PRE-SERVICE SCIENCE TEACHERS' MISCONCEPTIONS OF CARBON CYCLE AND GLOBAL WARMING

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Abstract

Pre-service science teachers have some information about carbon cycling and global warming. Their information level is so important to teach environmental issues and develop students' environmental awareness. In the study, the misconceptions held by 4th year pre service science teachers about carbon cycle and global warming was investigated. A total of 52 4th year pre-service science teachers attending Kahramanmaraş Sütçü İmam University, Faculty of Education, Science Education Department participated in the study. A questionnaire consisted of 10 open ended questions was developed to determine pre-service science teachers' conceptions about the key components of the carbon cycle and global warming. Results have revealed that pre-service science teachers have conflicting, scientifically incorrect ideas and many misconceptions relating to the subject.

Key Words: Pre-service science teacher, carbon cycle, global warming, misconception

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ KARBON DÖNGÜSÜ VE KÜRESEL ISINMA İLE İLGİLİ KAVRAM YANILGILARI

Özet

Fen bilgisi öğretmen adayları karbon döngüsü ve küresel ısınma ile ilgili bazı bilgilere sahiptirler ve bu bilgilerin seviyesi çevre konularını öğretmelerinde ve öğrencilerinin çevresel farkındalıklarını geliştirebilmelerinde büyük öneme sahiptir. Çalışma kapsamında, 4. Sınıf fen bilgisi öğretmen adaylarının karbon döngüsü ve küresel ısınma ile ilgili sahip oldukları kavram yanılgıları araştırılmıştır. Çalışmaya, Kahramanmaraş Sütçü İmam Eğitim Fakültesi, Fen Bilgisi Öğretmenliği 4. Sınıf öğrencileri (N=52) katılmıştır. Karbon döngüsü ve küresel ısınma konularının temel bileşenlerini sorgulayan on adet açık uçlu sorudan oluşan bir görüşme formu geliştirilerek, öğretmen adaylarından cevaplamaları istenmiştir. Bulgular, öğretmen adaylarının birbiri ile çelişen ve bilimsel olarak yanlış fikirlerinin olduğunu ve konu ile ilgili çok sayıda kavram yanılgısına sahip olduklarını ortaya koymuştur.

Anahtar kelimeler: Fen bilgisi öğretmen adayı, karbon döngüsü, küresel ısınma, kavram yanılgısı

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INTRODUCTION

In the recent years, there have been many increasing environmental problems such as increased greenhouse effect, depletion of ozone layer, water pollution etc. (Gudovitch & Orion, 2001). Nowadays, climate change has become one of the most serious environmental problems and this subject has been dealt with by school curriculums as well as media (Papadimitriou, 2004; Çimer, Çimer, & Ursavaş, 2011; Lombardi & Sinatra, 2012). Even, people feel that they personally experienced global warming (Akerlof, Maibach, Fitzgerald, Cedeno, & Neuman, 2013). Climate change which occurs as a result of global warming is a complex phenomenon. The cause of global warming is the increase in the amount of "greenhouse gases" such as carbon dioxide, ozone (at tropospheric altitudes), hydrofluorocarbons (HFCs), methane, perfluorocarbons (PFCs), chlorofluorocarbons (CFCs), nitrous oxide, sulphur hexafluoride, and water vapor. Today, although the main greenhouse gas is carbon dioxide, there are other gases which create greenhouse effect such as methane. The sources of these gases are various. The significant increase in the amount of gases which cause greenhouse effect today in the atmosphere creates a serious problem for a sustainable life on earth. Besides taking immediate precautions to stop climate change or at least slow it down, bringing up environmentally sensitive individuals carries great importance as well. But the studies display that the people don't feel responsible for environmental problems (Dutt & Gonzales, 2012). For example, Whitmarsh (2009) conducted a research on the public understanding of climate change and global warming in the south of England. The findings reveal that the people are not aware of their responsibility for global warming and climate change.

