school biology program in Turkey in 2007. With the objectives of this program, it is expected that students will inquire into their roles which bring about environmental problems.

Due to this expectation, the main aim of this study is to determine whether students become aware of their own footprints, which of their daily life activities do they relate with CF and whether or not they comprehend CF and climate change after instruction in this subject. In this respect, the question "Is CF education given at school efficient?" is aimed to be answered.

Educators can develop better teaching methods for the instruction of climate change if they understand thoroughly what people think and this contributes to their understanding of science as well as teaching the subject in a better way as indicated by Cordero et al. (2008). When considered in this perspective, the determination of the present situation is essential to conduct holistic and rapid steps in order to reduce carbon emissions. This study is significant It this respect. It can be a direction for future ideas for determining whether or not the concepts of EF and CF and the objectives related to these concepts are achieved by the program.

The Ecological Footprint and the Carbon Footprint

The ecological footprint is a concept that considers the relationship between human beings and their environment. The concept of the ecological footprint signifies the measurement of the area that a population needs to sustain life on earth (Martin and Henrichs, 2010). The ecological footprint is made up of components such as the cropland footprint, fishing grounds footprint and carbon footprint. In order to determine the impact of humans on the environment, it is necessary to evaluate all these components in a holistic manner (Galli et al, 2012). Although over the period 1961-2007, there was an expansion in the footprints of all land categories, the greatest growth was seen in the carbon footprint (WWF, 2012). Greenhouse gases (GHGs) emissions are the main reason for the global climate change having reached the levels which have not been observed before the pre-industrial stage (IPCC, 2007). The consideration of the gases such as CH_4, N_2O except CO_2 in terms of CF is a controversial issue in the literature (Wiedmann and Minx, 2007). However, according to Wiedmann and Mix (2007), gases except CO_2 should not be included in GHGs, otherwise this issue becomes climate footprint rather than carbon footprint. Gases such as CH_4, N_2O, HFC, PFC and SF_6 are GHGs (Galli et al., 2012; U.S.Report, 2007). GHGs, such as carbon dioxide, methane, and nitrous oxide prevent the re-emitted radiation from exiting the earth's system, resulting in a new equilibrium at higher temperatures. Therefore, one major focus of pro-environmental education has focused on mitigation – actions that decrease anthropogenic GHG emissions, especially carbon dioxide (Bofferding and Kloser, 2015).

Many different definitions have been set down for the carbon footprint; several of these are the following: "The carbon footprint is a special measure of the exclusive total

amount of CO_2 emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product" (Wiedmann and Minx, 2008), "The carbon footprint is a measurement of an individual's share in climate change" (Lynas and Kutluğ, 2009), "The biocapacity necessary to sequester CO_2 emissions resulting from the burning of fossil fuels" (GFN, 2012). The carbon footprint is composed of two sources, a primary (direct) source and a secondary (indirect) source. The primary carbon footprint is the measurement of the direct carbon dioxide emissions from activities such as household energy consumption and transportation that require the burning of fossil fuels. The secondary carbon footprint encompasses the entire life cycle of products. It starts from the manufacture of the product, through its transport, and at the end, continues up until its final breakdown and is the measurement of the carbon dioxide emissions emerging during this process (Carbon Footprint, 2012). In the study to determine the carbon footprint carried out in British schools (GAP, 2006), it is reported that 26% of the CF derives from direct emissions.

There are basic areas which are utilized for individual CF calculations among the entire carbon emission. These are households, transportation and lifestyle. According to the data of several studies, the proportions of these areas have been identified. The proportion of gain in the case of awareness and behavior change can be predicted according to the amount of the proportions of these areas. Due to these reasons, the studies which identify the proportions of these areas gain significance. For example, in the U.K., household CO_2 emissions were found to be at a level of 20.7 tonnes (SEI, WWF and CURE, 2006). According to the data of this study, the use of electricity at home produced almost one-third of the total of home and water heating emissions. Another study conducted according to 2004 data reported on a review of household-generated CO_2 emission rates in the U.S., found that about 13%-37% of the carbon footprint was composed of these household-based CO_2 emissions and that energy was among these emissions, with personal transportation, services and health, respectively (Weber and Matthews, 2008). In another study that evaluated household wastes in British schools, it was found that 22% of the Carbon Footprint was formed by electricity consumption (GAP, 2006). On the global level, 72% of greenhouse gas emissions are related to household consumption, 10% to government consumption, and 18% to industrial investments. Food accounts for 20% of GHG emissions, operation and maintenance of residences accounts for 19%, and mobility for 17%. Food and services are more important in developing countries, while mobility and manufactured goods rise rapidly with income and dominate in rich countries (Hertwich and Peters, 2009). Again according to the study of Hertwich and Peters (2009), other proportions in Turkey are as follows: domestic share, 82%; population (million), 66.2%; construction, 9%; shelter, 15%; food, 27%; clothing, 3%; manufactured products, 10%; mobility, 24%; service, 9%; trade, 5%. In Turkey, the Carbon Footprint makes up the greatest share in the ecological footprint with 46-49% (1.24-1.36 kha per person). The greatest share which constitutes the carbon footprint in Turkey comes from electricity consumption. This value, which accounts for 14% of the footprint of consumption in the country, is about 26% of the carbon footprint. About 19% of CO_2 emissions in Turkey stem from individual transport, 21% of this emanates from production and 17% from food consumption (WWF, 2012).

The Carbon Footprint as a Tool in Environmental Education

Students can display positive behavior when they comprehend the significance of environmental problems and why it is necessary to save the environment. Therefore, the area of environmental education should be considered specifically in all dimensions of education (Yücel et al., 2008). The disadvantage in environmental education is just focusing on science and not focusing on individual and social relationships; to provide social change, environmental education which focuses on

science cannot succeed (Uzzel, 1999). As a result of their study, which was about the reduction of carbon emissions, Lee et al. (2013) reported that considering conceptual knowledge and procedural knowledge was not efficient in terms of eliminating misconceptions. Caring about the reduction of CF raises the awareness of population and supplies, a movement towards handling those environmental problems at present and in the future in a concrete manner rather than in an abstract manner (Hsu, 1993; Lee et al., 2013). In this respect, to prevent individuals feeling powerless, it will be an important initial step to develop their attitudes and behaviors beginning from the elementary level. We cannot conclude that ~~the~~ knowledge is only transferred from teacher to the student. Contrarily, authentic learning that will be reflected on the attitudes and behaviors of the students should be carried out (Cross and Price, 1999; Lee et al., 2013). Authentic learning uses the constructivist learning model as a basis and it involves learning which is about the transfer of the complexity of daily life issues and problems into the classroom environment (Cholewinski, 2009). Ballantyne and Packer (2009) highlight the benefits of authentic learning strategies which are based on experiences in environmental education in terms of developing pre-attitudes and actions towards the environment. In recent years, learning activity life experiences and learning strategies to investigate the knowledge, behavior and attitudes of students have been researched (Lee et al., 2013).

