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Middle School Students' Cognitive Perceptions of Cycles of Matter and Environmental Problems: A Word Association Test

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Abstract

This study employed a word association test to determine middle school students' cognitive perceptions and misconceptions of the key concepts regarding "cycles of matter and environmental problems." The study adopted descriptive research in survey model. The sample consisted of 457 eighth-grade students from four middle schools affiliated with the Ministry of National Education (MoNE) in the central district of Muş province in the 2020-2021 academic year. Data were collected using a word association test developed by the researcher. The test addressed eight key concepts: "water cycle," "nitrogen cycle," "oxygen cycle," "carbon cycle," "ozone layer," "global warming," "greenhouse effect," and "ecological footprint." The data were analyzed using content analysis. Concept networks were created based on participants' responses. Participants associated "water cycle," "nitrogen cycle," "oxygen cycle," "carbon cycle," "ozone layer," "global warming," "greenhouse effect," and "ecological footprint" with "evaporation," "lightning," "photosynthesis," "carbon dioxide," "ozone hole," "melting of glaciers," "global warming," and "humans," respectively. Participants did not make adequate associations with oxygen cycle, which was one of the key concepts. It was found that participants did not know enough about the key concepts from the sentences they wrote, preventing them from making scientific statements. They mostly had unscientific and superficial remarks and misconceptions. Within the scope of the research, it is recommended that teachers create effective learning environments where they can use different methods and techniques to help students eliminate misconceptions.

Keywords: Cycles of matter, Environmental problems, Misconceptions, Cognitive perception, Word association test

Introduction

Environmental problems have escalated and come to threaten all large industrial nations worldwide since the Industrial Revolution. At first, environmental problems were seen mainly in terms of the pollution of separate areas of the environment. However, today, they negatively affect social life. Therefore, environmental problems have become a popular topic of research and discussion (Görmez, 2007). Climate change, global warming, rapid population growth, technological developments, and industrialization have made it necessary to prioritize environmental issues in every field. Environmental problems affect social life more and more. Therefore, countries have introduced measures and policies to mitigate their adverse effects. In addition, value judgments have been instrumental in raising public awareness of living beings and sustainable settings (Özkan, 2008). Environmental problems have been long ignored because they progress too slowly to recognize their adverse consequences. This is particularly evident in cycles of matter. At first, we hardly understand the consequences of our unconscious interventions in the cycles of matter because nature heals itself. However, we have faced numerous environmental problems because we are destroying nature at an unprecedented rate. For example, significant changes in the carbon cycle have led to environmental problems that threaten humanity, such as global warming, air pollution, and the destruction of wetlands. We still do not know the consequences of significant changes in the nitrogen cycle (Gökmen & Solak, 2015). Environmental pollution is increasing rapidly and continuously due to rapid population growth, unplanned urbanization, wars, pesticides, artificial fertilizers, and chemicals. Air, water, and soil pollution is a significant threat to the survival of organisms (Ministry of Environment, 1998).

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One of the leading causes of environmental problems is a lack of awareness and knowledge. People who are not environmentally conscious do not recognize that they hold the Earth in trust for future generations (İnanç & Kurgan, 2000). On the other hand, the key to the survival of states is sustainable natural resources. Therefore, educating people, institutions, and organizations about the environment is crucial. We should also educate children to transform them into eco-friendly individuals (Tombul, 2006). In recent years, educators have focused on the concept of environmental education. According to educators, environmental education aims to turn students into eco-friendly individuals who act consciously toward the environment, develop a critical perspective in their interactions with the environment, and do their best to leave future generations on a livable planet (Doğan, 1997). In this context, educational institutions are places where people develop cognitive, affective, and psychomotor skills (Topkaya, 2016). In 1993, the European Parliament emphasized that teachers and schools played a critical role in developing and implementing environmental education and policies (Stokes, Edge, & West, 2001). Since then, curricula have started to address environmental education. In Turkey, environmental education is mainly taught in science classes (Özata-Yücel & Özkan, 2013). Environmental education should primarily focus on the importance and current state of the environment and possible environmental problems. Environmental education should be provided for all ages, at all levels, and in both formal and non-formal education (Nalçacı & Beldağ, 2012).

Environmental education starts in a child's home and immediate neighborhood. What children learn from their parents forms the basis of their future moral, cognitive, affective, and psychomotor behaviors. According to developmental psychologists, children develop mental sensitivity toward the environment and delve into the interaction between humans and nature at the age of 9 or 10, which corresponds to primary school years (Armağan, 2006). Primary education is the first and most crucial step in environmental education because young people are part of and affected by environmental problems. Therefore, young people need to gain knowledge and develop awareness and sensitivity toward the environment (Erol & Gezer, 2006). In this context, middle school students should also be provided with environmental education. The science curriculum in Turkey was revised in 2018 in line with the relationship between science and the environment. The curriculum includes the topic of "Cycles of Matter and Environmental Problems," which covers the basic concepts of ecology. We should determine how students perceive those concepts because students with environmental awareness are more likely to understand the leading causes of environmental problems and offer solutions. Therefore, this study focused on middle school students' cognitive perceptions of cycles of matter and environmental problems. Data were collected using a word association test, which is a helpful and practical instrument for revealing what people think of concepts. In other words, word association tests are effective tests that help us understand how people perceive and comprehend concepts (Özata-Yücel & Özkan, 2014). In a word association test, the participant is presented with a concept and then asked to write down the words that come to mind. This helps the researcher identify the participant's perceptions of that concept (Atabek Yiğit, Balkan Kıyıcı, & Yavuz Topaloğlu, 2019). Researchers use metaphors, illustrations, interviews, concept maps, concept cartoons, and word association tests to determine how well students know and perceive concepts (Ahi & Alisinanoğlu, 2016; Akgün, Duruk & Gülmez Güngörmez, 2016; Cardellini & Bahar, 2000; Çelik, 2020; Ertürk, 2017; Polat, 2013; Kayhan, 2019; Kızılay, 2020; Seçgin, Yalvaç & Çetin, 2010; Selçuk & Yılmaz, 2017; White & Gunstone, 2000). However, only a few researchers have investigated how students perceive cycles of matter. Moreover, they have focused on the effect of different methods and techniques on the teaching cycles of matter (Ercan, Girgin, & Atılboz, 2017; Gökmen, & Solak, 2015). Scientists address cycles of matter and environmental problems extensively. However, the topic is imbued with misconceptions. Therefore, we should identify students' cognitive perceptions of cycles of matter and environmental problems before we expect them to attain achievement in that regard. Research shows that students know little about cycles of matter and have misconceptions about them. Research also shows that they have difficulty understanding cycles of matter and find them hard to grasp (Çetin, 1998; Ercan et al., 2017; Özkan, 2001; Öztaş, 2005). Students cannot achieve permanent and meaningful learning because they mostly receive theoretical education and, therefore, cannot associate what they learn with what they see (Öztaş, 2005) There is only a small body of research on cycles of matter and environmental problems, although we should address human-induced and global environmental problems due to changes in cycles of matter. We should also address cycles of matter and environmental problems together to understand the problems we face and find solutions to them (Nacaroğlu, Bektaş, & Kızkapan, 2020). This is the first study to investigate middle school students' cognitive perceptions of cycles of matter and environmental problems. We think this study will fill a gap in the literature and pave the way for further research. We also think that our results will help authorities take measures to raise students' awareness of environmental problems and develop policies to mitigate their adverse impacts.

Research Objective

This study used a word association test to determine eighth graders' perceptions and misconceptions regarding cycles of matter and environmental problems. The following are research questions:

1. What kind of cognitive perceptions do eighth graders have regarding cycles of matter and environmental problems?
2. What kind of misconceptions do eighth graders have regarding cycles of matter and environmental problems?

Method

Research Model

This study adopted a descriptive survey model as a research design, aiming to reveal the cognitive structures of students through word association tests. The descriptive survey model is a research approach that aims to describe in depth a situation that exists in the past or today (Karasar, 2014). In survey research, current situations, conditions, and features are tried to be revealed in every aspect, and "what" is described. It includes processes such as interpretation, evaluation, and reaching generalizations to be applied to new situations by analyzing and explaining the data (Şen, 2010). Since this research aims to determine the cognitive structures and misconceptions of secondary school students regarding the subject of matter cycles and environmental problems, it was deemed appropriate to use this model.

Study Group

The sample consisted of 457 (214 female and 243 male) eighth graders from four public middle schools in a province in the Eastern Anatolia Region in the 2020–2021 academic year. Table 1 shows the participants' descriptive characteristics.

Table 1. Descriptive Characteristics

School	Gender	Frequency	Total
School A	Female	51	112
	Male	61	
School B	Female	22	55
	Male	33	
School C	Female	72	154
	Male	82	
School D	Female	69	136
	Male	67	

Participation was voluntary. Participants were recruited using criterion sampling, which is a purposive sampling method. The primary purpose of criterion sampling is to recruit a sample that satisfies a set of predetermined criteria (Patton, 2015). Criterion sampling is a time- and cost-efficient method by which researchers select participants most suited to the research purpose (Yıldırım & Şimşek, 2013). The Science Curriculum in Turkey (2018) addresses the topic of "cycles of matter and environmental problems" in the eighth grade [MoNE, 2018]. The main criterion was recruiting students familiar with the concepts of cycles of matter and environmental problems. Therefore, the sample consisted of eighth graders.

Data Collection

Data were collected using a word association test. Researchers use word association tests to determine how people make associations between concepts (Atasoy, 2004). A word association test consists of four steps. First, the researcher identifies key concepts. Second, she investigates how respondents associate the key concepts with other important words. Third, she checks the key concepts' number, type, scientific nature, and associated power. Fourth, she focuses on the power of the cognitive structure to determine how well the respondents have learned the concepts (Çetin, 2010). In this study, the researcher developed the word association test based on expert feedback. The test addressed eight key concepts derived from the science curriculum. Those key concepts were "water cycle," "nitrogen cycle," "oxygen cycle," "carbon cycle," "ozone layer," "global warming," "greenhouse effect," and "ecological footprint" (MoNE, 2018). The test consisted of two parts. The first part consisted of items on the research procedure and demographic characteristics. The second part consisted of eight

concepts written five times in a row with a blank space in front of them. Participants were asked to write down the words that occurred to them when they heard the concepts. The stimulus key concepts were written one after the other to prevent participants from giving a chain response. They were also asked to respond within a certain time limit (Polat, 2013). In this way, participants returned to the stimulus keyword after each response, which prevented them from making off-topic associations (Ekici & Kurt, 2014). A page was reserved for each concept. Participants were also asked to write a sentence about the key concepts to determine how much they knew about them and whether they had misconceptions about them (Nacaroğlu & Bozdağ, 2020). The researcher visited each school on different days and collected data in each classroom at different times. She gave each participant one minute to answer each concept. Afterward, she analyzed all participants' responses. Figure 1 shows a sample word association test page.