At this point, a great responsibility falls on the shoulders of schools. Çakır, İrez, and Doğan (2010) state that one of the main goals of education is developing people's understanding the subjects relating to the environment and environmental problems. Unfortunately, even in terms of very current environmental issues, the researches display that both teachers and students have misunderstandings about environmental subjects. For example, Papadimitriou (2004) displayed that students are unaware of the precautions that should be taken to slow the climate change down, and as well they have some misconceptions relating to many environmental problems such as acid rain, ozone layer depletion. Summers, Kruger, Childs, and Mant (2000) search for the primary school teachers' knowledge about biodiversity, the carbon cycle, ozone and global warming. The results of the study reveal that students have lack of adequate knowledge relating to the subject. Additionally, Kılınç, Stanisstreet and Boyes (2008) display that students believe that global warming causes heart attack, fish and food poisoning and the rate of skin cancer will

increase as a result of global warming. The pre-service teachers believe that decreasing nuclear energy usage will help to decrease global warming (Stanisstreet & Boyes, 2004). Gudovitch and Orion (2001) state that students are aware of environmental problems but they don't have adequate knowledge.

Global warming is a concept related to numerous issues. One of these is carbon cycle. The understanding of issues related to carbon cycle carries great importance in the understanding of many concepts related to the environment (Summers, Kruger, Childs, & Mant, 2000). McCaffrey and Buhr (2008) state that the carbon cycle is one of the most important biogeochemical cycles relating to the climate. Although there is a significant relationship between the carbon cycle and global warming, it has been observed that students do not have sufficient knowledge about the carbon cycle. For example, Özay and Öztaş (2003) display that many of the secondary school students don't know the role of photosynthesis in the carbon cycle. In order for the issue of global warming to be understood, firstly carbon cycle should be understood. In addition, due to the serious dimensions, global warming has reached today, the concept "carbon footprint" has emerged. We all have a carbon foot print and there are numerous precautions we can take to individually decrease this mark. However, individuals need to understand concepts such as carbon cycle and global warming to be able to take these precautions At this point, teachers have a great duty. The teachers should develop specific instructional methods to develop a better understanding of specific scientific concepts (Cordero, Todd, & Abellera, 2008).

The importance of the study

One of the possible reasons for students' misconception about the carbon cycle and global warming is the misconceptions of teachers. In the mentioned researches, it can be seen that teachers have misconceptions about global warming as well. According to Khalid (2003), when science teachers have misunderstandings relating to the environmental subjects they transfer them to their students in the classrooms. Teachers should have good field knowledge to teach effectively (Summers, Kruger, Childs, & Mant, 2000). Within the scope of the study, the misconceptions of pre-service science teachers who will be graduating in the next term about the carbon cycle and global warming have been analyzed. It is considered that the obtained findings will give information about the level of knowledge and existing misconceptions of teacher candidates about the subject and will be beneficial in taking various precautions.

When studies in the literature are analyzed, it can be seen that there are many misconceptions about global warming. In general, these studies analyzed the misconceptions related to global warming and ozone layer depletion. When literature is reviewed, it can be seen that students' misconceptions about carbon

cycle have not been researched. However, primary the reason for the gradual exacerbation in the greenhouse effect is the serious amount of increase in carbon dioxide emission. The acknowledgment of the sources of carbon is extremely important in understanding carbon dioxide emission. Therefore, questions were posed to the students about carbon cycle in the study and these questions were associated with global warming. Science teacher candidates who are seniors participated in the study. The teacher candidates in question will be graduating in one semester. Therefore, they have already taken classes such as environmental science and special topics in chemistry which are a part of the undergraduate program. Identification the knowledge on the subject of teacher candidates who have reached the graduation level is important in reflecting what they will be teaching in their classes when they graduate.

Aim of the study

The aim of this study is to identify the misconceptions of science teacher candidates about the carbon cycle and global warming and discuss how these misconceptions and their sources can be eliminated in the light of achieved findings.

METHOD

The study is a qualitative research. Descriptive analysis model was used in the study. Descriptive analysis model tries to explain the current situation (Karasar, 2015). In the study, it was aimed to determine pre-service science teachers misconceptions related to the subject. The study conducted in the 2016-2017 academic year in the fall semester.

