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Exploring Levels of Secondary School Students' Knowledge: Global Warming, Acid Rain, and Ozone Layer Depletion

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Abstract
The aim of this study was to investigate the levels of secondary school students' knowledge about three Global Environmental Problems: Global Warming, Acid Rain, and Ozone Layer Depletion. 638 7th grade (N=316) and 8th grade (N=322) students enrolled in five different secondary schools participated in this study. The survey method was used to determine the levels of students' knowledge of three global environmental problems. In this study, drawings (separate for each topic) and open-ended questions specific to all three topics were used as data collection tools. The data obtained from drawings and open-ended questions were analyzed together and assessed based on three knowledge categories (informed view, transitional view, and naïve view). The results indicated that the levels of secondary school students' knowledge about three global environmental problems were low. It was also found that they held various misconceptions and their knowledge levels on each topic were close to each other. The results of the Pearson Correlation indicated that there was a significant relationship between the levels of secondary school students' knowledge about only GW and OLD, but a weak correlation. The results of MANOVA indicated that there was a significant difference in the mean scores of students' knowledge of GW from 8th to 7th-grade students, while there was a significant difference in favor of 8th-grade students with respect to the topics of AR and OLD.

Keywords: Global Warming, Ozone Layer Depletion, Acid Rain, Secondary School Students, Science Education

1. Introduction

The increasing needs of societies in parallel with the development of technology, population increase, expansion of heavy industry, and continuous migration from villages to cities in the last century have led to the unconscious use of natural resources in the world and therefore the deterioration of natural balances. Another reason for the disruption of the natural balance may be that the needs of societies and their political/economic visions are considered more important than the interaction of environmental events in harmony with each other. For example, it is clearly seen that many countries do not fulfill their responsibilities for their own interests, despite the international organizations and agreements for the solution of global environmental problems. For

these reasons, the effects of global environmental problems such as GW, AR, and OLD, which are among the most important environmental problems, have concretely been observed in recent years. Furthermore, the fact that GW, AR, and OLD are among the problems that affect the whole world may be another importance of these issues. Since the topics of GW, AR, and OLD, which are interdisciplinary and socio-scientific topics, are both complex and abstract (Boyes, Chambers, and Stanisstreet, 1995), the definition of these three global environmental issues, how they occur, their reasons, effects and the relationship between these three issues are difficult to understand and be taught. In addition, the research indicated that the learners have many misconceptions about these three topics (Khalid, 2003). One of the most basic and effective ways to overcome such important environmental problems is to prepare conscious individuals who are equipped with knowledge related to environmental problems. The way to provide individuals with the characteristics of these qualities can be possible with qualified environmental education. Therefore, students are expected to first have adequate conceptual knowledge on such important environmental issues.

Since the 1970s, there have been numerous attempts to reveal students' views of science topics. In the literature, students' prior knowledge of any subject is defined in different ways such as misconceptions, alternative concepts, unscientific opinions, or naive views. Misconceptions, which pose an obstacle in the construction of knowledge, strongly resist to change with the true knowledge; however, they should be overcome (Clough and Driver, 1985; Hammer, 1996; Osborne, Bell, and Gilbert, 1983; Posner, Strike, Hewson, and Gertzog, 1982). Therefore, it is important to determine the students' views and the reasons for their misconceptions, prior to teaching, in terms of the planning of the course in order to ensure the restructuring of learning (Clough and Driver, 1985; Odom and Barrow, 1995; West and Pines, 1985).

1.1. Significance of the study

We believe that this study may provide important contributions to the literature, considering all these reasons described above. When the studies on global environmental problems were examined, GW, AR, and OLD are among the topics that researchers have focused more (Marinopoulos and Stavridou, 2002) and there were many studies regarding the conceptual understanding of students, teachers and pre-service teachers (Andersson and Wallin, 2000; Aydemir et al., 2010; Boyes and Stanisstreet, 1992; Boyes, Stanisstreet and Papantoniou, 1999; Cordero, 2000; Dove, 1996; Groves and Pugh, 2002; Herman, Feldman and Vernaza- Hernandez, 2017; Jafer, 2020; Karakaya, 2012; Kaya, 2011; Khalid, 1999; Koulaidis and Christidou, 1999; Syibo, 1995). The researchers indicated that the participants had a variety of misconceptions about these environmental issues (Khalid, 2001; Papadimitriou, 2004; Vosniadou 1994; Vosniadou and Verschaffel, 2004). In the literature, there have been studies in which each topic was separately investigated, or no more than two topics (e.g. GW and OLD or GW and AR, etc.) were explored together. However, there is a limited number of studies in which these three topics are investigated together to determine secondary school students' knowledge. In addition, the fact that this study was conducted with a number of secondary school students is one of the importance of the study, which provides an opportunity to more comprehensively evaluate students' understanding of these issues.