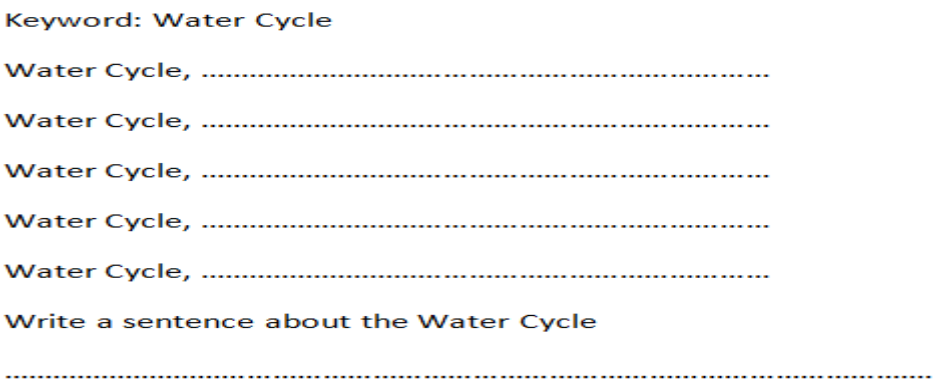


Figure 1. A sample word association test page

Data Analysis

The data were analyzed using content analysis. Researchers employ content analysis to develop concepts and categories to explain the data. Content analysis involves the following steps: (1) analyzing data and (2) collecting similar data under categories. A content analysis begins with coding and ends with categorizing (Yıldırım & Şimşek, 2018). In this study, the data were analyzed based on the number of responses, words, and semantic associations (Atasoy, 2004). The researcher and two experts independently analyzed and compared the data at different times. The data were analyzed based on the steps identified by Bahar, Johnstone, and Sutcliffe (1999). The researcher assigned each participant a code (P1, P2, P3, etc.). She listed the responses, determining frequency values, cutoff ranges, and corresponding response words. Next, she developed concept networks and established their validity and reliability. She used the cutoff points technique to develop the concept networks based on the frequency of words derived from the key concepts. According to this technique, the cutoff point is set 3-5 below the word with the highest repetition frequency. Afterward, the cutoff point is moved down a certain range each time to add to the concept network (Bahar et al., 1999). The first cutoff point was ≥180, after which the cutoff point was moved down to ≥20 each time. Lastly, the concept networks corresponding to each cutoff interval were shown in different colors. Figure 2 shows the concept of network colors corresponding to each cutoff point and interval.

Cut-off Point	Concept Network Color
180-Above	Pink
179-160	Purple
159-140	Yellow
139-120	Green
119-100	Blue
99-80	Red
79-60	Orange
59-40	Brown
39-20	Turquoise
19-10	Navy blue

Figure 2. Cutoff Points and Concept Network Colors

The researcher and two experts categorized and compared all the sentences made by participants. They continued to analyze them until they reached a consensus. They used Ercan, Taşdere, and Ercan's (2010)

method to group the sentences into four categories: (a) scientific sentences, (b) unscientific sentences or superficial sentences, and (c) sentences with misconceptions. A scientific sentence is a sentence that is scientifically true and associated with the key concepts. An unscientific or superficial sentence is an everyday-life and emotional sentence that is not scientifically true and is not associated with key concepts. A sentence with misconceptions is a sentence that contains misconceptions (Balbağ, 2018) (see Table 3). Direct quotes were used to provide an accurate and coherent picture of participants' perceptions and to improve reliability. Lastly, the "Blank" category was used when participants did not make any sentences about the key concepts.

Results

The results were presented in tables and figures. Table 2 shows the key concepts, the number of responses, the most frequently repeated word for each key concept, and their frequency.

Table 2. Number of Responses Given to Keywords

Key Concept	Number of Words	Most Frequent Word for	Frequency
Greenhouse Effect	202	Global warming	62
Global Warming	190	Melting of glaciers	88
Ecological Footprint	171	Humans	50
Water Cycle	150	Evaporation	228
Ozone Layer	146	Ozone hole	71
Carbon Cycle	137	Carbon dioxide	150
Nitrogen Cycle	124	Lightning	135
Oxygen Cycle	98	Photosynthesis	209
Total	**1218**		**993**

Participants generated 1218 words about the key concepts. The most common word for "water cycle" was "evaporation" (f=228). The most common word for "nitrogen cycle" was "lightning" (f=135). The most common word for "oxygen cycle" was "photosynthesis" (f=209). The most common word for "carbon cycle" was "carbon dioxide" (f=150). The most common word for "ozone layer" was "ozone hole" (f=71). The most common word for "global warming" was "melting of glaciers" (f=88). The most common word for "greenhouse effect" was "global warming" (f=62). The most common word for "ecological footprint" was "humans" (f=50). Participants generated the highest and lowest number of words for "greenhouse effect" (f=202) and "oxygen cycle" (f=98), respectively.
According to their cutoff points and intervals, other words with ten or more frequencies were shown as concept networks. The words under each key concept are presented in the figures below according to their cutoff points and intervals.

Figure 3 shows the concept network for the frequencies with a cutoff point of ≥180.

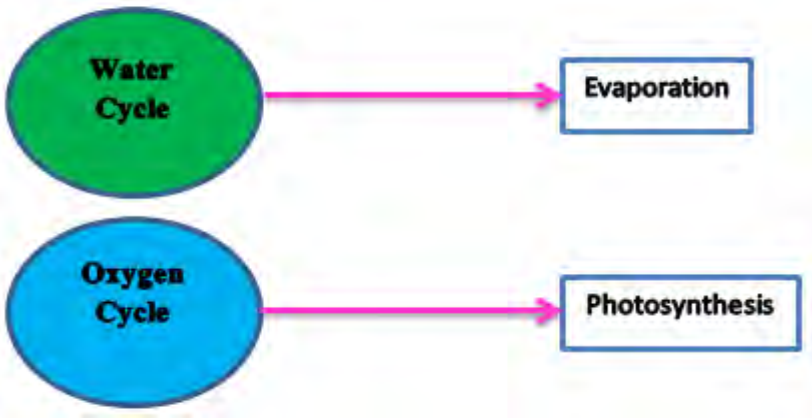


Figure 3. Concept network for the frequencies with a cutoff point of ≥180

"Water cycle" and "oxygen cycle" had frequencies with a cutoff point of ≥180. Participants associated "water cycle" and "oxygen cycle" mostly with the words "evaporation" and "photosynthesis," respectively. Moreover,

"evaporation" was the most frequently repeated word. However, a relationship was not established between response words and other keywords.

Figure 4 shows the concept network for the frequencies with a cutoff point of 179 to 160.

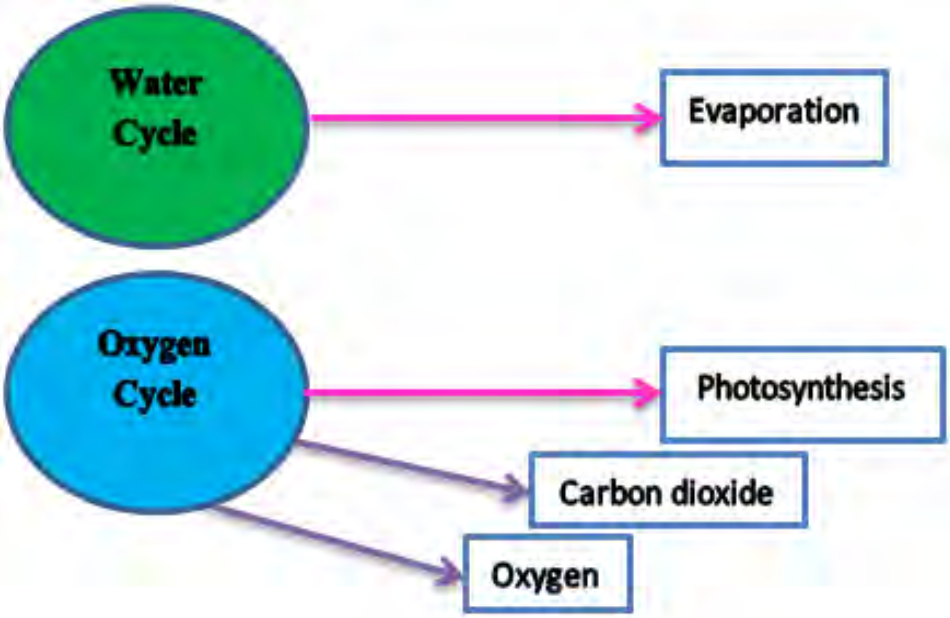


Figure 4. Concept network for the frequencies with a cutoff point of 179 to 160

"Oxygen cycle" was at the cutoff point of 160 to 179. Participants associated the concept of "oxygen cycle" with "oxygen" and "carbon dioxide." There was no association between response words and other keywords.

Figure 5 shows the concept network for the frequencies with a cutoff point of 159 to 140.

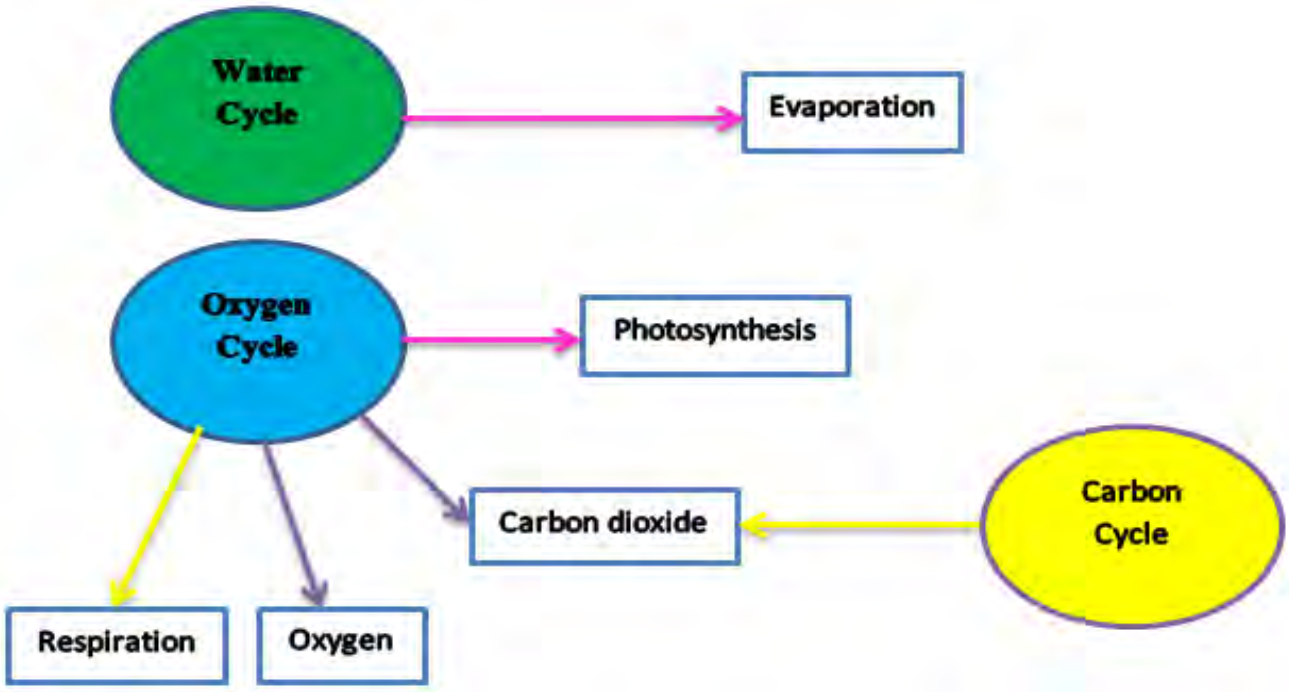


Figure 5. The concept network for the frequencies with a cutoff point of 159 to 140

"Carbon cycle" was at the cutoff point of 159 to 140. Participants associated both the key concepts of "oxygen cycle" and "carbon cycle" with "carbon dioxide." They associated the "oxygen cycle" with "respiration."