Samples

The sample of the study consisted of 52 pre-service science teachers attending Kahramanmaraş Sütçü İmam University Faculty of Education, Department of Science Education. The pre-service science teachers are 4th -year students. The purposeful sampling method has been used.

Data collection tool

The questionnaire on the carbon cycle and global warming was developed to determine students' knowledge and misconceptions related to the subject. The test consists of 10 open-ended questions. The questions were prepared in the light of wide-spread misconceptions in literature and the misconceptions observed by the researchers during their classes with their students. The questions and the content validity of the test were examined by the 3 chemistry education experts. These experts have Ph.D. degree in chemistry education and

study in this field. The test consisted of open-ended items designed to determine students' ideas about carbon as a natural substance, the carbon cycle, carbon dioxide resources, global warming, the greenhouse effect, and the results of global warming.

The items of "What do we know about the carbon cycle and global warming?" are given below:

1. Do you think that carbon is a natural pollutant? Explain your answer.

2. What is carbon cycle? Please explain.

3. What are the CO_2 resources in the atmosphere?

4. What are the reasons for CO_2 increase in nature?

5. Is there any connection between CO_2 and the warming of the atmosphere? Please explain.

6. What kind of natural events do you expect as a result of global warming (drought, floods, storms, etc.)? Why?

7. Does global warming affect the whole world at the same rate and the same way? Why?

8. Is there a relationship between global warming and forest fires? Explain the reasons for your answer.

9. Why do we call CO_2 as a greenhouse gas? Do you know any other greenhouse gases? Please explain.

10. Please explain the importance of carbon for liveliness.

DATA ANALYSIS AND FINDINGS

The responses of the students for the open-ended questions in the Carbon cycle and global warming achievement test were analyzed. The misconceptions of the students were classified and the frequencies and percentages of the misconceptions are presented in Table 1.

Table 1. The frequencies and percentages of students' misconceptions

Misconceptions (MCs)	Item No.	N	%
MC 1a.Carbon is a natural pollutant. It exists in the structure of numerous compounds and gets mixed with the environments as it is used	1	23	44,2
MC 1b. Carbon is a natural pollutant. Because, mixing of carbon with water through petroleum and its derivatives pollutes the environment	1	5	9,6
MC 1c. Carbon is a natural pollutant.	1	13	25
MC 2a. The carbon cycle is turning of carbon dioxide into oxygen.	2	10	19,2
MC 2b. Carbon in soil is taken by the roots of plants and exhaled to the atmosphere back by human and animals. That is carbon cycle.	2	18	34,6
MC 2c. Plants take the carbon dioxide into the atmosphere, turn it to the oxygen and carbon hydrate, the carbon hydrate used by humans	2	19	36,5

and animals and turned to carbon dioxide and exhaled to the atmosphere back. That is the carbon cycle.

MC 3a. Humans and animals are the sources of the carbon dioxide in the atmosphere.	3	5	9,6
MC 3b. Factories and exhaust gases are the resources of the carbon dioxide in the atmosphere.	3	12	23
MC 3c. Coal, exhaust and factory gases are the resources of the carbon dioxide in the atmosphere.	3	10	19,2
MC 3d. Humans, animals and factory gases are the resources of the carbon dioxide in the atmosphere.	3	15	28,8
MC 4a. The reasons for increase of carbon dioxide concentration in nature are the use of fossil fuel and respiration.	4	15	28,8
MC 4b. The decrease in the number of plants responsible for the increase of carbon dioxide.	4	6	11,5
MC 5a. Carbon dioxide causes ozone layer depletion.	5	17	32,6
MC 5b. Carbon dioxide creates a shield and reflects back the sun rays falling on the surface of the earth. This causes an increase in the warming of the earth.	5	12	23
MC 6a. As a result of global warming, droughts will take place (no explanation).	6	9	17,3
MC 6b. As a result of global warming, excessive evaporation takes place and it causes drought.	6	12	23
MC 6c. As a result of global warming, glacial melting will take place. Glacial melting causes floods.	6	3	5,7
MC 6d. Global warming causes droughts and floods (no explanation).	6	15	28,8
MC. 6f. As a result of global warming, the ozone layer gets damaged. And this causes drought.	6	10	19,2
MC 7a. Global warming will affect the whole world in the same manner (no explanation)	7	14	26,9
MC 7b. Since the ozone layer is the same everywhere in the world, all places will get affected in the same manner can be seen	7	10	19,2
MC 7c. Humid places will be less affected than the arid places.	7	5	9,6
MC 8a.Carbon dioxide exhaled as a result of forest fires depletes the ozone layer.	8	15	28,8
MC 9a. Carbon dioxide is the only green house gas.	9	12	23
MC 9b. Since carbon dioxide depletes the ozone layer, it is called as green house gas.	9	10	19,2
MC 10a. Carbon is the most important source of energy.	10	13	25