Since it has been realized that calculations of ecological footprint and carbon footprint are important tools in global climate change education (Cordero et al., 2008), EF and FC calculations have been utilized in various studies (Scott, 2011; Fusco et al., 2012; Gottlieb et al. 2012; O'Gorman and Davis, 2013; Lee et al. 2013; Howell, 2013 please arrange in alpha order). In CF teaching programs, generally, it is expected that students calculate their own CF on web sources. Next, they are asked to determine solutions to prevent the impacts of their own footprint that they have calculated and to discuss this situation with their peers (Fusco et al., 2012).

Carbon Footprint Education in Turkey

When the countries in the world are examined in terms of carbon emissions, according to data of " Per Capita GHG Footprint of Nations in 2001", the carbon footprint amount in GHC Footprint is 33.8 [tCO2e/p] for Luxemburg and 28.6 [tCO2e/p] for the United States which indicate very high levels whereas it is a value of 4.6 [tCO2e/p] for Turkey, which is a considerable level. However, carbon emissions are not constant. The country, which shows the highest carbon emission increase, when compared to the level in 1990 is Turkey (WWF, 2012). Since 1990, as a result of increasing carbon emissions in the world and in Turkey, this subject has been realized and added to the program by the Turkish curriculum planners.–The issues of Ecological footprint (EF) and carbon footprint (CF) are–emphasized in the explanation related to the objective concerned, namely "1.2 Students inquire their role as an individual in the emergence of actual environmental problems" in the ninth grade biology teaching program renewed by TR National Ministry of Education - Board of Education in 2007. The unit "Conscious Individual - Sustainable Environment" directly indicates CF and shows that this concept has has been introduced into the high school program for the first time. This program was prepared with a constructivist approach (TTKB, 2007). In line with constructivist principles, environment-based education is argued to provide a high-quality educational curriculum that is conducive to the promotion of positive attitudes, sensitivities, literacy, knowledge, and skills (Ernst, 2009) about the environment. The objectives in the biology program have been generally given by the teachers through lectures and by definitions based on knowledge (İrez and Yavuz, 2000). There are no studies in the literature at present related to the teaching of CF at the high school level. No activities and applications about this subject apart from the definitions in the book resources on this subject are available. The biology program has been renewed in

2013–in the 9th grade level. As in the previous program the name of the related unit is "9.3 Actual Environmental Problems". In this unit, as in the 2007 program, there is an objective, 9.3.1.2, in which students inquire their role as an individual in the emergence of actual environmental problems. In the 2013 program, there is an explanation about practices related to the ecological footprint and carbon footprint, which is different from the former program.

A review of the Turkish research literature showed that there were studies in which the ecological footprint calculation and evaluation were carried out by the teacher candidates (Akıllı et al., 2008; Keleş et al., 2008). Prospective teachers' opinions were presented about the reduction of their ecological footprint (Keleş and Aydoğdu, 2010), and young people's general behaviors were investigated for sustainability (Tuncer et al., 2005). It was also found that the book "Yüz Yeşil Adım" (One Hundred Green Steps) is an important source that can be used as an educational tool to encourage the business world to change its habits (Karataş, 2012). Apart from this, another comprehensive work concerning the subject of the Carbon Footprint was the section titled, "Turkey's Ecological Carbon Footprint Report" that was included in the report of carbon footprints of the World Wildlife Fund (WWF, 2012). It is becoming more important that recommendations about reducing the carbon footprint are highlighted. In Article 7 of the WWF 2012 Report on putting an end to exceeding the ecological limit, it is stressed that all segments of populations including state organizations, the private sector, civil organizations, universities and other groups concerned must also cooperate in working on environmental issues. Additionally, in Article 9 of the Report, it is stated that consumption geared to waste accumulation must end and that sustainable alternatives should be found in food, transportation, goods and services. It is emphasized that it is important for people in high income brackets to lean towards the use of natural resources and sustainable products (WWF, 2012). These recommendations in actuality are not foreign to the behavior that Turkish people have displayed in their cultural history. However, this type of behavior has been forgotten over the years due to various reasons.

The establishment of the National Economics and Savings Association (Turkish acronym, MİTC) in 1929, in the early days of the Republic can be appreciated as a study in terms of sustainability which aimed to raise awareness about saving in the community and encouraging consuming local products (Turan and Ödekan, 2009). The main objective of the MİTC was to urge the general public to avoid being wasteful, live prudently and cost-consciously, and become accustomed to putting aside savings. The second objective of the association was to promote, and to foster a love for and urge people to use locally-manufactured products. Those two objectives and the approach regarding the reduction of the CF in the teaching program complemented each other. The subject of CF which is an universal issue has been revived again in the curriculum by including this subject in National Ministry of Education biology program in 2007.

With this study, it will be possible to make curriculum developers and teachers realize the case for teaching this subject. It is expected that the study will guide people on what to do regarding the present situation. Also, this study is believed to contribute to the literature in terms of being the first detailed study about CF education introduced in Turkey.