The aim of this study was to investigate the level of secondary school students' knowledge about global warming, acid rain, and ozone layer depletion. Within the scope of this main aim, the following research questions were investigated:

1. What is the level of secondary school students' knowledge about GW, AR, and OLD?
   1.1. What is the level of secondary school students' knowledge about the definitions of GW, AR, and OLD?
   1.2. What is the level of secondary school students' knowledge about the reasons for GW, AR, and OLD?
   1.3. What is the level of secondary school students' knowledge about the effects of GW, AR, and OLD?
   1.4. What is the level of secondary school students' knowledge about how to prevent GW, AR, and OLD?
2. Is there a statistically significant relationship among the levels of secondary school students' knowledge about the topics of GW, AR, and OLD?
3. Are there significant differences in the level of secondary school students' knowledge of GW, AR, and OLD by the grade level of secondary school students?

2. Method

In this study, the survey method was used to determine the level of conceptual understanding of secondary school students about global environmental problems. This method is an approach that describes the past or current situation as it is, and includes data collection over a period of time (Creswell and Plano-Clark, 2007).

2.1. Participants

The sample included a total of 638 7th grade (N=316) and 8th grade (N=322) students enrolled in five different secondary schools in Elazığ/Turkey during 2016-2017 academic year. In this study, the convenience sampling method was used to determine the sample of this study.

2.2. Instrument

In this study, the triangulation, which refers to the "the use of two or more methods of data collection in the study of some aspect of human behavior" (Cohen, Manion and Morrison, 2007, p. 141), was used to verify and validate the data obtained from the study. Data collection tools were a form consisting of (1) drawing and (2) open-ended questions for each of the topics of GW, AR, and OLD. Drawings are important and useful tools because they provide the opportunity to effectively express views, misconceptions, or conceptual change on a particular topic without limiting words or sentences (White and Gunstone, 1992). Furthermore, drawings help students, who do not want to answer questions during the assessment, give answers quickly (Thomas and Silk, 1990). The open-ended questions provide the participants to deeply express their own views (Mukherji and Albon, 2015). Therefore, students were first asked to make drawing, reflecting their opinions on each topic, and then answer open-ended questions. For example, while the question- "Can you describe what you know about global warming" was used for the global warming issue on the front face of the form, open-ended questions (such as "Can you explain what you draw in the picture?", "What is global warming?", "What causes global warming?", "What will happen if global warming occurs?", "How can we prevent global warming? Can you explain?") were addressed to students on the backside of the form. This process was performed in the same way for the other two topics (acid rain and ozone layer depletion). For each topic, the students were given 30 minutes for drawing and 15 minutes for open-ended questions.

2.3. Data Analysis

The data obtained from drawings and open-ended questions were analyzed together and assessed based on three knowledge categories (informed view, transitional view, and naïve view). The students' views, as shown in Table 1, were scored as "informed view: 3,5-point, transitional view: 1 point and naive view: 0 point" (Vazquez-Alanso and Manassero-Mas, 1999). In addition, an independent researcher analyzed the data to ensure reliability, and Cronbach's alpha was found to be 0.87. On the other hand, Pearson Correlation was used to determine whether there is a statistically significant relationship among secondary school students' knowledge about the topics of GW, AR, and OLD. Also, the one-way multivariate analysis of variance (one-way MANOVA) was conducted to explore the impact of the students' grade level on their level of knowledge about GW, AR, and OLD.

Table 1: Categories used in the analysis of data

Level	Description
Informed View (3,5 Points)	It is the level at which there is no misconception or partial concept and the answer is fully expressed.
Transitional View (1 Point)	It is the level at which there is no misconception but the answer is partially expressed.
Naive View (0 Point)	It is the level at which there are misconceptions or no answer.