RESULTS AND DISCUSSION

When the answers of the students for the open-ended questions were analyzed, it was determined that they had many misconceptions about the carbon cycle and global warming. When the answers of the students for the first question "Do you think that carbon is a natural pollutant? Explain your answer" were analyzed, it was seen that 44% of the students viewed carbon as a natural pollutant and justified this view by stating that it existed in the structure of

numerous compounds and get mixed with the environments as it was used (MC 1a). 9,6% of the students made a similar explanation and stated that mixing of carbon with water through petroleum and its derivatives polluted the environment (MC 1b). 25% of students stated that carbon was a natural pollutant but did not state a reason. These statements about carbon showed that carbon reminded the students of the damages given to the environment through fossil fuels and the use of fossil fuels. It could be seen that they didn't form a connection with carbon's elementary characteristics. The answers given to the 10th question which was asked in relation to the 1st question also supported the misconceptions about the subject. 25% of the students gave the answer "carbon is the most important source of energy" to the 10th question (10. Please explain the importance of carbon for liveliness) (MC 10a). It could be seen that they were not aware of the importance of carbon in terms of liveliness. When the answers to the 2nd question about carbon cycle were analyzed (What is carbon cycle? Please explain), it became noteworthy that the students had insufficient knowledge about carbon cycle. The statements seen in MC 2a, MC 2b and MC 2c showed that, the students regarded carbon cycle as plants taking in carbon dioxide and turning it into nutrition, the created nutrition being consumed by other beings and the recreation of carbon dioxide. At this point, the students showed that they had no information about what happens after live organisms die and what kind of a transformation carbon in dead bodies goes through. Another misconception of the students determined was about how carbon dioxide was taken in by plants. 34,6% of students expressed that carbon in soil was taken in by the roots of plants (MC 2b). This showed that the students has a serious misconception about photosynthesis as well. When the answers given to the 3rd question "What are the CO_2 resources in the atmosphere?" were analyzed, it was seen that 9,6% of the students gave the answer "humans and animals" (MC 3a), 23% gave the answer "factories and exhaust gases" (MC 3b), 19,2% gave the answer "coal, exhaust and factory gases" (MC 3c) and 28,8% gave the answer "humans, animals, factory gases" (MC 3d). While the answers given showed that some of the students were not aware of the use of fossil fuel, those students who were aware of the use of fossil fuel didn't think that other natural events such as forest fires and volcanic eruptions caused carbon dioxide oscillation. The answers given to the 4th question (What are the reasons of CO_2 increase in the nature?) showed that 28,8% of students thought that the reasons for the increase of carbon dioxide concentration in nature were the use of fossil fuel and respiration (MC 4a). It was interesting that the students thought about the use of fossil fuels and the respiration activities of living creatures together and evaluated them in the same category. 11,5% of the students hold the decrease in the number of plants responsible for the increase of carbon dioxide (MC 4b). The students' not being

able to think multi-dimensionally about carbon dioxide increase, stating an unimportant event such as respiration instead of human activities which is the main cause of carbon dioxide increase and one group only giving the decrease in the amount of plants as the reason points out to quite serious misconceptions. When the answers given to the 5th question (Is there any connection between CO_2 and the warming of the atmosphere? Please explain) were analyzed, it was seen that 32,6% of the students thought that carbon dioxide caused ozone layer depletion (MC 5a). In addition, 23% of the students thought that carbon dioxide created a shield and reflected back the sun rays falling on the surface of the earth (MC 5b). Here, there were two important misconceptions.