Methodology

Research Design

This study involved an exploratory mixed study design. Firstly, it was based on qualitative approaches. Then, the quantitative dimension was utilized to support its

qualitative dimension. The qualitative dimension of the study is related to revealing the environmental problems suggested by the students and the ways in which the students gave meaning to the CF as an environmental problem (Gay and Airasian, 2000). The document analysis technique was used in this context (Yıldırım and Şimşek, 2008). The quantitative dimension of the study is related to the comparison of the number of environmental problems at the 9th and 10th grade level by using an SPSS software (Büyüköztürk et al., 2010; Karasar, 2007). The interviews were conducted with five students from each of the experimental and comparison groups to determine whether the subject of .... was instructed or not. The interviews were structured and in the form of conversations. It included two questions that students were asked: whether or not the subjects of CF and EF were instructed especially in biology courses and whether there was a relationship between global climate change and CF.

The study group, methods, data collection instrument, data collection process and data analysis were explained in detail in order to present the reliability and validity of the study. To prove the reliability, data obtained from one classroom was evaluated by another researcher. The themes constructed from the responses of the students by the second researcher were found to be highly consistent with the researcher of the study. An important strategy for proving the reliability is related to the development of data gathering instrument. The items in CF calculation instruments were analyzed while developing the text which was utilized for data collection. A number of items were written specific for the areas in the instruments. The text contained all the areas in carbon footprint calculation instruments in terms of the context. Also, area specialists' opinions were taken for the reliability of the instrument. Quotations from students' responses were presented to prove the internal validity of the study.

Study Group

The study group consisted of 9th and 10th grade level students who were being taught at high school in the fall semester of the 2011-2012 academic year. A total of 140 students, 77 (41 girls and 36 boys) of whom were 9th graders and 63 (35 girls and 28 boys) of whom were 10th graders participated in the study. The typical case sampling method, an offshoot of purposeful sampling, was used to determine the research sample (Büyüköztürk et al., 2010). Tenth graders were the experimental group whereas 9th graders were the control group. The subject of CF is one of the final subjects of the 9th grade level. The instruction to the 10th graders was conducted at the beginning of the academic year. On the other hand, the instruction to the 9th graders was conducted nearly at the end of the academic year. Thus, the groups were closer to each other by reducing the differences in age and grade level. Such a method was preferred in order to fix the variables of school and teacher and to avoid a decrease in the number of students. Also, there is not an option to teach the subject of CF to only one group of students and not to teach it to another group since this subject is included in the programs at both levels. Therefore, the experimental and control groups were formed by considering the students who had just learnt and who were just going to learn the subject. The students are admitted to this high school based on the results of an exam which is conducted all over the country. This school accepts the students whose academic achievement levels are the highest in the city. The school is in Balıkesir which is a mid scale city; the participants generally live in this city and nearby. The socioeconomic status of the students' parents not the same. The reason for the selection of this school for this study is the fact that the academic achievement of its students is the highest level in the city. So, it was intended to focus on CF teaching in this study by increasing the learning potential of the students based on the instruction.

Data Collection Instrument

An original text which was prepared based on authentic learning was utilized as a data collection instrument for the research. In the creation of the text, firstly, the literature was examined and no measurement instrument prepared for this purpose was found. Many websites were reviewed for CF calculations and from these, the website was selected as the basis for the items in the text. Using this website[2], a text was created entitled, "A ..... Day" that contained as many items as could be included from the household, transportation and lifestyle domains and sub-domains that constituted the criteria for calculating CF in the website. The text was written about a birthday party and the things that were done to organize it, especially what was done to increase the CF; the items were chosen from behavior that the students were very familiar with in their daily lives. There were 23 items related to the domains of households, transportation and lifestyle. Some of this behavior contained aspects that could cause problems from many angles. The term CF was not mentioned, either in the text itself or in the instructions related to the text. This way, the students could write down themselves why they viewed the behavior as damaging; thus it could be deduced whether or not they had an integrated perception of the concept of CF. Table 1 shows the sub-domains and the examples of activities that were perceived to be damaging to the environment. The text is given in the Appendix 1.

Data Colleciton

The prepared text was printed and handed to the students who were asked to point out which actions in the text they thought were damaging to the environment; they were told to underline the sentences about these actions and then to explain the reasons why they thought these underlined actions were problems for the environment. In addition, they were asked to fill in the blanks on the heading of the text or write up a new heading. One course hour was provided to the students for this activity. For 10th graders, the activity was conducted in one course hour at the beginning of the academic year with the classes 10A, 10B and 10C. For 9th graders, the activity was conducted nearly at the end of the academic year with the classes, 9A, 9B and 9C.

Data Analysis

The raw data obtained with the data collection instrument were analyzed both qualitatively and quantitatively. Collected qualitative data was first subjected to document analysis. The analysis of the environmental problems about which students were aware was conducted according to previously determined three domains and 15 sub-domains. The way these problems were related to CF was revealed in students' explanations of the items they had underlined. The themes related to the domains and sub-domains were determined as indicated in Tables 2, 3 and 4. In addition, content analysis was conducted for the headings of the text which the students were asked to write. The headings were collected under three main groups as positive, negative and undecided or no answer. The frequencies of each theme are provided in Tables 5 and 6. Subsequently, the number of 9^{th} and 10^{th} grade students who realized the environmental problems were presented quantitatively. For this purpose, the SPSS 15.0 program was used to determine whether or not there was a statistical difference between the grade levels. The results are summarized in Table 7.

[2] http://www.karbonayakizi.com/calculator/calculator.aspx

Results

Situations Identified as Environmental Problems

After the students read the text and identified the environmental problems, frequencies and percentages were calculated for the 9th and 10th grades as shown in Table 1.

Examining Table 1 shows that among the household, transportation and lifestyle domains, the behaviors that the students believed caused problems for the environment were largely in the household domain, followed by the transportation domain. The behaviors under lifestyles, were the ones the students thought that would cause the environment the least harm. In the household domain, the percentage in electricity consumption that caused the least problems was the use of many ordinary light bulbs. In transportation, the car sub-domain contained the highest percentage whereas airplanes were not seen as a problem at all. In addition, the percentage of individual and public motor transportation is very low. In the lifestyle domain, the least striking of the group, not recycling and lots of canned soda had the highest percentages compared to the other items in terms of being problems for the environment. Of the total of 140 students, only three thought that birthday parties could cause problems for the environment.

Table 1.