Figure 6 shows the concept network for the frequencies with a cutoff point of 139 to 120.

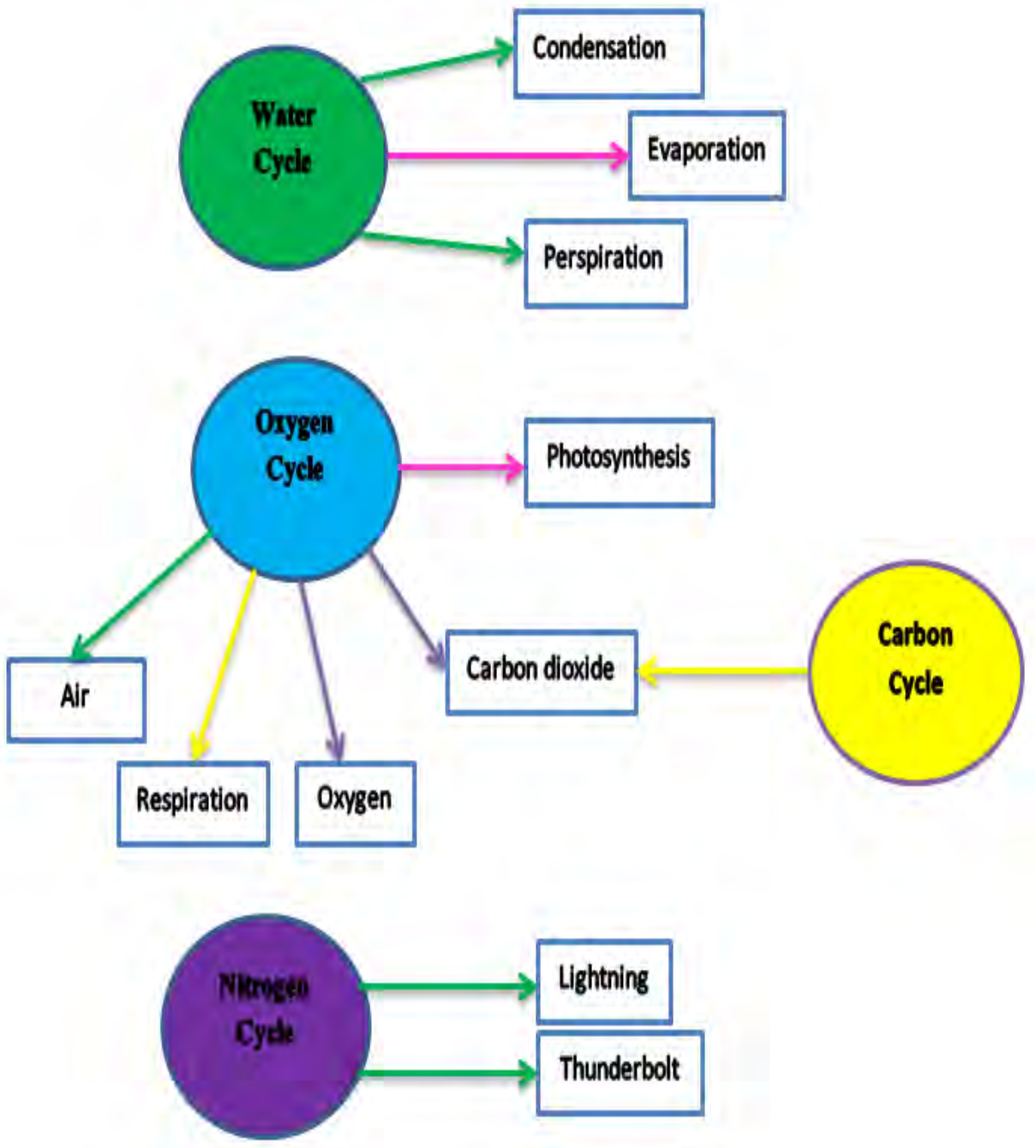


Figure 6. The concept network for the frequencies with a cutoff point of 139 to 120

"Nitrogen cycle" was at the cutoff point of 139 to 120. Participants associated "nitrogen cycle" with "lightning" and "thunderbolt." They associated "water" with "condensation" and "perspiration," while they associated "oxygen cycle" with "air." There was no association between response words and other keywords.

Figure 7 shows the concept network for the frequencies with a cutoff point of 119 to 100.

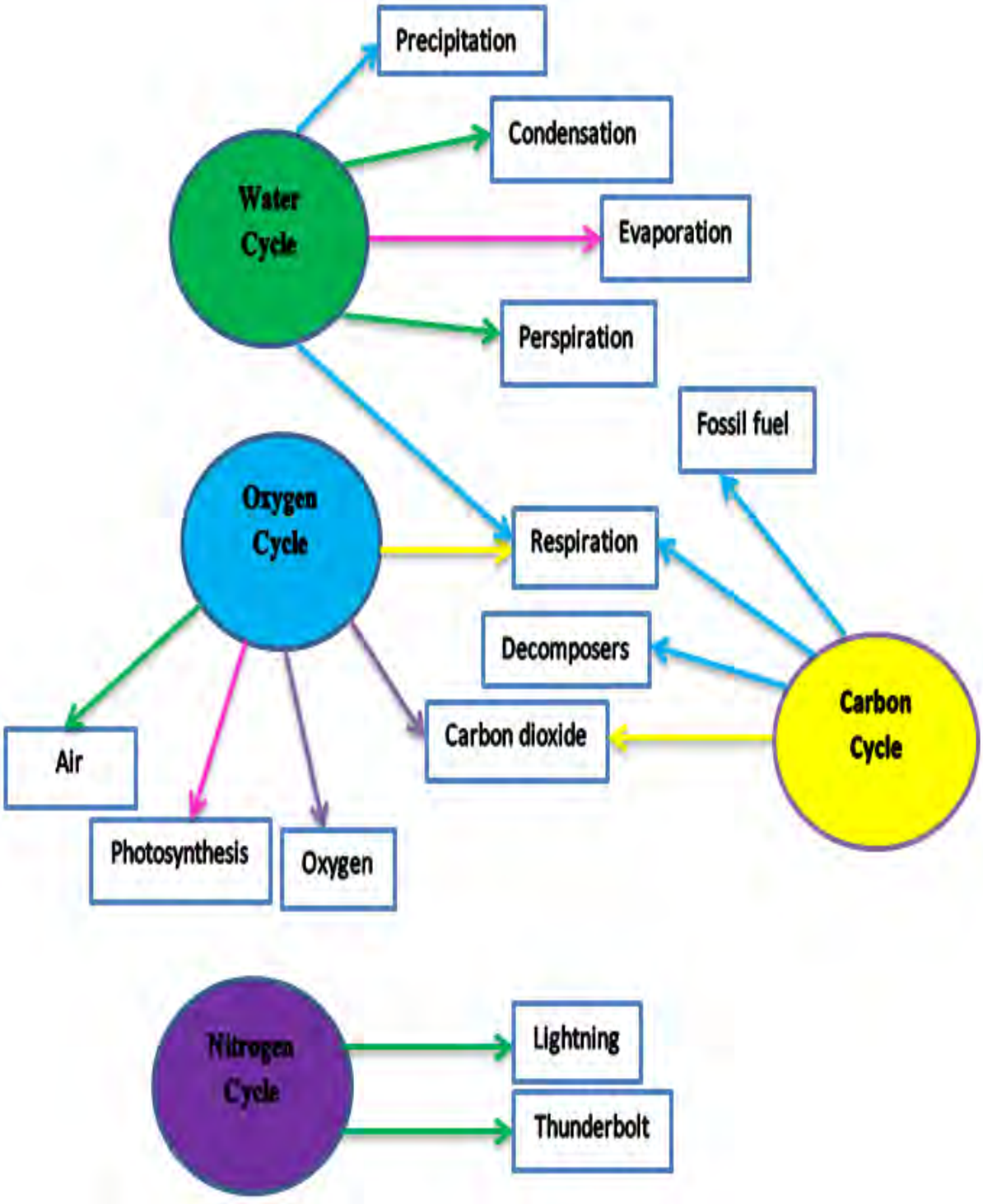


Figure 7. The concept network for the frequencies with a cutoff point of 119 to 100

Neither did participants generate new key concepts, nor did they associate the key concepts with each other. However, they associated "respiration" with it the most. They associated the “water cycle” with “precipitation,” while they associated the “carbon cycle” with “fossil fuel” and “decomposers.”

Figure 8 shows the concept network for the frequencies with a cutoff point of 99 to 80.