The first of these was the students' misinterpreting the relationship between ozone layer depletion, temperature rise, and carbon dioxide. The second was their mentioning that carbon dioxide absorbed heat and caused a shield instead of causing the greenhouse effect. Another misconception the students had about global warming and ozone layer depletion was that as a result of global warming the ozone layer get damaged (MC 6f, 19,2%). 28,8% of the students thought that carbon dioxide produced as a result of forest fires caused ozone layer depletion (MC 8a). 19,2% of the students thought that the term greenhouse effect was used since carbon dioxide caused ozone layer depletion (MC 9b) and 23% of students thought that there were no greenhouse gases other than carbon dioxide (MC 9b). Similar misconceptions are seen in the literature as well. Similarly, Kılınç, Stanisstreet and Boyes (2008) stated that there was a confusion between global warming and ozone layer depletion. In their study, students stated that carbon dioxide caused greenhouse effect and ozone layer depletion. The second misconception they stated, the holes in the ozone layer caused global warming. As a result of ozone layer holes, extra sun rays reached the earth and increased the temperature. The same misconception determined by Meadows and Wiesenmayer (1999). Additionally, Dove (1996) searched for the misconceptions of pre-service teachers relating to greenhouse effect and the ozone layer depletion. The findings of the study revealed that the pre-service teachers had root understanding of the subjects. They didn't know any other greenhouse gases except carbon dioxide and they believed that ozone layer depletion caused global warming. The findings of Boyes, Chambers, and Stanisstreet's study (1995) displayed that pre-service teachers believed that the emissions of motor vehicle caused ozone depletion and the depletion of ozone layer directly caused global warming. Additionally, Çimer, Çimer, and Ursavaş (2011) searched for the misconceptions of pre-service first and fifth-year biology student teachers related to global warming and climate changes. They had similar findings. The findings of the study revealed that both groups had some confusions and concerns about global warming. All of the participants believed

that ozone layer depletion was the main cause of global warming. The misconception that the holes in the ozone layer caused global warming was determined in several studies too (Summers, Kruger, Childs, & Mant, 2000; Gudovitch and Orion, 2001; Papadimitriou, 2004; Leiserowits, Smith, & Marlon, 2011; Arslan, Çiğdemoğlu, & Moseley, 2012).

When the answers given to the 6th question about the consequence of global warming were analyzed (What kind of natural events do you expect as a result of global warming (drought, floods, storms, etc.? Why?) It was seen that the students were not able to give explanations for their answers (MC 6a, MC 6d). The analysis of the students' answers showed that in general, they thought that droughts would take place (MC 6a-6b-6d). The students gave droughts or floods as answers. They didn't state any views about the extinction of species, possible diseases, etc. The answers given to the 7th question (Does global warming affect the whole world at the same rate and the same way? Why?) showed that 26,9% of the students thought that global warming would affect the whole world in the same manner (MC 7a). Here, the effect of the misconception about the ozone layer and the erroneous view that since the ozone layer was the same everywhere in the world, all places will get affected in the same manner could be seen (MC 7b, 19,2%). 9,6% of the students thought that humid place would be less affected. At this point, it was seen that the students didn't know that factors such as longitude and altitude in the world, geographical formations, etc. could affect being affected by global warming. The answers of the students showed that they had serious misconceptions about the carbon cycle and global warming. The misconceptions related to global warming and the ozone layer could be seen in the studies in literature and in the studies mentioned above. Various explanations were stated about the students' mistaking these two concepts with each other. Similar to the findings of this study, Ocal, Kisoglu, Alas and Gurbuz (2011) aimed to determine the Turkish elementary prospective teachers' opinions on global warming. The findings revealed that prospective teachers had some misunderstandings about the subject.