Environmental problems identified by 9th and 10th graders and frequencies and percentages for these problems

			9th graders		*10th graders*	
Domain	***Sub-domain***	***Environmental problems in the text***	***Frequency***	***Percentage***	***Frequency***	***Percentage***
Households	Electricity Consumption	The use of a lot of ordinary light bulbs	29	37.6	23	36.5
		Leaving all the lights on	63	81.8	48	76.2
		Leaving an electrical device plugged in for hours	72	93.5	60	95.2
	Heating	Lighting the fireplace needlessly	58	75.3	46	73
		Unnecessary energy expenditure (opening windows to cool off)	47	61	48	76.2
Transportation	Short-distance flights	Flying	3	3.9	1	1.6
	Automobiles	Driving a big car for a short distance	75	97.4	60	95.2
		Driving a private automobile	56	72.7	52	82.5
	Motorcycles	Use of motorcycles for transportation	34	44.2	9	14.3
	Buses	Use of buses for transportation	7	9.1	4	6.3
	Subways	Use of subways for transportation	8	10.4	4	6.3
	Trams	Use of trams for transportation	7	9.1	4	6.3

(Continuation of Table 1)

Domain	*Sub-domain*	*Environmental problems in the text*	*9th graders*		*10th graders*	
			Frequency	*Percentage*	*Frequency*	*Percentage*
Lifestyles	Food preferences	Continuous consumption of red meat	30	39	15	23.8
	Seasonal food consumption	Consumption of off-season food	48	62.3	35	55.5
	Clothes preferences	Buying the latest trend imported aged jeans	45	58.4	33	52.4
	Packaging preferences	Not enjoying the package of the present and replacing it with a new one by throwing away it	12	15.6	6	9.5
		Using a lot of plastic bags--over-consumption of packaged foods	20	26	25	39.7
	Preferences for furniture, electronics, and other articles	A lot of canned sodas	68	88.3	43	68.2
		A present of the latest model tablet	3	3.9	2	3.2
		Changing furniture frequently	41	53.2	37	58.7
		Perfume	39	50.6	16	25.4
	Recycling preferences	Not recycling	53	68.8	40	63.5
	Entertainment and activities	Birthday parties	-	-	3	4.7

Reasons for Being an Environmental Problem and the Association with the Carbon Footprint

To understand what aspects of the actions the students identified were perceived as problems and which of these they associated with the CF, a content analysis was performed, the findings of which are in Table 2.

Table 2.

The reasons for perceiving the identified problems under the household category

Sub-domain	*Problem*	*The reason of the problem (9^{th} and 10^{th} graders)*
Electric consumption	The use of a lot of ordinary light bulbs	Waste of electricity, waste of money, environmental pollution, light pollution, greenhouse effect (1 person)
	Turning on all the lights	Waste, thermal power plant-air pollution, light pollution, energy lost, exhaustion of sources
	Switching on electrical devices for hours-leaving them on	Waste of water, electricity and energy, radiation-cancer, pollution
Heating	Burning fireplace needlessly	Consuming very much energy, waste, use of unnecessary sources, cutting down trees to no avail, CO_2 emission (5 persons)
	Unnecessary energy expenditure (opening windows to cool off)	Waste of money and energy, unnecessary consumption of natural resources, air pollution, noise pollution, harm to the environment, harmful gases, radiation, fire possibility

With respect to the consumption of electricity in the "household" domain, it was found that the students mostly focused on the economic aspects of money and electricity waste, expense, damage to the budget and damage to the country's economy. Additionally, it was also seen as a problem in terms of environmental pollution. Besides those that believed that it caused damage to the atmosphere, one student spoke about the greenhouse effect. The students also emphasized the issues of radiation and cancer. In connection with household heating systems, the students focused on the topics of energy waste, money waste, needless consumption of natural resources, and the needless cutting down of trees. Many of the students mentioned air pollution whereas only five students included any statement about CO_2 emissions. The answer given by Student 10.27 is very significant in this context yet the student did not speak of the concept of the Carbon Footprint.

Student 10.27: The energy sources used in supermarkets are numerous.

Student 9.20: Operating household appliances needlessly and going to bed without removing plugs out of the sockets increases radiation and environmental pollution.

Student 9.30: The smoke coming out of chimneys is released into the air and causes an accumulation of hazardous gases. These gases eventually cause the layers of the atmosphere to thin out and the greenhouse effect is brought about.

Table 3.

The reasons for perceiving the identified problems under the transportation category

Sub-domain	*Problem*	*The reason of the problem (The total of 9th and 10th graders)*
Short distance flight (Turkey-Europe)	Flying	Pollution (1), Harmful gases to the ozone layer (1), Fuel consumption (1), Not economical (1)
Car	Driving a big car for a short distance	Waste of fuel and money, traffic jam, danger for pedestrians, global warming and greenhouse effect (1), air pollution, damage to ozone layer, CO_2 gas, exhaust gas, noise pollution
	Driving private automobile	Waste of fuel, harm to the economy, production cost, light pollution , noise pollution, harmful gas emission, air pollution, CO_2 emission (3)
	Driving latest model vehicle	It is not accepted as problem by the students.
Motorcycle	Use of motorcycles for transportation	Harmful gas, air pollution, damage to the environment, harmful to the economy, fossil fuel-pollution, loss of extra energy, spending fuel, CO_2 emission
Bus	Use of buses for transportation	Exhaust gas, loss of extra energy, damage to the environment, CO_2 gas
Subway	Use of subway for transportation	Energy loss, air pollution, damage to the environment, harm to the economy
Tram	Use of tram for transportation	Gas emission, air pollution, damage to the environment, CO_2 emission, fossil fuel-pollution

Another domain suggested by the examples in the text is "transportation" (Table 1). Students do not see airplanes flying as an activity that damages the environment. Only four students pointed to pollution (1 student), gases hazardous to the ozone layer (1 student), fuel consumption (1 student), and to being uneconomical (1 student) as factors that made airplanes an environmental problem. The students pointed to heavy vehicles and private cars mentioned in the text as an economic waste and a burden on traffic, dangerous for pedestrians and, in connection with their direct effect on people and on environmental pollution, they listed noise pollution, air pollution, the damaging of the ozone layer, exhaust gases, CO_2 gas, climate change and the greenhouse effect (1 student).

Student 9.37: Everybody driving in their own cars causes traffic jams and also increases gasoline consumption; besides this, releasing the car's exhaust fumes like this is a thoughtless action.