3. Results

The frequency and percentage values of the 7th and 8th grade students' understandings on the topics of GW, AR, and OLD are summarized in Table 2, 3, 4 and 5.

3.1. What is the level of secondary school students' knowledge about GW, AR, and OLD?

3.1.1. What is the level of secondary school students' knowledge about the definitions of GW, AR, and OLD?
The results obtained from the drawings and open-ended questions showed that most of the 7th (%93.35) and 8th-grade students (%82.61) had various misconceptions or no knowledge about the definition of the GW (Table 2). The students with naïve views mostly defined global warming as the sun rays entering the earth's atmosphere or the increase of harmful gases such as greenhouse gases. For example, these students believed that greenhouse gases were harmful gases and when the amount of these gases (e.g. CO, SO_2, etc.) increases, GW occurs. % 6.65 of the 7th and %15.84 of the 8th-grade students had partial understandings about the definition of the GW. These students mentioned the concepts of the greenhouse effect, temperature increase, but, were not able to adequately explain their views. On the other hand, of the students, the only %1.55 8th grade students were able to explicate the definition of GW. The students with informed view in general noted that GW was the gradual heating and temperature changes of Earth's atmosphere, waters, and surface, or it occurs as a result of the increase the amount of gases called greenhouse gases.

Table 2: Findings on secondary school students' knowledge level of the definitions of GW, AR, and OLD

Level	Grade	GW	AR	OLD
Informed View	**7th**	0	5	20
		(%0)	(%1.56)	(%6.25)
	8th	5	8	11
		(%1.55)	(%2.48)	(%3.42)
Transitional View	**7th**	21	15	177
		(%6.65)	(%4.75)	(%55.31)
	8th	51	27	165
		(%15.84)	(%8.39)	(%51.24)
Naive View	**7th**	295	296	119
		(%93.35)	(%93.67)	(%37.66)
	8th	266	287	146
		(%82.61)	(%89.13)	(%45.34)

With respect to the definition of acid rain, Table 2 indicates that the vast majority of 7th (%93.67) and 8th grade students (%89.13) held naïve views. Many students believed that AR is pure acid or accumulation of harmful gases or type of rain that directly and suddenly damages everything. Some students portrayed or explained that AR occurs when dirty and harmful gases (e.g., CO_2) react with rainwater in the atmosphere. %4.75 7th and %8.39 8th grade students had transitional views (Table 2). Some students mentioned that some gases react with water vapor, but were unable to explain the nature of these gases. Some students with transitional views seemed to believe that the conversion of SO_2 to other compounds causes acid rain to occur, but they had no knowledge about these compounds. Contrary to this, of the students, only a minority of 7th (%1.56) and 8th-grade students (%2.48) were well informed about the definition of AR. Some of these students emphasized that acid rain is a dry or wet form of precipitation and occurs when the gases of $SO2$ and NO_x are combined with water vapor. Some students defined precipitation with pH less than 5.4 as acid rains. Compared to the definition of AR and GW, it is seen that students had a better understanding of the definition of OLD, even partially. Table 2 shows that more than half of 7th (%55.31) and 8th-grade students (%51.24) had transitional views. These students in general reported or portrayed that OLD is the reduction of the amount of ozone or the damage to the ozone layer in the atmosphere because of some reasons, however, they were unable to give a reason for their answers. On the other hand, %37.66 of 7th and %45.34 of 8th-grade students held various misconceptions, while the remaining

students were able to articulate informed views. Almost all students with naïve views believed that OLD was a "physical hole" in the atmosphere. Also, some students stated that OLD was formed as a result of some harmful gases or chemicals damaging the ozone layer. When these students were asked the nature of these harmful gases and chemicals, they mentioned the concepts of CO, CO_2. Some students mentioned that OLD was the accumulation of harmful gases in the atmosphere and when the amount of these gases reaches more than ozone gas, OLD is formed, etc. The students that had sound understandings about the definition of the OLD in general emphasized that substances containing CFCs break down ozone and OLD occurs because of the decrease in the amount of O_3 in the stratosphere. Figure 1 presents several drawings of students about the definition of GW, OLD and AR.