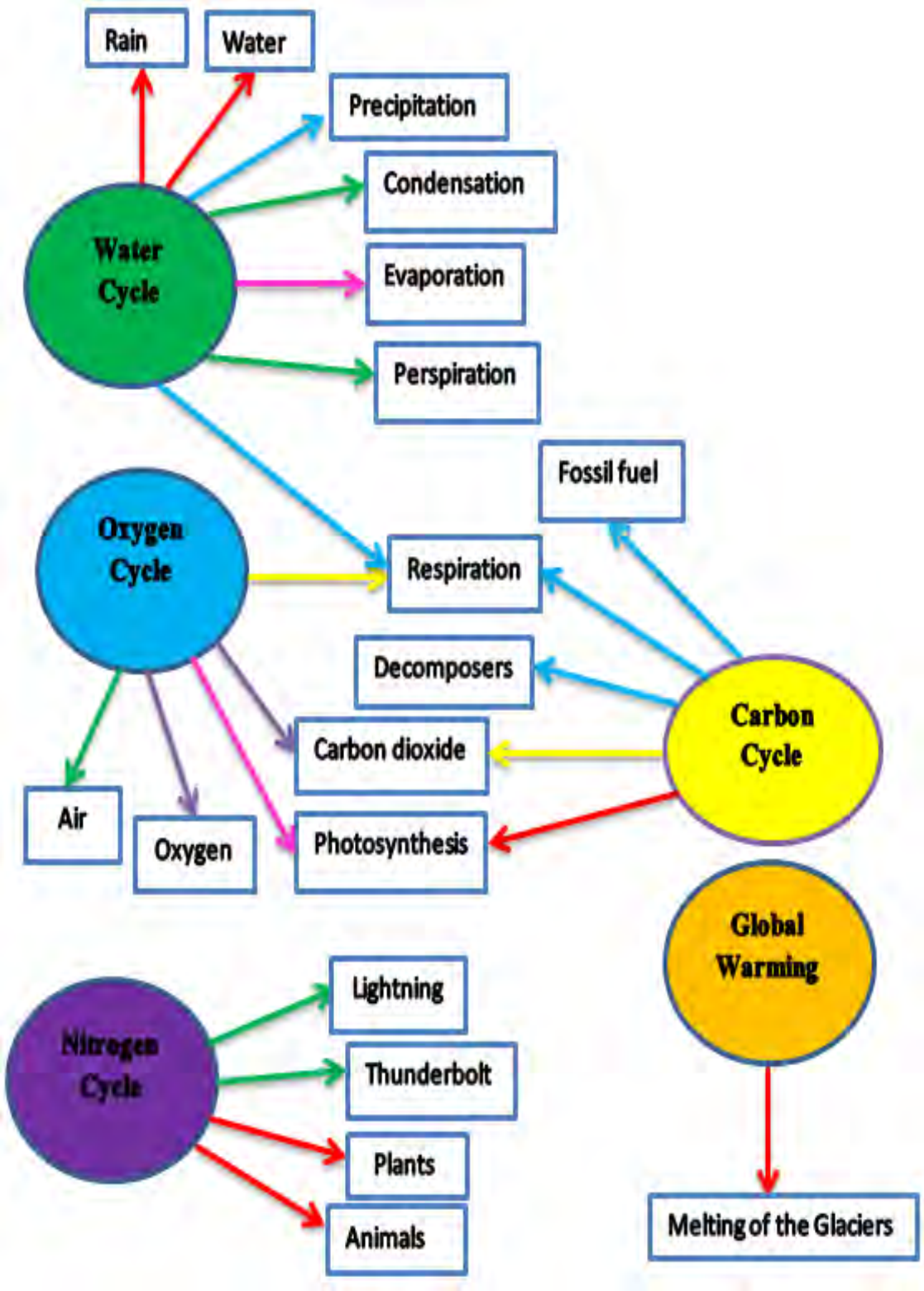
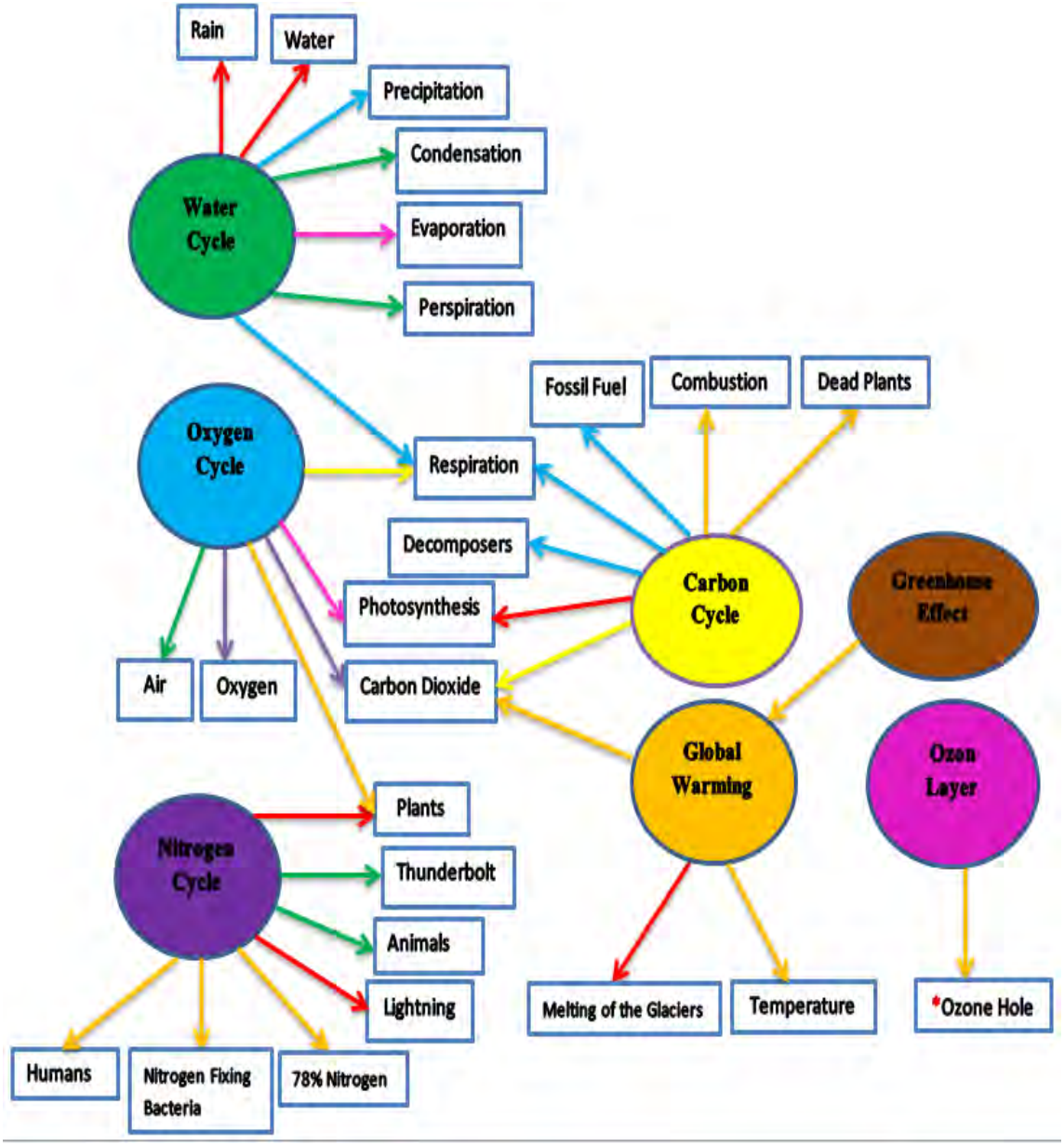


Figure 8. The concept network for the frequencies with a cutoff point of 99 to 80

Participants developed the key concept of "global warming" and associated it with the "melting of glaciers." They associated the key concept of the "nitrogen cycle" with "animals" and "plants," while they associated the "water cycle" with "rain" and "water." They associated the "carbon cycle" with "photosynthesis." There was no association between response words and other keywords.

Figure 9 shows the concept network for the frequencies with a cutoff point of 79 to 60.

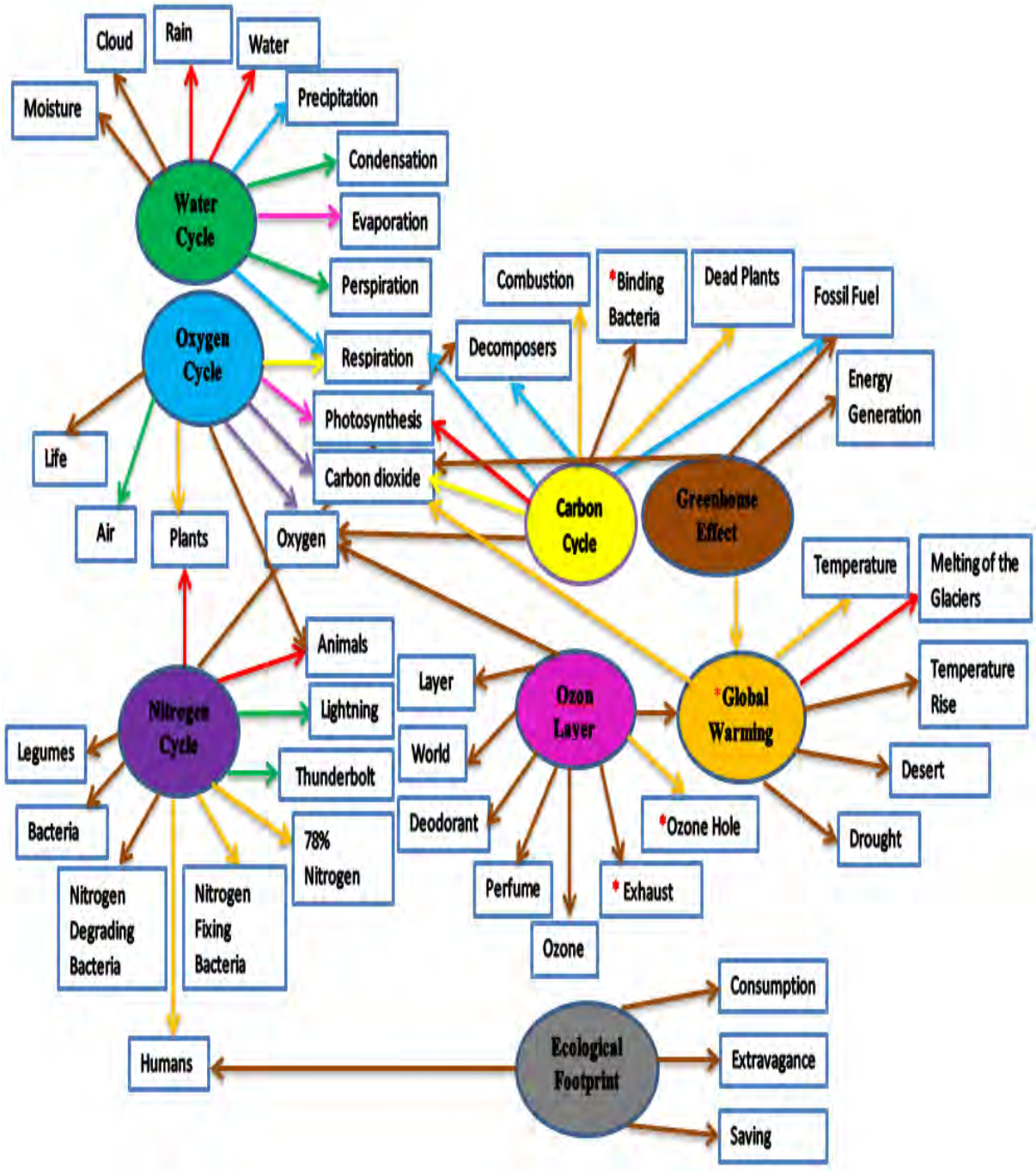


Note: *"*" indicates misconceptions.*

Figure 9. The concept network for the frequencies with a cutoff point of 79 to 60

Participants developed the key concepts of the "greenhouse effect" and "ozone layer." For the first time, they associated two key concepts: the "greenhouse effect" and "global warming." They also associated the key concept of the "ozone layer" with the "ozone hole." We can state that participants had a misconception regarding the "ozone hole" because the ozone layer is a natural layer of gas consisting of ozone, a molecule containing three oxygen atoms. As is known, when a substance is in the gaseous state, it has gaps between the molecules. We can talk about the dilution or thinning of a gaseous substance rather than a hole. Participants associated the "nitrogen cycle" with "nitrogen-fixing bacteria," "78% nitrogen," and "humans." They associated the "carbon cycle" with "dead plants" and "combustion." They associated "global warming" with "temperature" and "carbon dioxide." They associated the "oxygen cycle" with "plants." Most participants generally associated the key concepts of "carbon dioxide" and "respiration" with each other. They also associated "plants" and "photosynthesis" with each other. Participants generated keywords regarding the key concepts.