A large majority of the examples in the text are topics that fall into the domain of "lifestyles" (Table 4).

Table 4.

The reasons of perceiving the identified problems under lifestyle category

Sub-domain	*Problem*	*The reason of the problem (The total of 9th and 10th graders)*
Food selection	Continuous consumption of red meat	Waste of money, waste of energy (spending water, electricity and power), harmful to the health, unbalanced diet, death of living things, unconscious hunting, cutting off animals, extinction of animal species, the deterioration of the balance of the nature
Seasonal food consumption	Consumption of off season food	Harm to the health (food with hormones), deterioration of the genetic structure of the plants, food with hormones polluting soil and water, pesticides, greenhouses effecting the climate negatively, air pollution, damage of carbon balance (1), CO_2 emission (1)
Clothing selection	Buying the latest trend imported aged jeans	Waste, worker health, loss of energy, water pollution, process harmful to the environment, harmful gases
Packaging selection	Not enjoying the package of the present and replacing it with a new one by throwing away it	Waste of money and paper, soil pollution, difficult to disappear in nature, dangerous chemicals, harm to the health
	Using a lot of plastic bags-over-consumption of packaged foods	Difficult to dissolve in nature, environmental pollution, soil pollution, the deterioration of the balance of the nature, waste of oil in plastic bag production, harm to the health
	A lot of canned sodas	Waste, harm to the health, Packing environmental pollution, it takes a long time to disappear in nature, soil pollution, much waste, damage to the ozone layer, CO_2 emissions (1), cutting down trees
	A present of latest model - imported tablet	Unnecessary spending, radiation, a big present
Furniture, electronic device etc. selection	Changing the furniture frequently	Waste of money and energy, cutting down trees, air pollution in the production.
	Perfume	Harmful gases, damage of ozone layer, air pollution, air pollution, global warming, damage to the atmosphere, environmental pollution
Recycling selection	Not recycling	Waste, made of oil, it pollutes nature, it mixes with soil in a long period of time, loss of energy
Entertainment & Activities	Birthday party	Wastes produced during party damage ~~to~~ the environment, noise pollution, moral degeneration

The students focused on human health by mentioning the daily consumption of red meat as detrimental to the health and evidence of an unbalanced diet; they also mentioned wasting money, wasting energy (water, electricity and power) and killing wildlife, haphazard hunting, slaughtering of animals, the extinction of animal species, and disturbing the balance in nature. They considered the consumption of out-of-season fruit, eating chips and chocolate as unhealthy habits, also mentioning the hormones found in foods and thus made their assessments in terms of human health. The students' comments on damaging the genetic structure of plants, pollution of the earth and water by foods with hormones, agricultural pesticides, the adverse effects on the climate of greenhouses, and air pollution were under the general category of environmental pollution; students mentioned the disturbing of the carbon balance (1 student), CO_2 emissions (1 student) and finally, one student (Student 10.63) expressed an opinion that could be evaluated within the context of the Carbon Footprint. There was no mention, however, of the concept of CF.

Student 10.63: Eating a lot of meat causes an increased consumption of water, electricity and power in animal husbandry and when their products are distributed.

In the clothing sub-domain in the text, the students mentioned imports of the latest fashions, the process of creating worn jeans and especially the use of chemicals in this process, focusing at the same time on occupational health and the effect on the environment of such processes as well as the different dimensions of water pollution and the emission of hazardous gases. Energy lost and wasted was a topic that was commonly mentioned.

Student 9.25: The process of making worn-down jeans causes fatal diseases in workers who are involved in the process.

Student.10.42: The chemicals used in deodorants and in making worn-out jeans are bad for human health and they are harmful to the environment.

In the topic of packaging preferences, the students mentioned the fact that plastic bags took a long time to disintegrate and that this was damaging to the earth, air and water, and that because there was so much waste matter, the balance of nature was being destroyed. They also stated that packaging was a waste of money and paper and they particularly focused on the petroleum wastes of plastic manufacturing. There were many students who emphasized that unnecessary packaging and food containing acids were health hazards. The students said that packaging caused damage to trees and to the ozone layer, also referring at the same time to emissions of CO_2 (1 student).

Student 9.62: They could have used environment-friendly bags instead of the plastic ones or they could have put 1-2 items in one bag and used less bags. Plastic bags are one of the wastes that nature cannot destroy for a long time.

Five students considered furniture, electronic equipment preferences or a present of the latest model iPad problems for the environment. They said that these items were hazardous to human health because of radiation and by stating that the presents were unnecessarily expensive, they touched upon the economic dimension of the problems.

Student 9.73: They bought the latest model iPad. This way they're emitting radiation and harming the environment. Also, because they don't really need the latest model, by buying it they've squandered their money.

The example given in the recycling preference category caused the students to remark on the waste produced by disposable plates and forks, the loss of energy produced, the polluting of the environment because of the plastics being made of petroleum, and the slow reabsorption into the earth.

Student 9.29: Disposable plates are plastic and plastics don't disintegrate in the environment and are therefore harmful.

Only three students in the 10th grade thought that birthday parties were environmental problems. One of the students stated that they thought this was a problem because it was a type of moral degeneration and another student said that it was a problem due to the noise pollution it produced. Another student expressed the following thought:

Student 10.27: The waste, etc. from the party are harmful to the environment.

Although the students spoke, albeit very little, of pollution caused by household appliances, transportation, gas emissions and CO_2 emissions, none of the statements had anything to do with the ecological footprint or the carbon footprint. In the lifestyle domain, there were two students who pointed to the concept without identifying it as the carbon footprint; none of the students mentioned the carbon footprint directly.

The Headings Given to the Text and the CF

The headings were reviewed, grouped and are given in Tables 5 and 6.

Table 5.