For example, Meadows and Wiesenmayer (1999) stated that students probably thought a hole in a protective layer will let more sun rays to come into the atmosphere and the temperature rises. Rye et al. (1997) stated that while explaining the concepts of global warming and ozone layer depletion, the same concepts are used such as temperature, sun rays. This might cause confusion for students. In addition, it was seen that the students also had problems in subjects such as carbon dioxide, the relationship between carbon dioxide and global warming and greenhouse effect-global warming. The answers given showed that they had a view about the mentioned subject; because although they learnt about these within the scope of their lessons once in a while, the issue of global

warming which is a serious problem today is frequently given place to in the media. However, it is noteworthy that the students' knowledge about the subject is quite superficial. The students who participated in the study will graduate the next semester and will start working as science teachers. It is inevitable that they will experience difficulties while teaching such an important subject as global warming which they are not very aware of and have various misconceptions about. Another consequence of misconceptions will be students' not displaying the desired sensitivity towards global warming which is a very serious problem today. Therefore, it is necessary to raise the students' level of knowledge and the subject and carry out various applications to remove their misconceptions.

Unfortunately, the misconceptions of the teacher candidates are transferred to their students as well. The students to be taught by teachers who are not at a sufficient knowledge and awareness level will regrettably be insufficient. It is possible to see an example of this in Boon's study. Boon's (2010) research was on pre-service teachers' understanding and knowledge of climate change and the study compared the results with secondary students. The results displayed that pre-service teachers and secondary students had a similar level of understanding related to the subject. The understanding of the pre-service teachers was unacceptably low. Studies carried out both in Turkey and in other countries draw attention to the fact that views of individuals on global warming are insufficient. It has been stated in various studies that insufficient environmental education caused this problem. For example, Yazdanparast, Salehpour, Masjedi, Seyedmehdi, Boyes, Stanisstreet, and Attarchi (2013) analyzed Iranian high school students' ideas about the greenhouse effect and their findings showed that a majority of the society had no sufficient and efficient education to be aware of this important environmental problem.

Global warming is not only a problem caused by industry. Greenhouse gases emissions of household and personal consumption play a significant role in the percentage of total emissions (Wolf & Moser, 2011). Therefore, individuals first need to know the role of carbon dioxide in global warming and climate change. Today, the concept "carbon footprint" has come to the fore and this concept is related to the carbon dioxide emission caused by individuals' activities in daily life. However, this study shows that science teacher candidates have serious misconceptions about carbon and its sources and the relationship between carbon dioxide and the green house effect. What distinguishes this study from the others is that this study focuses on the carbon cycle and the role of carbon in this process and establishes its relationship with global warming. In addition, the findings show that classes related to subjects such as "Environmental Sciences" and "Special Topics in Chemistry" are not sufficient in developing students' knowledge. In the light of the obtained data, special activities about

the subject taught in these classes should be organized and the current misconceptions of teacher candidates in lower classes should be eliminated in this manner.

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GENİŞLETİLMİŞ ÖZET

Günümüzde iklim değişikliği en önemli çevre problemlerinden bir tanesidir. Küresel ısınma neticesinde ortaya çıkan iklim değişikliği çok boyutlu bir konudur. Küresel ısınma karbondioksit gibi sera gazlarının atmosferdeki oranının artması ile ortaya çıkmaktadır. Küresel ısınma da pek çok konu ile bağlantılı bir kavramdır. Bunlardan bir tanesi karbon döngüsüdür. Karbon döngüsü ile ilgili bilgilerin anlaşılması, çevresel konulardaki pek çok kavramın anlaşılmasında büyük önem taşımaktadır. Küresel ısınma konusunun anlaşılabilmesi için öncelikle karbon döngüsünün anlaşılması gerekmektedir. Bu noktada öğretmenlere büyük görev düşmektedir. Günümüzde, sera etkisine sebep olan gazların oranının atmosferde ciddi oranda yükselmesi, dünyada sürdürülebilir bir yaşam için ciddi bir problem oluşturmaktadır. İklim değişikliğini durdurmak veya en azından yavaşlatmak için acil önlemler alınmasının yanında, çevre konusunda duyarlı bireylerin yetiştirilmesi büyük önem taşımaktadır. Ne yazık ki çok güncel çevre konularında bile, yapılan araştırmalar hem öğretmenlerin hem de öğrencilerin yanlış kavramaları olduğunu ortaya koymaktadır. Öğrencilerin karbon döngüsü ve küresel ısınma ile ilgili kavram yanılgılarının muhtemel sebeplerinden bir tanesi öğretmenlerin kavram yanılgılarıdır.