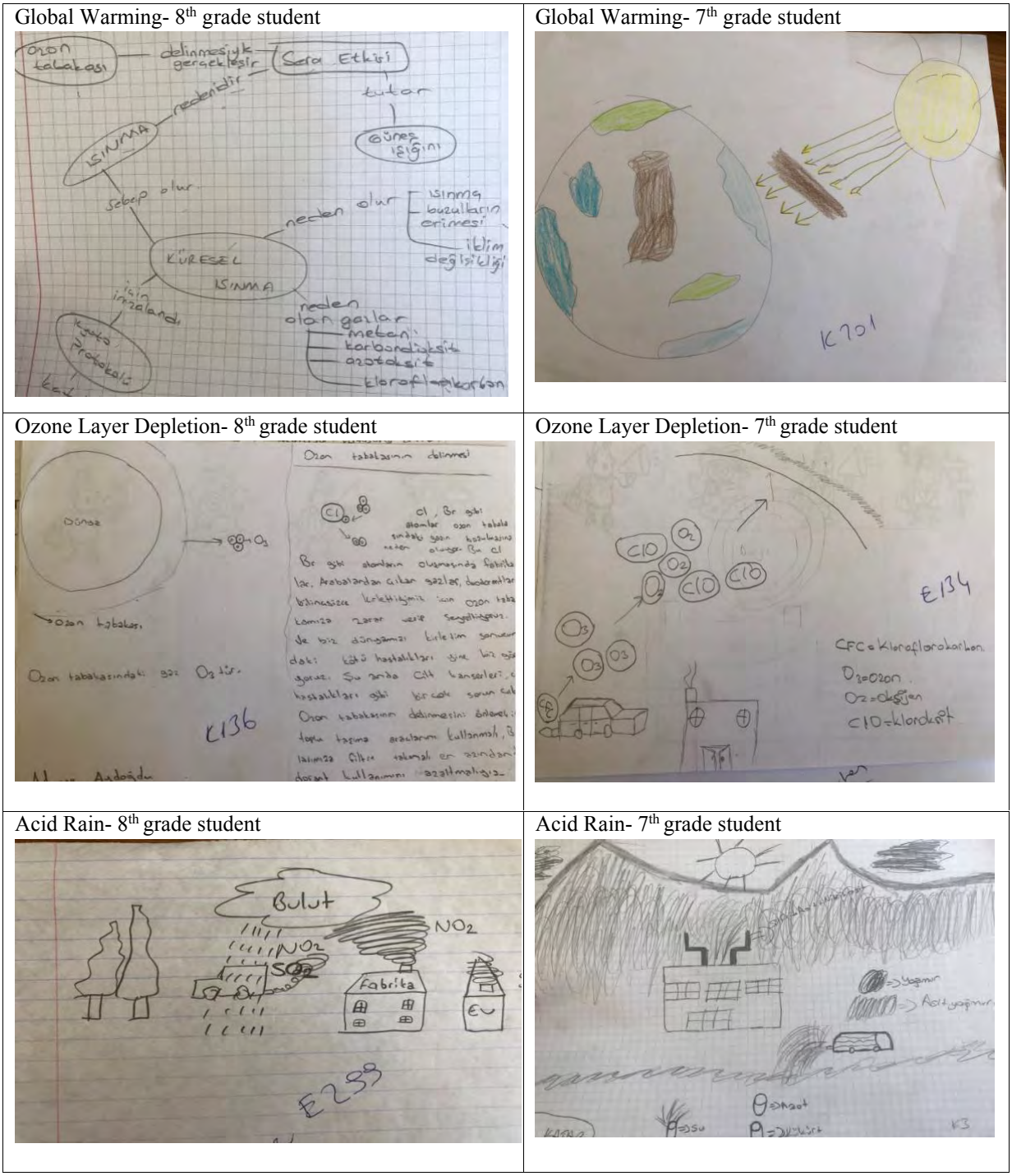


Figure 1: Some drawings of students about the definition of GW, OLD, and AR

3.1.2. What is the level of secondary school students' knowledge about the reasons of GW, AR, and OLD?
Table 3 indicates the findings on 7th and 8th-grade students' knowledge level of the reasons of GW, AR, and OLD. As shown in Table 3, no students were able to explicate an informed view about the reasons for these three topics. For the topic of GW, most of the 7th (%67.72) and 8th-grade students (%71.43) held various misconceptions, while the remaining students had partial knowledge. Many students with naïve views reported that ozone layer depletion is one of the main reasons for GW, the sun rays will get through the atmosphere due to the OLD, and thus the temperature in the earth will increase. This naïve view was one of the most common misconceptions they had. Some students argued that AR causes the GW, while some students mentioned the toxic gases such as CO, NO_2, etc., released from factories and cars are the ones of the main reasons for GW. Many students reported that climate changes caused GW. Few students mentioned the greenhouse gases but misunderstood these gases (e.g. CO, SO_2, etc.). The students that had transitional views in general reported or portrayed that use of fossil fuel, increasing the amount of greenhouse gases causes GW, but they had no or inadequate knowledge about the greenhouse gases. Some students believed that only CO_2 causes the GW, however, these students were unable to explain how CO_2 affects GW.

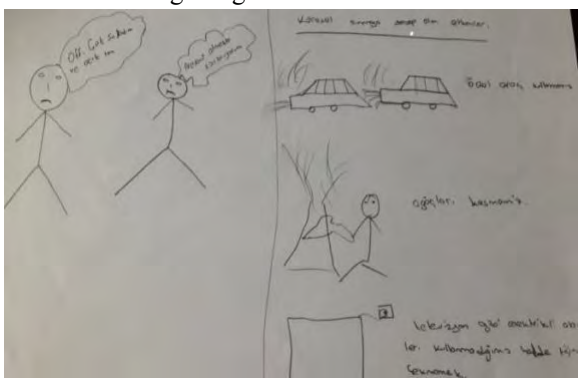
Table 3: Findings on secondary school students' knowledge level of the reasons of GW, AR, and OLD

Level	Grade	GW	AR	OLD
Informed View	**7th**	0 (%0)	0 (%0)	0 (%0)
	8th	0 (%0)	0 (%0)	0 (%0)
Transitional View	**7th**	102 (%32,28)	87 (%27,53)	85 (%26,56)
	8th	92 (%28,57)	164 (%50,93)	149 (%46,27)
Naive View	**7th**	214 (%67,72)	229 (%72,47)	231 (%73,10)
	8th	230 (%71,43)	158 (%49,07)	173 (%53,73)

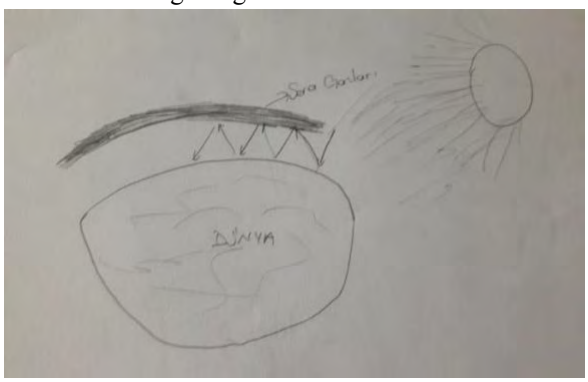