Figure 10 shows the concept network for the frequencies with a cutoff point of 59 to 40.



Note: *"*" indicates misconceptions*

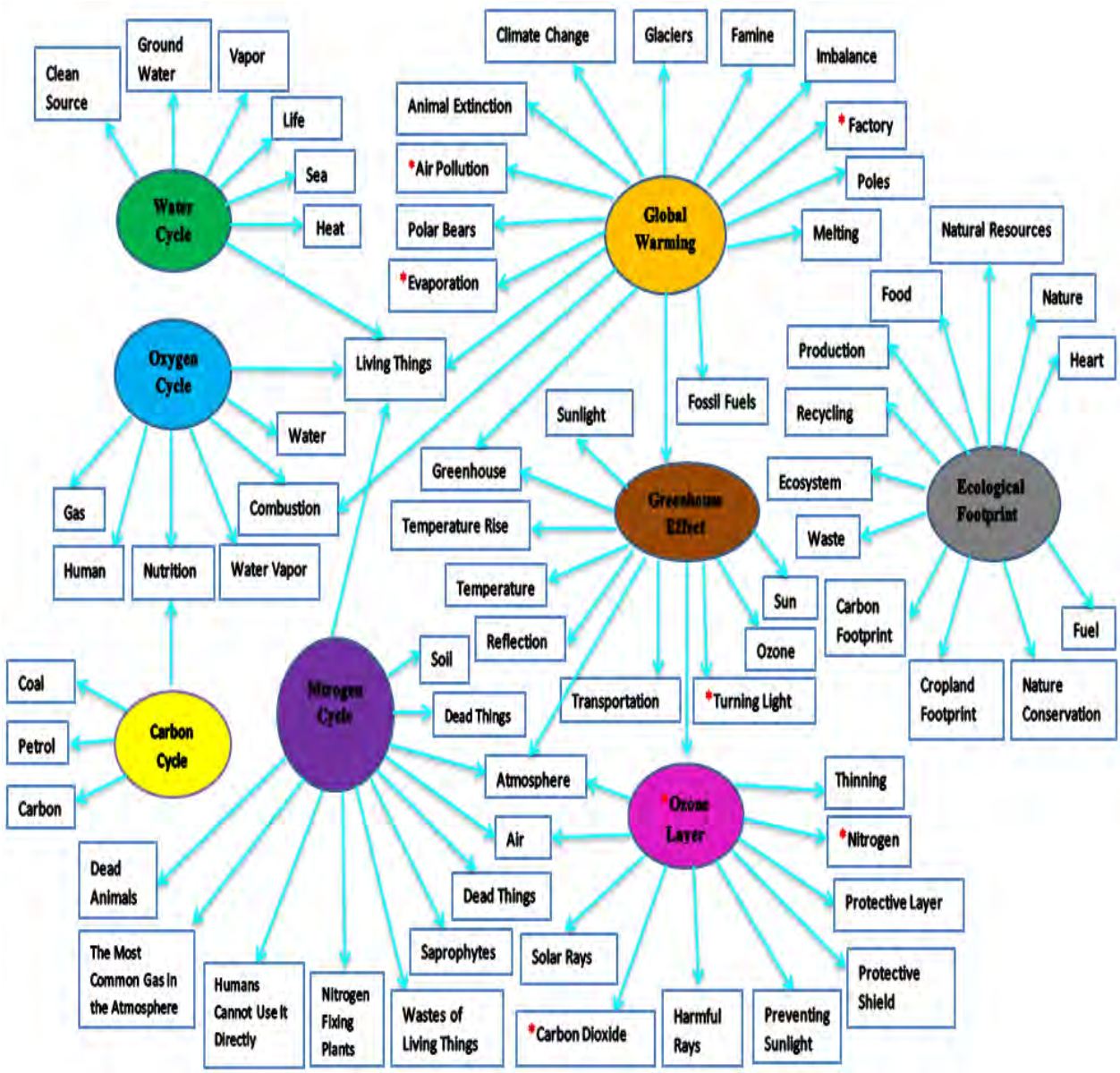
Figure 10. The concept network for the frequencies with a cutoff point of 59 to 40

For the first time, all key concepts were included in the concept network at the cutoff point of 59 to 40. Participants associated the concept of "global warming" with the concepts of "ozone layer" and "greenhouse effect." They still had misconceptions. For example, they talked about "exhaust" and "global warming" when they heard the concept of the "ozone layer." Exhaust gases (water vapor, carbon dioxide, etc.) cause a greenhouse effect, which leads to global warming. On the other hand, what causes the thinning of the ozone layer is chlorofluorocarbons (CFC), hydrofluorocarbons (HCFC), halons, etc. Therefore, the fact that participants associated "exhaust" with the "ozone layer" indicated that they had a misconception. Another misconception was that they viewed the "ozone layer" as the cause of "global warming." They also had a misconception about the "carbon cycle," as they associated it with "nitrogen-fixing bacteria." Although "nitrogen-fixing bacteria" is related to the "nitrogen cycle," no data suggests that those bacteria fix carbon. Participants generated the key concept of "ecological footprint" for the first time. They associated it with "humans," "consumption," "saving," and "extravagance." They also associated "humans" with the "nitrogen

cycle." Most participants generated associations with "carbon dioxide." Participants stated keywords and key concepts at the cutoff point of 59 to 40.

The figures for the cutoff intervals of 39–20 and 19–10 presented only the key concepts and words because, otherwise, the figures looked too complicated.

Figure 11 shows the concept network for the frequencies with a cutoff interval of 39 to 20.

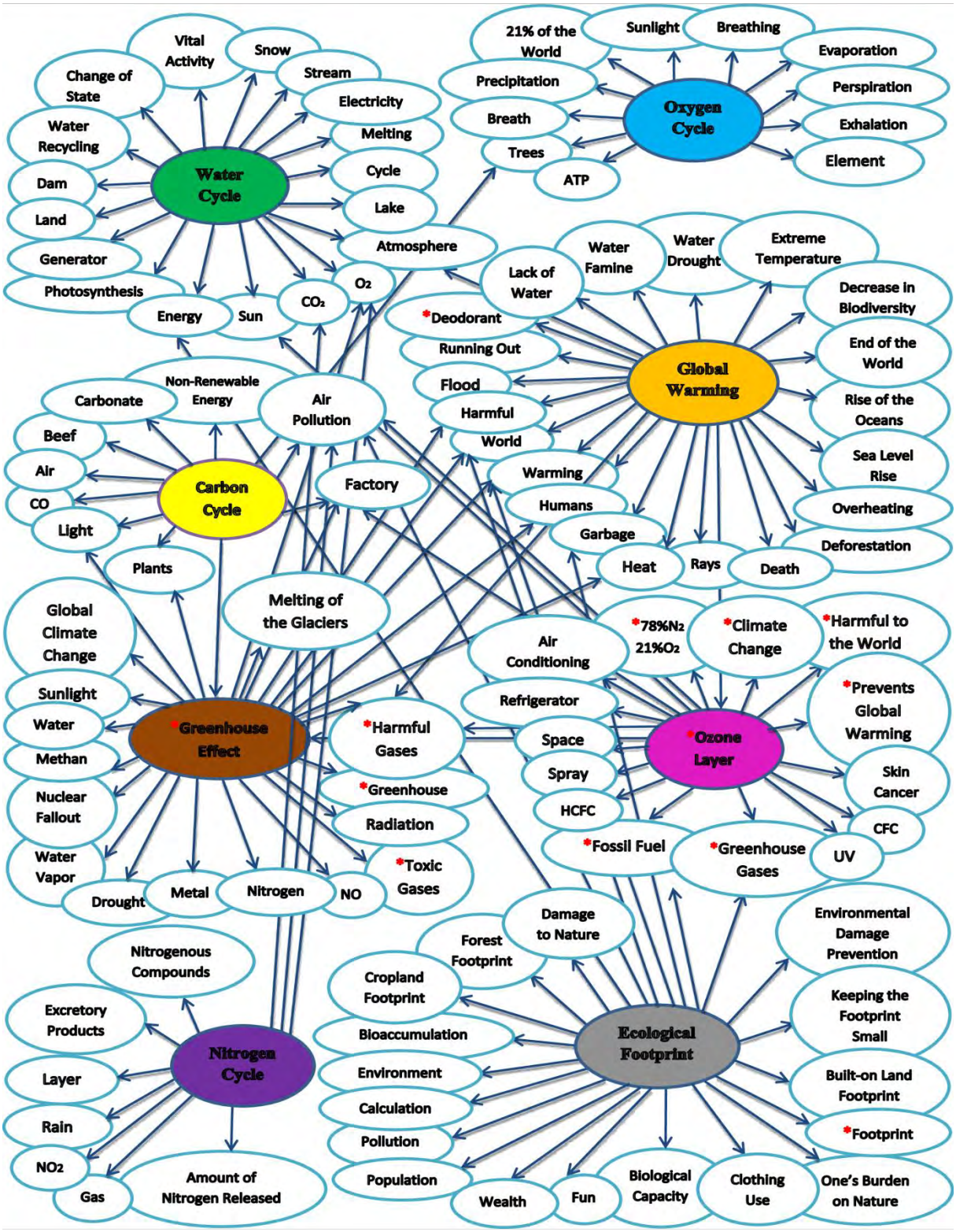


Note: *"*" indicates misconceptions.*

Figure 11. The concept network for the frequencies with a cutoff interval of 39 to 20

Participants generated associations with all key concepts but "ecological footprint." They associated "global warming" with the "greenhouse effect." They associated the "greenhouse effect" with the "ozone layer." They still had misconceptions, as they viewed the "greenhouse effect" as the cause of the thinning of the ozone layer. Similarly, they associated "nitrogen" and "carbon dioxide" with the "ozone layer," which was another misconception. Another misconception was that they associated the "turning light" with the "greenhouse effect." They probably meant "reflected light" by "turning light." They generated words related to the basic elements of the concept of "ecological footprint" and the types of ecological footprints.