Çalışma kapsamında, 4. Sınıf fen bilgisi öğretmen adaylarının karbon döngüsü ve küresel ısınma ile ilgili sahip oldukları kavram yanılgıları araştırılmıştır. Çalışmaya, Kahramanmaraş Sütçü İmam Eğitim Fakültesi, Fen Bilgisi Öğretmenliği 4. Sınıf öğrencileri (N=52) katılmıştır. Karbon döngüsü ve küresel ısınma konularının temel bileşenlerini sorgulayan on adet açık uçlu sorudan oluşan bir görüşme formu geliştirilerek, öğretmen adaylarından cevaplamaları istenmiştir. Elde edilen bulguların, öğretmen adaylarının konu ile ilgili bilgi düzeyleri, mevcut kavram yanılgıları hakkında bilgi vermesinin yanı sıra, çeşitli önlemlerin alınmasında yardımcı olacağı düşünülmektedir.

Öğrencilerin açık uçlu sorulara verdikleri cevaplar analiz edildiğinde, karbon döngüsü ve küresel ısınma ile ilgili çeşitli kavram yanılgılarının olduğu belirlenmiştir. Öğrencilerin 1. sorudaki "Karbon doğal bir kirletici midir? Açıklayınız." sorusuna verdikleri cevaplar incelendiğinde, öğrencilerin karbon deyince akıllarına fosil yakıtların ve bu yakıtlarının kullanımının çevre üzerindeki zararlarının geldiği anlaşılmaktadır. Karbonun elementer özellikleri ile bir bağlantı kuramadıkları ve karbonun canlılık için öneminin farkında olmadıkları görülmektedir. Karbon döngüsü ile ilgili olan ikinci soruya verilen cevaplar incelendiğinde, öğrencilerin karbon döngüsü konusundaki yetersiz bilgileri dikkat çekmektedir. Verilen cevaplar, öğrencilerin karbon döngüsü deyince bitkilerin karbondioksiti alıp besine dönüştürmesi, oluşturulan besinin de diğer canlılar tarafından tüketilerek, tekrar karbondioksit oluşmasını

anladıklarını göstermektedir. Bu noktada öğrenciler, canlı organizmaların ölümlerinin ardından ne olduğu, cansız bedenlerdeki karbonun nasıl bir dönüşüme uğradığı konusunda bir bilgiye sahip olmadıklarını göstermişlerdir. Burada öğrencilerde belirlenen bir diğer kavram yanılgısı, karbondioksitin bitki tarafından nasıl alındığı ile ilgilidir. Atmosferdeki karbondioksit kaynakları nelerdir sorusuna verilen cevaplar incelendiğinde, bazı öğrencilerin fosil yakıt kullanımın farkında olmadıklarını gösterirken, fosil yakıt kullanımının farkında olanların da orman yangınları, volkanik patlamalar gibi diğer doğa olaylarının karbondioksit salınımına sebep olduğunu düşünmediklerini göstermektedir.