Evaluation of the headings written by the 9th grade students about the text

Heading Content	*Frequency*	*Examples*
Positive	8	Happy (1), surprising (1), rich (1), beautiful (1), entertaining (1), enjoyable (1), different (1), special (1)
Undecided - Blank	7	Good or bad (1), ordinary (1), in the 21st century (1), any (1), empty (3)
Negative	62	
Damage	31	Damaging (20), disastrous (1), wrong (3), mistaken (2), bad (2), sleepy (4)
Material damage	22	Wasteful (11), expensive (1), squandering (3), consumption crazy (1), time for consumption (1), spent (2), saved (1), damaging day (2)
Damage to the environment	9	Forgetting the environment (1), the environment's happiest day! (1), environmental enemy (2), how can we destroy the environment (1), difficult for the environment (1), egotism (1), making nature unhappy (1), bad for nature (1)
Total	77	

Table 6.

Evaluation of the headings written by the 10th grade students about the text

Heading content	*Frequency*	*Examples*
Positive	3	I wanted to have fun (1), warm (1), to make a kid happy (1)
Undecided - Blank	15	-Blank (13), weird (1), ordinary (1) day??.
Negative	45	
Damage	19	Useless (1), unnecessary (5), an accustomed mistake (1), mercy (1), come on (3), disgusting (1), ruined (1), bad (2), monotonous (1), silly (1), redundant (1), crazy (1)
Material damage	14	A wasteful (10), expensive (1), full of squandering (1), costly (1), too high-priced (1)
Damage to the environment	12	A day of insensitivity (1), the world's killers (1), damage to the environment (7), ingratitude (1), environmental disaster (1), environmental enemies (1).
Total	63	

As can be seen in Tables 5 and 6, the total number of students who interpreted the sample events in the text as negative was 107. The total number of students who were undecided about the events or evaluated them as positive was 33. The events qualified as negative belong to three headings: damage, only material damage, damage to the environment. Of the students, 76% assessed the events as negative. The students who evaluated a day's activity as harmful to the environment accounted for 15% but there was no heading referring to the CF, EF, and climate change.

Differences between the Classes in terms of Identifying Environmental Problems

After the environmental problems that the students identified from the text were evaluated one by one, a statistical comparison was made to determine whether there was a difference between the classes; the results are shown in Table 7.

Table 7.

9th and 10th grade students comparison of their identification of environmental problems in the text

Students	N	$\overline{X}$	sd	t	*p*
9th grade students	77	15.21	4.870		
10th grade students	63	12.43	4.872	3.359	.001
Total	140				

(t= 3.359 and p< .05)

A significant difference in favor of the 9th grade was found in the comparison of the 9th and 10th grades in terms of their identification of the environmental problems in the text.

Discussion

When the items that fall into the household domain in the text were evaluated in terms of the awareness of the students, it was seen that the biggest problem identified by the students was keeping electrical appliances on for a long time and keeping them plugged in when not in use resulting in waste and causing fire. A low percentage of students considered using a lot of ordinary light bulbs as a problem. In a similar study, although 82% the students associated the use of an energy-saving light bulb with savings, the same students could not associate this with global warming (Cordero et al., 2008). It is important however that the examples of electricity usage caught the student's attention since the big proportion of the CF comprises electricity used in home. Opening the windows in a warm house in the wintertime was not seen as a problem by as many students as had been expected. What the students generally mentioned in terms of problems related to electricity and heating were economic factors such as wasting money, being too expensive and health problems such as cancer and radiation. No student made an association with the CF in any of the explanations. As indicated by Cordero et al. (2008), in the previous studies also, the level of comprehension of students regarding the relationship between energy usage and global warming is low. The students can be made construct relationships with individual energy usage by utilizing active learning methods.

Such problems as driving an oversized automobile for short distances, driving private automobiles mentioned in the domain of transportation were again mostly indicated as waste, heavy traffic, and being a hazard to human health. Although the references made were few, CO_2 gas was mentioned with regard to air pollution. In previous works, as parallel to the present study, it was reported that only visible and local pollution such as automobile exhaust fumes and factory chimney emissions could be associated with global warming (Andersson and Wallin, 2000; Cordero et al., 2008). No student indicated travelling by plane as an environmental problem. The reason for this situation might stem from the fact that travelling by plane is a distant thing for their lifestyles. There was no student, in fact, that wrote down the term CF about transportation or made any association with this domain.

When the problems stated by the students and their frequencies and explanations were examined, it was seen that the students were less aware of the way lifestyles affect the environment than they were of the effects of the other two domains. This result has parallel consequences with the study conducted in 2005 (Tuncer et al., 2005). In this study which was conducted with the same age group students, it was seen that students could not associate their daily lifestyles with this subject although they were aware of the destruction of natural resources and individual responsibilities. Cordero et al. (2008) also signified that although most Americans thought that human factor was significant in climate change, it was unclear ~~in~~ at what level they were educated sufficiently regarding the relationship between humans' lifestyles and climate change. The regular consumption of meat is a low-level problem due to the reasons such as health, expenditure and animal slaughtering. One study has reported that 80% of students who had learned about vegetarian eating habits accepted that this type of nutrition could reduce climate change (Cordero et al. 2008). This situation is also valid for other situations related with food as well (Eshel and Martin, 2006). In package selections, although 88% of the students considered many packaged soda drinks as an environmental issue, only one student mentioned CO_2. This situation is as bad as the fact that 21% of the students responded positively to the statement "buying bottled

water contributes to global warming" (Cordero et al., 2008). As indicated in the same study, in this present study many students mentioned recycling but did not describe the direct connection between consumption and energy. In another study, the percentage of making household energy saving was high, however changing travelling and shopping habits was a less popular situation (Whitmarsh et al., 2011). In the domain of entertainment and activity preferences, "holding birthday party" was indicated as the statement causing the least amount of problems. Entertainment and activity preferences can be evaluated in terms of indirect CF. It was determined that indirect CF, which requires more conscious perspectives when compared to the other domains, was not noticed by any students. Such a deficiency was also determined by Galli et al. (2012) and it was stated by the researchers that consumers should be made aware of greenhouse emissions caused by their own lifestyles in public and private sector environments.

In this study, a misconception such as "carbon emissions cause ozone depletion" was identified as indicated in the previous studies (Cordero et al., 2008; Whitmarsh et al., 2011).