With respect to the reasons for acid rain, 7th (%27.53) and 8th-grade students (%50.93) had transitional views (Table 3). For example, many students portrayed or mentioned that human activities, the fumes from the volcanoes, or the exhaust from cars were one of the main causes of it. Some students also pointed out that some pollutants such as air pollution caused it. These students mentioned the sources of acid rain but were not able to explain the reasons for it. On the other hand, the remaining students had naïve views and commonly emphasized that harmful gases such as CO, CO_2, or nuclear waste caused acid rain. Some students stated that GW is one of the main reasons for acid rain, while some students believed that UV rays triggered the formation of AR because of OLD. Few students both portrayed and reported perfumes and deodorants as the cause of acid rain. In addition, several students interestingly claimed that there was a strong relationship between earthquakes and global warming.

Looking at Table 3, it is seen that most 7th (%73.10) and 8th-grade students (%55.73) held various misconceptions about the reasons for OLD. For example, they in general believed that the causes of GW and AR such as CO_2, CH4 from car emissions and air pollution especially coming from factories are responsible for OLD. Some students mentioned that intense sun rays damaged the ozone layer as a result of solar flares. Several students claimed that missiles launched into space and nuclear tests seriously damaged the ozone layer. It was also understood that some students portrayed the harmful gases, exhaust from cars, etc., as the reasons for OLD. Contrary to this, %26.56 of 7th and %46.27 of 8th-grade students had partial understandings of the reasons for OLD. For example, almost all of these students recognized perfumes and deodorants as ozone-depleting substances. However, they had no knowledge about which ingredient(s) in perfumes and deodorants caused the OLD. Figure 2 presents several drawings of students about the reasons for GW, OLD, and AR.