Figure 12 shows the concept network for the frequencies with a cutoff interval of 19 to 10.



Note: *"*" indicates misconceptions.*

Figure 12. The concept network for the frequencies with the cutoff interval of 19 to 10

Participants addressed all the key concepts and associated them with one another. However, they still had misconceptions regarding the key concepts of "global warming," "greenhouse effect," and "ozone layer." They associated "global warming" with "deodorant" and "ozone layer," which was a misconception because global

warming has nothing to do directly with the ozone layer. It is the deodorants that adversely affect the ozone layer. Another misconception was that participants associated the "ozone layer" with "greenhouse effect," "greenhouse gases," "fossil fuels," "prevents global warming," "climate change," "78%N2 21%O2," and "harmful to the world." Fossil fuels and greenhouse gases are related to the greenhouse effect, while climate change results from global warming. In addition, not every gas released by the combustion of fossil fuels damages the ozone layer. The fact that participants associated the "ozone layer" with "harmful to the world" was another misconception because the ozone layer acts as an invisible shield that protects us from harmful ultraviolet radiation from the sun. Moreover, oxygen and nitrogen are two gases in the atmosphere. Therefore, we can state that participants had misconceptions in that regard. Lastly, participants associated the "greenhouse effect" with "harmful and toxic gases," which was another misconception because not every gas that causes a greenhouse effect is toxic or harmful. For example, water vapor (H2O(g)) is a nontoxic gas that causes a greenhouse effect. Such overgeneralizations led participants to make misconceptions. Participants knew the keywords about the ecological footprint and the types of ecological footprints. However, they confused it with "footprint," resulting in a misconception.

Participants tried to sound scientific in their sentences, but they either used the wrong concepts or confused them with one another.

Table 3. Quotations

Key Concept	**Scientific Sentences**	**(f)**	**Unscientific or Superficial Sentences**	**(f)**	**Sentences with Misconceptions**	**(f)**	**Blank (f)**
Water Cycle	P40: Earth's water evaporates and enters the atmosphere, forming clouds. Later, this water vapor condenses and descends to the Earth as precipitation. P115: The water cycle keeps the amount of water on Earth balanced. P413: Earth's water evaporates and mixes with the air, forming clouds, and then condensing water vapors descend back to the Earth as precipitation.	**31**	P8: Earth's water evaporates, rises into the air, and comes back as rain. P142: Evaporation of water resources on Earth and respiration and perspiration made by living beings. P200: The water evaporates, goes to the clouds, and then reaches the Earth as rain.	**149**	P34: Condensation of water on Earth is part of the water cycle. P58: The condensation of vapors, such as water vapor, going up and coming down again is called the water cycle. P229: We drink water, and our urine goes into the sewer, and then it is cleaned, and we drink it again.	**71**	**206**
Nitrogen Cycle	P140: Legumes incorporate nitrogen through nitrogen-fixing bacteria in their roots. P304: Both bacteria and lightning and thunder are involved in nitrogen fixation. P448: nitrogen-fixing bacteria bind nitrogen gas to produce nitrogenous compounds.	**114**	P153: In the nitrogen cycle, nitrogen is introduced into the soil by things like lightning. P411: Nitrogen cycles between air and soil. P434: Nitrogen passes from the soil to the plant and from the plant to all living things through the food chain thanks to	**60**	P344: The nitrogen cycle is caused by too much deodorant. P454: Storms are caused by the nitrogen cycle. P143: An increase in nitrogen causes global warming. P413: Only through lightning does nitrogen pass directly into the soil.	**61**	**222**

			lightning and thunder.				
Oxygen Cycle	P39: Plants carry out photosynthesis and release oxygen into the atmosphere. Oxygen passes to living organisms through respiration. Water vapor produced by respiration is released into the atmosphere. It condenses in the atmosphere, becomes liquid, and is used again in photosynthesis. P125: Producers take in carbon dioxide and produce oxygen during photosynthesis. Consumers use oxygen and release carbon dioxide into the atmosphere. P322: Photosynthesis and respiration are part of the oxygen cycle.	**46**	P122: Respiration and combustion produce carbon dioxide, while photosynthesis produces oxygen. P130: The oxygen circulation between the living and non-living environment is called the O2 cycle. P222: People and animals get fresh air thanks to the oxygen cycle.	**135**	P184: The oxygen cycle is the layer that surrounds the Earth, separating harmful light. P123: The oxygen cycle is the layer below the layer of the atmosphere. P455: The oxygen cycle is when the clouds meet, and the rain clouds come down to Earth.	**44**	**232**
Carbon Cycle	P29: Decomposers break down dying organisms and release them back into the atmosphere as carbon and carbon dioxide. P83: The carbon dioxide released by the combustion of fossil fuels and respiration goes back into the atmosphere. P330: Carbon in carbon dioxide gas passes into food through photosynthesis.	**25**	P8: Gases released from the combustion of non-renewable energy sources contribute to the carbon cycle. P189: Fossil fuels and respiration release carbon back into the atmosphere. P326: Humans and plants play a very important role in the carbon cycle.	**88**	P9: The circulation of inorganic substances, such as water, oxygen, and carbon, between living and non-living environments is called the carbon cycle. P39: Overheating of the Earth due to harmful rays entering the Earth from the ozone layer due to burning fossil fuels. P259: The carbon cycle results from the reaction of carbon dioxide and oxygen.	**62**	**282**
Ozone Layer	P60: As the ozone layer thins, ultraviolet rays reach the Earth. P131: The ozone layer acts as a filter for ultraviolet rays. P225: Thinning of the	**28**	P268: The ozone layer protects us from bad sunlight. P295: The ozone layer is thinning, which means danger is	**29**	P11: The ozone layer is a layer that covers the Earth. P145: There would be global climate change if it weren't for the ozone layer. P178: If the ozone layer is depleted, the	**124**	**276**

	ozone layer leads to health problems.		imminent. P404: Too much deodorant is harmful.		world is exposed to the greenhouse effect, which causes global warming.		
Global Warming	P280: The increase in temperature in the world due to the increase in greenhouse gases in the atmosphere is called global warming. P293: The use of fossil fuels causes an increase in greenhouse gases in the atmosphere, which results in a rise in the Earth's temperature and global warming. P331: The increase in the world's temperature due to the increase in greenhouse gases in the atmosphere is called global warming.	**75**	P182: A great danger awaits the Earth because of global warming. Threats such as extinction and disruption of ecological balance will be the death of the Earth. P199: Extreme heat destabilizes the Earth. It can also lead to a bad life for people. P419: Global warming negatively affects the lives of many living things.	**71**	P136: Global warming occurs when more sunlight reaches the Earth as the ozone layer becomes thinner. P164: Gases accumulating in the upper layer of the Earth's nitrogen layer pierce the ozone layer, and harmful rays reach the Earth, which is called global warming. P204: Global warming is a weather event that occurs due to the harmful rays produced by the thinning of the ozone layer warming our world.	**82**	**229**
Greenhouse Effect	P21: The greenhouse effect is the effect of the sun's rays being trapped by greenhouse gases in the Earth's atmosphere. P284: The greenhouse effect increases temperatures on the Earth's surface, which causes global climate change. P348: Greenhouse gases in the atmosphere prevent the Earth from getting too hot or too cold.	**38**	P50: The greenhouse effect is one of the big problems for our world. P187: With the increase in greenhouse gases, the greenhouse effect is a problem that affects all living things. P302: harmful solar radiation is reflected by gases in the atmosphere, which is harmful.	**36**	P45: The greenhouse effect results from harmful gases piercing the ozone layer. 182: The greenhouse effect causes acid rain and poses many threats. P350: The ozone layer becomes thinner because of the greenhouse effect.	**123**	**260**
Ecological Footprint	P11: The ecological footprint shows the damage everyone does to the Earth and how many earths they will need if they continue to harm it. P140: Ecological footprint is a method used to calculate how much a population burdens nature with carbon dioxide, etc. P345: Ecological	**24**	P39: If we save or do not, we can increase or decrease our ecological footprint. P45: The smaller our ecological footprint, the smaller our damage to the world. P188: The more we reduce	**79**	P194: The remains of living things from the past are called ecological footprint. P199: An ecological footprint is the long-lasting remains of a living thing. P201: Ecological footprint is the study of the remains of living things. P230: The first footprint in space is	**80**	**274**

	footprint is a scientific measure that calculates how much space we need to reproduce natural resources and recycle waste.	environmental damage, the smaller our ecological footprint will be.	still there.

Participants did not fill in the blanks for many key concepts (Table 3). More than half of the participants did not write any sentences about the "carbon cycle" (f=282 and 61.7%). Less than half of the participants did not write any sentences about the "water cycle" (f=206 and 48.5%). The results showed that almost half the participants did not know enough to write anything about the key concepts. Participants wrote scientific sentences mostly about the nitrogen cycle (f=114), global warming (f=75), oxygen cycle (f=46), greenhouse effect (f=38), water cycle (f=31), ozone layer (f=28), carbon cycle (f=25), and ecological footprint (f=24). Participants knew scientific facts about the nitrogen cycle but lacked scientific knowledge regarding most of the key concepts. Participants wrote down unscientific or superficial sentences mostly about the water cycle (f=149), oxygen cycle (f=135), carbon cycle (f=88), ecological footprint (f=79), global warming (f=71), nitrogen cycle (f=60), greenhouse effect (f=36), and ozone layer (f=29). These results showed that participants had unscientific or superficial opinions about the key concepts. Participants expressed misconceptions mostly about the ozone layer (f=124), greenhouse effect (f=123), and global warming (f=82). Only forty-four participants expressed misconceptions about the oxygen cycle.

Conclusion and Discussion

This study employed a word association test to determine middle school students' cognitive perceptions of eight key concepts regarding cycles of matter and environmental problems. Participants generated 1218 words for the key concepts. Considering the sample size, we can state that participants did not generate many words. Most participants could not write sentences about the key concepts. These two results showed that participants did not know enough about the key concepts. Çelikler and Topal (2011) also found that students lacked adequate knowledge of key concepts regarding the cycles of matter. Oztas (2014) reported that students were mostly unaware of fundamental ecological phenomena (cycles of matter, etc.) and had misconceptions about global environmental problems (global warming, greenhouse gases, acid rains, etc.). Çimer (2012) determined that the greatest challenge for most students was to learn the cycles of matter. On the other hand, Bilgiç (2019) found that students grasped the cycles of matter and their significance in life. Research shows that preservice teachers know little about global environmental problems (Azapagic, Perdan & Shallcross, 2005; Bahar, 2000; Cirit & Aydemir, 2021; Güven, 2013; Jeffries, Stanisstreet & Boyes, 2001; Makki, Khalick & Boujaoude, 2003). The results showed that our participants did not know much about the cycles of matter and environmental problems, probably because they go over that topic in the last weeks of the semester (MoNE, 2018) when they have to prepare for high school entrance exams. Our participants generated the highest number of words for the greenhouse effect, global warming, and ecological footprint. On the other hand, they generated the lowest number of words for the oxygen, nitrogen, and carbon cycles. These results showed that participants knew more about environmental problems than the cycles of matter. This is probably because they hear about environmental problems in daily life and on the news.