The evaluation of the headings that the students wrote down showed that although 76% of the students who indicated the things done in the text were generally harmful, the students who stated that this harm ~~was~~ directly affected nature was at a lower percentage of 15%. A check of all headings showed that no concepts of "CF" or "EF" which could be mentioned due to several sections or "global climate change" were encountered. The headings written down by the students demonstrate to us that most of the students are aware of the fact that their behaviors are wrong, however it was indicated that they could not associate with the concepts of global climate change, EF and CF.

When 9th and 10th graders were compared in terms of their identification of environmental problems related to the CF, it was seen that there was a statistically significant difference between the two groups. The difference ~~is~~ was in favor of the 9th grade students. The concept of the CF takes place in the 9th Grade Biology Teaching Program (TTKB, 2007). Since these concepts are taught in the last lessons of 9th grade, it was expected that 10th grade students would be more aware of this topic. The study showed a striking result, however, a difference in favor of 9th graders. All of these results demonstrate to us the problem in the instruction of the concepts of CF and EF and the objective "Questioning the contribution of the individual to the emergence of environmental problems".

This problem is the fact that students could not associate the situations given in the text with CF, EF and climate change. The 9th graders did not respond since they did not know the subject matter, however the reason that 10th graders did not indicate that might stem from two situations. The first situation might be that they did not include the given events into this definition because they did not know the definitions of these concepts and they never used these concepts. The other situation was that although they knew the definitions of these concepts they could not introduce their knowledge entirely because they could not include them in their experiences. Due to the nature of this study, which situation is more valid cannot be tested. This fact indicates a limitation of the present study. The present study might be important for understanding the connections among knowledge, internalizing knowledge and behavior. If the first situation is valid, teaching is unsuccessful; in other words knowledge gain was not supplied. Regarding the second situation, insufficiency of teaching, where attitude and behavior level cannot be achieved from knowledge level, arises. Based on the observations during the study, the second situation is more likely thought to occur during teaching. So, presumably, many students could respond to this question as the definition, if the concept of CF was given and asked to the students directly. It was also

thought that the percentage of students' responses would rise if that question was given as a multiple choice question. This consequence is not surprising as it comes out after the application of knowledge-based environmental education program. Since students could not include their knowledge into their experiences, they could not introduce them in another perspective with a holistic view.

The situation related to the teaching of CF is also valid for various other environmental subject matters. The studies conducted in environmental education show that students do not always reflect their knowledge on their affections and behaviors (Devine-Wright and Fleming, 2008). Pooley and O'Connor (2000), in their study where they evaluated the teaching program, have stated that the dimensions of attitudes and behavior are neglected in the programs and that education is mostly focused on providing knowledge. We should not only teach science in terms of environmental education but also the gain of positive attitudes, behaviors and values should be provided (Cross and Price, 1999). Knowledge cannot be considered as the transfer from teacher to the student; conversely, authentic learning should be achieved by reflecting on the attitudes and behavior of the student (Lee et al. 2013). In this respect, the development of environmental science programs might be beneficial in terms of bringing in responsibilities to the students at this point and associating the environmental problems with their behaviors (Fusco et al. 2012). Environmental education programs demonstrate a change towards the development of environmental behavior as the increase in conceptual knowledge related to the environment (Pooley and O'Connor, 2000; Lee et al. 2013). The point here is how these environmental education programs will be designed (Lee et al. 2013). It is necessary to think about the dimensions of the program - positive attitude, behavior and value these will have in its design as this study has shown deficiency in the teaching of those concepts.

Besides the content, teachers constitute another important dimension of the program. According to UNESCO's (2005) recommendations and guide to re-planning teachers' education from the perspective of sustainability, "Education for Sustainable Development" can be attained not only by learning passively and understanding but also by developing skills, attitudes, values and relevant concepts. Sibbel (2009) says that graduates of traditional educational programs have not provided radical solutions for the world's new and complex problems. These problems are multi-dimensional and they cannot be treated with the accustomed applications of traditional scientific, economic and social theories. CF is a relatively new concept. Its entry into the 9th grade Biology program in 2007 is also relatively new. For many teachers, too, it is a new concept and subject that they have not encountered before. For this reason, teachers' awareness about the importance of providing effective instruction about climate change must be raised through in-service training programs. In order to teach students how to make the connection between global climate change and their daily habits and consumption behavior, teachers must be provided with materials of authentic instruction, specifically prepared for and focused on practical applications.

In the 2013 program, there is an explanation: Practices related to the ecological foot print and carbon foot print are carried out. There is need for materials which can be utilized at this respect. The data gathering instrument utilized in this study - "....One Day" was also designed and can be utilized in the instruction of CF. This text is very ideal for using in its original form or by changing its various parts by considering cultural differences or classroom status. It is recommended to use this text as a course material in addition to CF calculations in CF teaching or using it as an alternative. CF calculations are very significant in terms of teaching global climate change since they give direct quantitative values and since they are web-based. This material can be supportive in this aspect as it allows students to become aware of their behaviors in daily life and it can be used when there is no internet connection. It is an important

instrument to draw attention to real world problems and to generate solutions in authentic teaching approaches to them.

The regression coefficient for XM was found to be 0.041 and was not statistically different from zero, with t(1631) being 0.532 and p being 0.595. Thus, the effect of concern on responsibility does not depend on gender. This means that the relationship between concern and responsibility did not differ in females and males. The non-significant moderation effect of gender on the relationship between concern and responsibility was also supported by the PROCESS output, which displayed the range between the lower limit confidence interval (LLCI = -0.1098) and the upper limit confidence interval (ULCI = 0.1914) for the interaction including zero.

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▪ ▪ ▪

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APPENDIX 1.

Original Text Prepared As A Data Collection Instrument

First and Last Name: Grade-Class: Date:

In the story below, which actions of the people in the story are damaging for the environment? Why? (Mark the situations in the text where the environment is being damaged by underlining and numbering the activity. Write down on the back of the paper, in detail, the reasons for why you numbered these situations.)

A ..... DAY

Doğa and Umut have decided to throw a birthday party for Rüzgar. The party was going to be at Doğa's house because Rüzgar's house was in construction since a natural gas system was being installed. And besides, Doğa's house was perfect for a party because it had so many rooms. They first called all their friends on their cell phones and invited them to the party. Fatma, Mustafa, Gül, Ahmet, Yağmur and some others were on the invitation list. Then they asked Umut's father to drive them to the shopping mall so that they could shop. They had so many things to buy for the party. They had plenty of time until the evening and everything had to be perfect. Umut's father took them to the mall in the huge truck he drove to work in every day. The shopping mall was very close but they got there sooner with the truck.