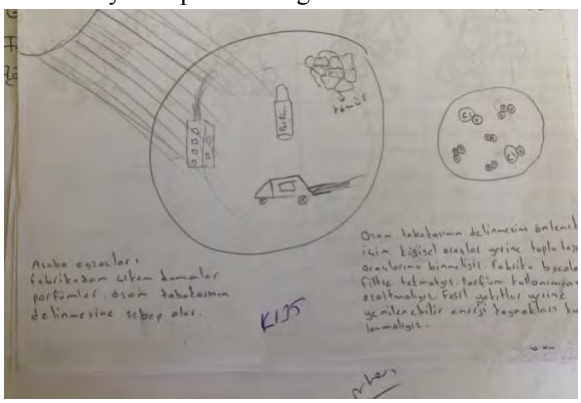
Global Warming- 8th grade student



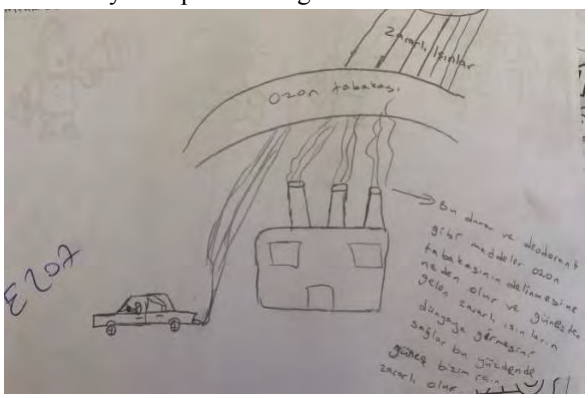
Global Warming- 7th grade student



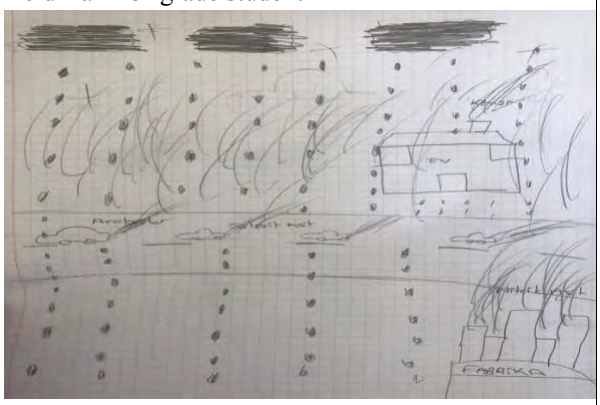
Ozone Layer Depletion-8th grade student



Ozone Layer Depletion-8th grade student



Acid Rain- 8th grade student



Acid Rain- 7th grade student

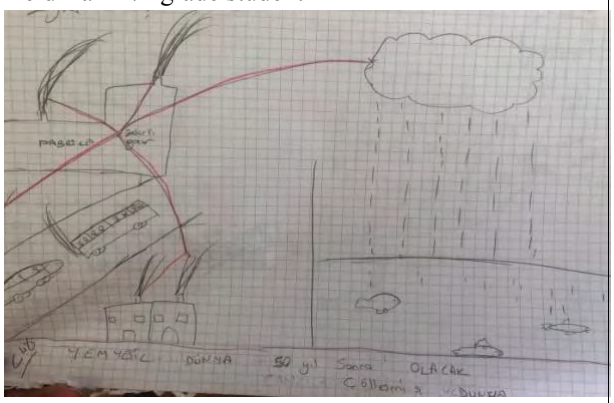


Figure 2: Some drawings of students about the reasons for GW, OLD, and AR.