Öğrencilerin % 28,8'inin doğada karbondioksit konsantrasyonunun artmasının sebebinin fosil yakıt kullanımı ve solunum olduğunu düşündükleri görülmüştür. Burada, öğrencilerin fosil yakıt kullanımı ile canlıların solunum faaliyetini bir arada düşünüp aynı kategoride değerlendirmeleri ise ilginçtir. Öğrencilerin cevapları, karbondioksit artışı ile ilgili olarak çok boyutlu düşünemedikleri, karbondioksit artışının temel sebebi olan insan faaliyetleri yerine solunum gibi bu faaliyetlerin yanında önemsiz kalacak bir olayı belirtmeleri, bir grubun ise sadece bitkilerin azalmasını öne sürmesi oldukça ciddi kavram yanılgılarına işaret etmektedir.

Öğrencilerin % 32,6'sının karbondioksitin ozon tabakasını deldiğine inandıkları görülmektedir. Bunun yanında, karbondioksitin bir kalkan oluşturup, yeryüzüne gelen güneş ışınlarını geri yansıttığını düşünenler ise öğrencilerin % 23'üdür. Burada iki önemli yanılgı vardır. Bunlardan birincisi, öğrencilerin ozon tabakası delinmesi, ısının yükselmesi ve karbondioksit arasındaki ilişkileri yanlış yorumlamalarıdır. İkincisi ise, karbondioksitin ısıyı absorplayarak sera etkisine sebep olması yerine bir kalkan oluşturmasından bahsetmektedirler. Küresel ısınma ve ozon tabakasının delinmesi ile ilgili öğrencilerin sahip oldukları bir diğer kavram yanılgısı da küresel ısınma sonucu, ozon tabakasının zarar göreceğidir.

Küresel ısınmanın sonuçlarıyla ilgili olan 6. soruya verilen cevaplar incelendiğinde, öğrencilerin verdikleri cevapların nedenlerini açıklayamadıkları görülmektedir. Öğrencilerin cevapları incelendiğinde genelde kuraklık olacağını düşündükleri görülmektedir. Öğrenciler ya kuraklık ya da sel baskınları cevabını vermektedirler. Canlı türlerinin yok olması, olası hastalıkla vb. konularda bir görüş bildirmemişlerdir. 7. soruya verilen cevaplar, öğrencilerin % 26,9'unun küresel ısınmanın dünyanın her yerini aynı şekilde etkileyeceğini düşündüklerini göstermektedir. Burada yine ozon tabakası ile ilgili görülen kavram yanılgısının etkileri, ozon tabakası dünyanın her yerinde aynı olduğundan her yer aynı etkilenir yanılgısında kendini göstermektedir.

Öğrencilerin yanıtları karbon döngüsü ve küresel ısınma konusunda ciddi kavram yanılgılarına sahip olduklarını göstermektedir. Bunun yanı sıra öğrencilerin karbondioksit, karbondioksit küresel ısınma ilişkisi ve sera etkisi-

küresel ısınma konularında da problemleri olduğu görülmektedir. Verilen cevaplar, öğrencilerin değinilen konularda fikir sahibi olduklarını göstermektedir. Çünkü, ders kapsamında zaman zaman bu konuları görseler de, günümüzde ciddi bir sorun olan küresel ısınma konusu sıklıkla medyada da yer almaktadır. Ancak öğrencilerin konu ile ilgili bilgilerinin oldukça yüzeysel olduğu da dikkat çekmektedir. Çalışmaya katılan öğrenciler, bir dönem sonra mezun olup fen bilgisi öğretmeni olarak çalışmaya başlayacaklardır. Öğretmen adayı olarak çok farkında olmadıkları, çeşitli kavram yanılgılarına sahip oldukları küresel ısınma gibi önemli bir konuyu öğretirken ciddi sıkıntılar yaşamaları kaçınılmazdır. Yanlış kavramaların bir diğer sonucu öğrencilerin günümüzde çok ciddi bir problem olan küresel ısınma konusuna istenilen duyarlılığı göstermemeleri de olacaktır. Bu nedenle, öğrencilerin konu ile ilgili bilgi düzeylerinin yükseltilmesi ve kavram yanılgılarının giderilmesi için çeşitli uygulamaların yapılması gerekmektedir.