They went into a supermarket. They were going to make a cake for the birthday party. They got all the ingredients for a cake. Then they had to buy some beverages to accompany the cake. They had a long discussion about the beverages. Doğa wanted to buy 4 bottles of the 2.5-liter soda but Umut insisted that they get a 330 ml can each for everyone. Doğa tried very hard to convince Umut but she was not successful. In the end, they bought twice the number of cans as there were guests, that is, they bought 30 cans. They also needed some food for some supper before the cake. Doğa liked to eat meat every day in order to eat a balanced diet and although there were other sources of protein. That's why she suggested right away that they should buy some lamb chops. Umut said that strawberries would be a good dessert after supper. Even though they were in winter, there were some huge strawberries at the entrance to the market that looked very fresh. Doğa suggested some organic food but Umut rejected the suggestion. After buying the meat and the strawberries, they also bought some potato chips and chocolate. They had finished their grocery shopping, their bags full of packaged foods.

It was now time to visit the mall. There they bought a lot of decorations and lighting that they were going to use for the party. Then it was time to get a present. Rüzgar was a very fashionable guy. They had to get him something that was very much in style. So they bought him a fashionable pair of worn-out jeans and a fragrance that they thought Rüzgar would like. Of course Rüzgar had 10 pairs of jeans but he didn't have this stylish pair from Italy. Doğa didn't like the packaging of the present so they decided to go and get some shiny wrapping paper. They opened up the package where the jeans where and when they couldn't find a wastepaper basket, they threw the package on the ground. Now the present had been wrapped in the shiny wrapping paper just the way they wanted. Meanwhile, while they were walking around in the mall, they bought themselves a few things even though they didn't really need them. After all their shopping was done, they had a lot of bags in their hands. Doğa phoned home and her mother came to pick them up in their car which was the latest model and burned 9.7 liters per 100 km. When they got home, the smoke going up the chimney made Doğa think that it would be very warm inside. When they went inside, it really was very warm. Umut wasn't used to having the heat up like this so in the end, he

couldn't stand it anymore and got up and opened up a few windows. They sprawled out and rested on the furniture in the house, which was very richly furnished and redecorated very frequently.

A short time after they got home, their friends started arriving one by one. Mustafa and Fatma had come by bus, Gül had taken the subway, Ahmet had come on his motorcycle and Yağmur had taken the tram. Rüzgar 's grandmother had sprung a surprise and had taken a plane from Germany to come to the party. She brought Rüzgar the latest model tablet as a birthday present. Everything was all ready for the party. When Rüzgar came home, all of the lights had been turned off. He stepped in and..... All the lights went on. They all thought there was no harm in leaving the lights on in the whole house for just one night. In addition to the coal-burning heating system in the house, they also lit up the fireplace. At the end of the party, everyone went back in their own private vehicles. When the party was over, Rüzgar 's mother put all the disposable plates, forks, beverage cans and food wastes into a plastic bag and threw the bag in the garbage. Then she took out the vacuum cleaner and cleaned up the place for hours. She started the wash too although she didn't have enough laundry to fill up the machine. Then, as usual, everyone went to bed and fell asleep without unplugging or even turning off the TV, computer, washing machine and the electrical appliances in the kitchen. Good night...

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RESEARCH ARTICLE

Türk Lise Öğrencilerinin Karbon Ayak İzi Konusundaki Farklılıkları ve Liselerdeki Biyoloji Programının Öğretiminin Bu Farklılığa Etkisi

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Özet

Küresel iklim değişikliğinin en önemli insan kaynaklı sebeplerinden olan karbon emisyonları tüm çabalara rağmen hızlı bir şekilde artmaya devam etmektedir. Karbon ayak izi (KAİ) eğitimi, bu durumu tersine çevirme açısından oldukça önemlidir. Bu çalışmanın amacı, lise öğrencilerinin Milli Eğitim Bakanlığı Ortaöğretim Biyoloji Dersi 9. Sınıf Öğretim Programında yer alan KAİ konusundaki farkındalıklarını ve programa göre uygulanan derslerdeki öğretimin bu farkındalığa olan etkisini belirlemektir. Bu amaçla, 140 lise öğrencisi ile keşfedici karma desene ait bir araştırma yürütülmüştür. KAİ için özel bir veri toplama aracı hazırlanmıştır. Toplanan nitel veriler öncelikle döküman analizi yöntemine tabi tutulmuştur. Öğrencilerin farkında oldukları çevre sorunlarının belirlenmesi önceden belirlenmiş temalar üzerinden yapılmıştır. Bu sorunların KAİ ile ilişkilendirme biçimleri öğrencilerin yaptıkları açıklamalar ve metne yazdıkları başlıklardan elde edilen temalar üzerinden ortaya konmuştur. Sonrasında sınıfların, sorunları farketme oranları ve aralarındaki farkları nicel olarak ortaya koymak için SPSS programı kullanılmıştır. Sonuçta, öğrencilerin KAİ bileşenlerinden ev ve ulaşım alanındaki sorunların farkındalığının yaşam tarzı alanındaki farkındalıklarına göre yüksek olduğu belirlenmiştir. Ancak öğrenciler KAİ ve küresel iklim değişikliği arasındaki ilişki hakkında bütünsel bir yaklaşıma sahip değillerdir. Bu durum değerlendirildiğinde KAİ kavramının öğretiminin ve programdaki buna bağlı kazanımın başarıyla gerçekleştirilemediği ortaya çıkmaktadır. Öğretim programının, öğretmen boyutunun yeniden değerlendirilmesi ve öğretim yöntemlerinin zenginleştirilmesi konunun öğretimi için önemlidir. Ayrıca bu çalışmada kullanılan test, aynı zamanda KAİ öğretiminde ders materyali olarak kullanılarak öğretimin zenginleştirilmesine katkı sağlayabilir.

Anahtar Kelimeler: Küresel iklim değişikliği, karbon ayak izi (KAİ) eğitimi, MEB biyoloji öğretim programı.

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