Participants associated the key concepts with the right words until the cutoff interval of 79 to 60. However, they associated the ozone layer with a hole, which was a misconception. In the following cutoff intervals, they associated the ozone layer, global warming, and greenhouse effect with the wrong words, indicating that they had misconceptions. Their sentences showed that they had more misconceptions about global environmental problems (ozone layer, global warming, and greenhouse effect) than the other key concepts, suggesting that they underwent wrong conceptual learning. Some examples of misconceptions were "the gases that cause greenhouse gases cause the depletion of the ozone layer" and "the greenhouse effect or global warming causes the depletion of the ozone layer." The other examples were "the depletion of the ozone layer causes the greenhouse effect or global warming" and "the gases that cause the greenhouse effect are harmful or toxic." Research shows that students from different grade levels have similar misconceptions regarding global environmental problems (Boyes & Stanisstreet, 1993; Jeffries, Stanisstreet, & Boyes, 2001; Kılınç, Stanisstreet, & Boyes, 2008; Meadows & Wiesenmayer, 1999; Österlind, 2005). On the contrary, Durmuş and Sert (2022) stated in their study that prospective teachers correctly interpreted global warming in their cognitive structures. Cirit and Aydemir (2021) focused on students' perceptions of environmental problems and reported three results. First, students viewed the depletion of the ozone layer as a hole. Second, they believed that global warming and the depletion of the ozone layer affected each other. Third, they thought that environmental problems caused one another. Kahraman (2020) investigated students' views of global environmental problems and reported three

findings. First, students had difficulty defining the greenhouse effect scientifically. Second, they believed that the greenhouse effect was exacerbated by sprays, deodorants, plastic bags, and cigarettes. Third, they associated the greenhouse effect with the thinning of the ozone layer. Kaya, Ateş, and Kılıç (2019) addressed preservice students' perceptions of global environmental problems and reported three findings. First, preservice teachers could make scientific sentences about global warming. Second, they achieved conceptual learning but thought that the depletion of the ozone layer and deodorants caused global warming. Third, they believed that the depletion of the ozone layer caused global warming. Erdoğan and Özsevgeç (2012) reported that students associated the ozone layer with global warming and believed that we could prevent global warming if we wore less perfume and deodorant. Students have this misconception because the media (Internet, magazines, books, animations, videos, and images) affects how they perceive global environmental problems (Khalid, 2003; Shepardson, Niyogi, Choi, & Charusombat, 2011). Pekel (2019) determined that eighth-grade science textbooks contained numerous misconceptions and unscientific information regarding the nitrogen cycle, global warming, the greenhouse effect, and the ozone layer. Unverified information from various sources also causes students to develop misconceptions about environmental problems. Our participants focused mostly on the steps, settings, and elements of the cycles of matter. For example, they generated the words "perspiration," "evaporation," and "condensation" (steps). They talked about the atmosphere, lakes, and rivers (settings). They addressed the sun, clouds, and heat (elements). They had the same trend when it came to the nitrogen, carbon, and oxygen cycles. They mostly made unscientific or superficial sentences about those cycles. However, they had fewer misconceptions regarding them. In other words, they tried to explain the cycles of matter with simple and unscientific sentences. This result showed that they had superficially learned those key concepts. Research also shows that students from different grade levels know relatively little about the cycles of matter (Çelikler & Topal, 2011; Derman & Yaran, 2017). Abasız (2019) found that students knew about the cycles of matter to a certain extent and tried to explain them with simple and scientific sentences. Participants chose words regarding the important components of ecological footprints and different types of ecological footprints. For example, they focused on "humans," "recycling," and "natural sources" (important components) or "carbon footprint," "cropland footprint," "forest footprint," and "built-on land footprint" (types of ecological footprint). Most participants made unscientific or superficial sentences with misconceptions.

The results showed that although participants generated the right words regarding the key concepts of cycles of matter and environmental problems, they had numerous misconceptions in their sentences. These results showed that they had limited scientific knowledge about the key concepts and generated the right words based on what they learned from different sources. However, one needs academic knowledge to construct scientific sentences. Therefore, our participants had difficulty making scientific sentences and had numerous misconceptions because they used unscientific information or misinformation from different sources. In other words, participants had limited perceptions of the key concepts of cycles of matter and environmental problems. Participants made more cross-connections between the key concepts when we gradually lowered the cutoff point. This is probably because the cycles of matter and environmental problems affect each other. Environmental problems caused by human activities disrupt the cycles of matter. A disruption in one step of the cycle of matter causes environmental problems.

Recommendations

Based on the results obtained from the research, some suggestions are made. Teachers should use word association tests to measure students' prior knowledge before moving on to the next topic and to assess how much they have acquired new knowledge after teaching. Teachers should use various audio-visual materials (figures, animations, videos, etc.) in multimedia that appeal to more sensory organs to help students better understand the topic and explain it scientifically. More research is warranted to better understand how students from different grade levels perceive cycles of matter and environmental problems. Researchers should focus on current misconceptions and misinformation regarding cycles of matter and environmental problems. Teachers should provide effective learning settings where they can use different methods and techniques to help students dispel their misconceptions and refute misinformation.

Limitations

This research is limited to eighth-grade students in the study group. The concepts in the word association test are limited to the key concepts in the subject "Matter Cycles and Environmental Problems."

Ethical Approval

The study was approved by the Scientific Research and Publication Ethics Committee of Muş Alparslan University (Date: January 14, 2021, No. 910). Permission was obtained from the Muş Provincial Directorate of National Education (Date: April 27, 2021, No. 10764). This study has not been published or presented as an abstract or full-text paper anywhere. All students were briefed on the research purpose and procedure and were informed that participation was voluntary. Informed consent was obtained from those who agreed to participate. The study adhered to the rules specified by the Directive on Scientific Research and Publication Ethics of Higher Education Institutions.

References

Abasız, D. B. (2019). *Lise öğrencilerinin ekosistem konusundaki bilişsel yapıları, algıları, duygusal semantik tutumları ve alternatif kavramlarının belirlenmesi* (Doctoral dissertation, Necmettin Erbakan University (Turkey)).

Ahi, B. & Alisinanoğlu, F. (2016). Okul Öncesi Eğitim Programına Kaynaştırılan Çevre Eğitimi Programının Çocukların" Çevre" Kavramı Hakkındaki Zihinsel Model Gelişimine Etkisi. *Kafkas Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, (18), 305-329.

Akgün, A., Duruk, U., & Gülmez Güngörmez, H. (2016). Ortaokul öğrencilerinin çevre eğitimi kavramına yönelik metaforları. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 28,* 215-224.

Armağan, F. Ö. (2006). *İlköğretim 7–8. sınıf öğrencilerinin çevre eğitimi ile ilgili bilgi düzeyleri. (*Yayımlanmamış Yüksek Lisans Tezi), Gazi Üniversitesi, Ankara.

Atabek-Yiğit, E., Balkan-Kıyıcı, F. & Yavuz Topaloğlu, M. (2019). İlkokul öğrencilerinin çevre sorunları ile ilgili kavramlara yönelik algılarının belirlenmesi. *Bolu Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 19*(3), 732-744.

Atasoy, B. (2004). *Fen öğrenimi ve öğretimi*. Asil Yayınevi.

Azapagic, A., Perdan, S. & Shallcross, D. (2005). How much do engineering students know about sustainable development? The findings of an international survey and possible implications for the engineering curriculum. *New Perspectives and New Methods in Engineering Education, 4*(1) 1-20.

Bahar, M. (2000). Üniversite öğrencilerinin çevre eğitimi konularındaki ön bilgi düzeyi, kavram yanılgıları. *Uluslararası Ekoloji ve Çevre Sorunları Sempozyumu (Ana Konu: Çevre Eğitimi) nda Poster Çalışması,* Tübitak, Ankara.

Bahar, M., Johnstone, A.H. & Sutcliffe, R.G. (1999). Investigation of students' cognitive structure in elementary genetics through word association tests. *Journal of Biological Education,* 33, 134-141.

Balbağ, M. Z., (2018). Fen bilgisi öğretmen adaylarının kelime ilişkilendirme testi (KİT) kullanılarak kütle ve ağırlık kavramlarına ilişkin bilişsel yapılarının belirlenmesi. *Eskişehir Osmangazi Üniversitesi Türk Dünyası Uygulama ve Araştırma Merkezi (ESTÜDAM) Eğitim Dergisi, 3* (1), 69-81.

Bilgiç, Ş. (2019). Ortaokul 8. Sınıf Öğrencilerinin Madde Döngüleri Kavramına İlişkin Algılarının Metafor Yoluyla Belirlenmesi. Yüksek Lisans Tezi. Aksaray Üniversitesi, Fen Bilimleri Enstitüsü, Aksaray.

Boyes, E. & Stanisstreet, M. (1993). The 'green house effect': Children's perceptions of causes, consequences and cures. *International Journal of Science Education, 15*(5), 531-552.

Cardellini, L. & Bahar, M. (2000). Monitoring the learning of chemistry through word association tests. *Australian Chemistry Resource Book, 19,* 59-69.

Cirit, D. K., & Aydemir, S. (2021). Exploring Levels of Secondary School Students' Knowledge: Global Warming, Acid Rain, and Ozone Layer Depletion. *Education Quarterly Reviews, 4*(1), 199-212.

Çelik, A. (2020). Investigation of environmental awareness and cognitive structures of the 5th grade students. *International Journal of Geography and Geography Education (IGGE), 41,* 73-87.

Çelikler, D., & Topal, N., (2011). İlköğretim fen bilgisi öğretmen adaylarının karbondioksit ve su döngüsü konusundaki bilgilerinin çizim ile saptanması. *Journal of Educational and Instructional Studies in The World, 1* (1), 72-79.

Çetin, G. (1998). A *Comparision of Some English and Turkish Students' Understanding of Selected Ecological Concepts. (*Unpublished Master Thesis), Leeds University, Leeds, UK.

Çetin, A. (2010). *" Fen ve teknoloji dersinde işbirlikli öğrenme tekniklerinin öğrencilerin başarı tutum ve zihinsel yapılarına etkisi"*. (Yayımlanmamış yüksek lisans tezi). Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü, Hatay.

Çimer, A. (2012). What Makes Biology Learning Difficult and Effective: Students' Views, *Educational Research and Reviews, 7*(3), 61-71.

Derman, A., & Yaran, M. (2017). Lise öğrencilerinin su döngüsü konusuyla ilgili bilgi yapıları. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 14*(39), 255-274.

Doğan, M. (1997). Çevre eğitimi. *Çevre ve İnsan*. Çevre Bakanlığı Yayınları.

Durmuş, E., & Sert, A. E. (2022). Sosyal Bilgiler Öğretmen Adaylarının Küresel Sorunlara İlişkin Bilişsel Yapılarının Kelime İlişkilendirme Testi İle İncelenmesi. *Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Dergisi*, *19*(3), 1177-1193.

Ekici, G. & Kurt, H. (2014). Öğretmen adaylarının "AIDS" kavramı konusundaki bilişsel yapıları: Bağımsız kelime ilişkilendirme testi örneği. *Türkiye Sosyal Araştırmalar Dergisi, 18*(3), 267-306.

Ercan, S., Girgin, S. & Atılboz, N. G. (2017). Öğrenme halkası modelinin 10. Sınıf öğrencilerinin madde döngüleri konusunu öğrenmeleri üzerine etkisi. *Eğitim ve Toplum Araştırmaları Dergisi*, *4*(2), 135-145.

Ercan, F., Taşdere, A., & Ercan, N. (2010). Observation of cognitive structure and conceptual changes through word associations tests. *Journal of Turkish Science Education, 7*(2), 136-154.

Erdoğan, A., & Özsevgeç, L. C. (2012). Kavram karikatürlerinin öğrencilerin kavram yanılgılarının giderilmesi üzerindeki etkisi: Sera etkisi ve küresel ısınma örneği. *Turkish Journal of Education, 1*(2), 38-50.

Erol, G. H. & Gezer, K. (2006). Sınıf öğretmenliği öğretmen adaylarının çevreye ve çevre sorunlarına yönelik tutumları. *International Journal of Environmental and Science Education, 1,* 65-77.

Ertürk, R. (2017). İlkokul öğrencilerinin çevre sorunları ve çevre eğitimine yönelik algıları. *İnönü Üniversitesi Eğitim Fakültesi Dergisi*, *18*(3), 12-24.

Gökmen, A., & Solak, K. (2015). Bilgisayar destekli çevre eğitiminin öğretmen adaylarının madde döngüleri konusundaki başarılarına etkisi. *Gazi Üniversitesi, Gazi Eğitim Fakültesi Dergisi*, *35*(3).

Görmez, K (2007). *Çevre Sorunları*. Nobel Yayınları.

Güven, E. (2013). Çevre sorunları başarı testinin geliştirilmesi ve öğretmen adaylarının bilgi düzeylerinin belirlenmesi. *Trakya Üniversitesi Eğitim Fakültesi Dergisi, 3*(2).

İnanç, N. & Kurgan, E. (2000). Çevre eğitimi ve halkın bilinçlendirilmesi. *V. Uluslararası Ekoloji ve Çevre Sorunları Sempozyumu: Çevre Eğitimi,* Ankara, 1-2 Kasım.

Jeffries, H., Stanisstreet, M. & Boyes, E. (2001). Knowledge about the "greenhouse effect": have college students improved? *Research in Science and Technology Education, 19*(2), 205-221.

Karasar, N. (2014). Bilimsel araştırma yöntemi: Kavramlar-ilkeler-teknikler. Nobel Yayın Dağıtım.

Kaya, B., Ateş, A., & Kılıç, S. (2019). Üniversite Öğrencilerinin Küresel Isınma Konusundaki Bilişsel (Zihinsel) Yapıları Ve Kavram Yanılgılarının Belirlenmesi, *International Journal of Social Science, 74* , 29-40.

Kayhan, Ö. (2019). *İlkokul 3. sınıf öğrencilerinin" Çevremizdeki Işık ve Sesler" ünitesi ile ilgili bilişsel yapılarının kavram karikatürleri ve kelime ilişkilendirme testi teknikleri ile belirlenmesi.* (Yüksek lisans tezi). Necmettin Erbakan Üniversitesi Eğitim Bilimleri Enstitüsü.

Khalid, T. (2003). Pre-service high school teachers' perceptions of three environmental phenomena. *Environmental Education Research, 9*(1), 35-50.

Kılınç, A., Stanisstreet, M., & Boyes, E. (2008). Turkish Students' Ideas about Global Warming. *International Journal of Environmental and Science Education, 3*(2), 89-98.

Kızılay, E., (2020). Sınıf öğretmeni adaylarının çevre sorunlarına yönelik metaforik algılarının incelenmesi. *Avrasya Uluslararası Araştırmalar Dergisi*, *8*(21), 230-240.

Kahraman, S. (2020). Fen Bilgisi Öğretmen Adaylarının Sera Etkisi Kavramı ile ilgili Bilişsel Yapıları. *İnönü Üniversitesi Eğitim Bilimleri Enstitüsü Dergisi, 7*(14), 42-55.

Makki, M. H., Khalick, F. A. E. & Boujaoude, S. (2003). Lebanese secondary school students' environmental knowledge and attitudes. *Environmental Education Research, 9*(1), 21-33.

Meadows, G. & Wiesenmayer, R. (1999). Identifying and addressing students' alternative conceptions of the causes of global warming: The need for cognitive conflict, *Journal of Science Education and Technology, 8,* 235–239.

Ministry of Environment, (1998). *Çevre Notları.* Çevre Bakanlığı Yayınları.

Ministry of National Education (MoNE), (2018). *Fen Bilimleri Dersi Öğretim Programı (İlkokul ve Ortaokul 3, 4, 5, 6, 7 ve 8. Sınıflar)*, Talim Terbiye Kurulu Başkanlığı.

Nacaroğlu, O., Bektaş, O., & Kızkapan, O. (2020). Madde döngüleri ve çevre sorunları konusunda başarı testi geliştirme: Geçerlik ve güvenirlik çalışması. *Kastamonu Eğitim Dergisi*, *28*(1), 36-51.

Nacaroğlu, O. & Bozdağ, T. (2020). Özel Yetenekli Öğrencilerin Çevre Sorunlarına Yönelik Algılarının Kelime İlişkilendirme Testi Kullanılarak İncelenmesi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, *40*(2), 385-409.

Nalçacı, A., & Beldağ, A. (2012). İlköğretim 7. ve 8. Sınıf Öğrencilerinin Çevre Tutumlarının Belirlenmesi (Erzurum Örneği). *Doğu Coğrafya Dergisi*, *17*(28), 141-154.

Oztas, H. (2014). Pre-service high school biology teachers' candidates and environmental phenomena. *Procedia-Social and Behavioral Sciences, 116,* 4482-4486.

Österlind, K. (2005). Concept formation in environmental education: 14-year olds' work on the intensified greenhouse effect and the depletion of the ozone layer. *International Journal of Science Education, 27*(8), 891-908.

Özata Yücel, E., & Özkan, M. (2013). 2013 fen bilimleri programının 2005 fen ve teknoloji programıyla çevre konuları Açısından karşılaştırılması. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, *26*(1), 237-265.

Özata-Yücel, E. & Özkan, M. (2014). Fen bilimleri öğretmen adaylarının çevre algılarının kelime ilişkilendirme aracılığıyla belirlenmesi. *e-International Journal of Educational Research, 5*(4), 41-56.

Özkan, O. (2001). *Remediation of seventh grade students' misconceptions related to ecological concepts through conceptual change approach.* (Unpublished Master Thesis), Middle East Tecnical University, Ankara.

Özkan, M. (2008). *Doğal Kaynakların Korunmasına Yönelik İlkeler ve Bazı Öneriler*. Uludağ Milli Parkı, Bursa ve Çevresinde Ekoloji Temelli Doğa Eğitimi-III Sonuç Raporu. Proje No: 108B027, .30-36. Bursa.

Öztaş, F. (2005). Lise 9. Sınıf öğrencilerinin madde döngüsü ve enerji akışı ile ilgili görüşlerinin saptanmasına yönelik bir araştırma. *Kastamonu Eğitim Dergisi*, 13(2), 381-390.

Pekel, F. O. (2019). 8. Sınıf Fen Bilimleri Ders Kitabının Eğitsel, Görsel, Dil ve Anlatım Yönünden İncelenmesi. *EKEV Akademi Dergisi,* (78), 221-259

Polat, G. (2013). 9. sınıf öğrencilerinin çevreye ilişkin bilişsel yapılarının kelime ilişkilendirme test tekniği ile tespiti. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi*, *7*(1), 97-120.

Patton, M. Q. (2015). *Qualitative research and evaluation methods* (4th ed.). Sage Publications.

Seçgin, F., Yalvaç, G., & Çetin, T. (2010). İlköğretim 8. sınıf öğrencilerinin karikatürler aracılığıyla çevre sorunlarına ilişkin algıları. In *International Conference on New Trends in Education and Their Implication. 11*, (13), 391-398.

Selçuk, A. & Yılmaz, M. (2017). Fen bilimleri öğretmen adaylarının çevre sorunlarına yönelik tutumları ve çevre kirliliğine yönelik metaforik algıları. *Kastamonu Eğitim Dergisi*, *25*(3), 1147-1164.

Shepardson, D. P., Niyogi, D., Choi, S., & Charusombat, U. (2011). Students' conceptions about the greenhouse effect, global warming, and climate change. *Climatic Change, 104*(3-4), 481-507.

Stokes, E., Edge, A., & West, A. (2001). Environmental education in the educational systems of the European Union. *Environment Directorate-General, European Commission*.

Şen, Ü.S., (2010). Sanat eğitiminde bilimsel araştırma yöntemlerinin kullanılması. *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 5(*1), 343-360.

Tombul, F., (2006). *Türkiye'de Çevre için Eğitime Verilen Önem.* (Yayınlamamış Yüksek Lisans Tezi), Ankara Üniversitesi Sosyal Bilimler Enstitüsü, Sosyal Bilimler Çevre Anabilim Dalı, Ankara.

Topkaya, Y. (2016). Sosyal bilgiler öğretmenlerinin değer aktarım yaklaşımları hakkındaki görüşlerine ait nitel bir çalışma. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, *17*(1), 637-652.

Yıldırım, A. & Şimşek, H. (2013). *Sosyal Bilimlerde Nitel Araştırma Yöntemleri*. Seçkin Yayıncılık.

Yıldırım, A. & Şimşek, H. (2018). *Sosyal Bilimlerde Nitel Araştırma Yöntemleri*. Seçkin Yayıncılık.

White, R. T. & Gunstone, R. F. (2000). *Probing understanding*. The Falmer Press.