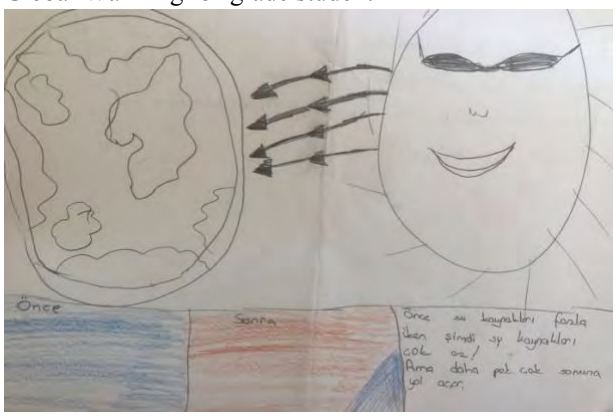
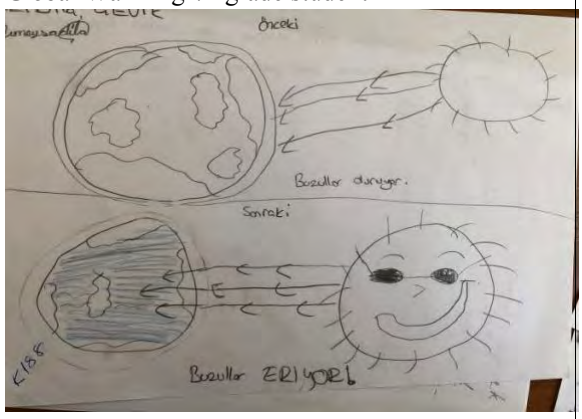
3.1.3. What is the level of secondary school students' knowledge about the effects of GW, AR, and OLD?

The findings on secondary school students' knowledge level about the effects of GW, AR, and OLD are presented in Table 4 and it can be seen that the levels of students' knowledge about the effects of these three topics are similar. Results indicated that no students had informed views about the effects of these three environmental problems. However, most of the 7th (%67.09) and 8th grade students (%62.73) had transitional views about the effects of GW. For example, these students mostly emphasized that GW mainly caused the melting of glaciers and sea-level rise. Some students reported that GW negatively impacted everything such as human life, plants, animals, etc., but couldn't explain how GW damaged. On the other hand, %32.91 7th and %37.27 8th grade students held many misconceptions that GW directly triggered great disasters such as huge earthquakes and volcanoes and there was a direct relationship between GW and the other environmental problems such as AR, OLD, etc. These students emphasized that GW had an important role in the formation of AR and OLD. Interestingly, some students claimed that GW caused communication devices such as the internet, telephone to slow down.

Table 4: Findings on secondary school students' knowledge level about the effect of GW, AR, and OLD

Level	Grade	GW	AR	OLD
Informed View	**7th**	0 (%0)	0 (%0)	0 (%0)
	8th	0 (%0)	0 (%0)	0 (%0)
Transitional View	**7th**	212 (%67,09)	147 (%46,52)	180 (%56,25)
	8th	202 (%62,73)	169 (%52,48)	145 (%45,03)
Naive View	**7th**	104 (%32,91)	169 (%53,48)	136 (%43,04)
	8th	120 (%37,27)	153 (%47,52)	177 (%54,97)

For the effects of AR, %46.52 7th and %52.48 8th grade students had partial understandings (Table 4). They in general portrayed and reported that when AR fell to earth, it could damage many things on earth such as plants, animals, historical monuments but not with the appropriate reasons of how it affects them. On the other hand, remaining 7th and 8th-grade students seemed to believe various misconceptions about the effects of AR. For example, many students argued that AR directly triggered the formation of GW, OLD, etc. because it increases the acidity of water, air, and soil. Some students also stated that AR was the essential cause of the extinction of species such as humans, plants, etc. When it comes to OLD, Table 4 indicates that %56.25 of 7th and %45.03 of 8th-grade students had partial understandings, while the remaining of the 7th and 8th-grade students had naïve views about the effects of OLD. The students with naive understandings mostly believed that the temperature of the atmosphere increased due to OLD because depletion of the ozone layer allows more sun rays to reach the earth. Many students reported that OLD caused global disasters such as AR, GW, flood, hurricane, etc. Figure 3 presents some drawings of students about the effects of GW, OLD, and AR.

Global Warming- 8th grade student	Global Warming-7th grade student
	
Ozone Layer Depletion- 8th grade student	Ozone Layer Depletion- 7th grade student

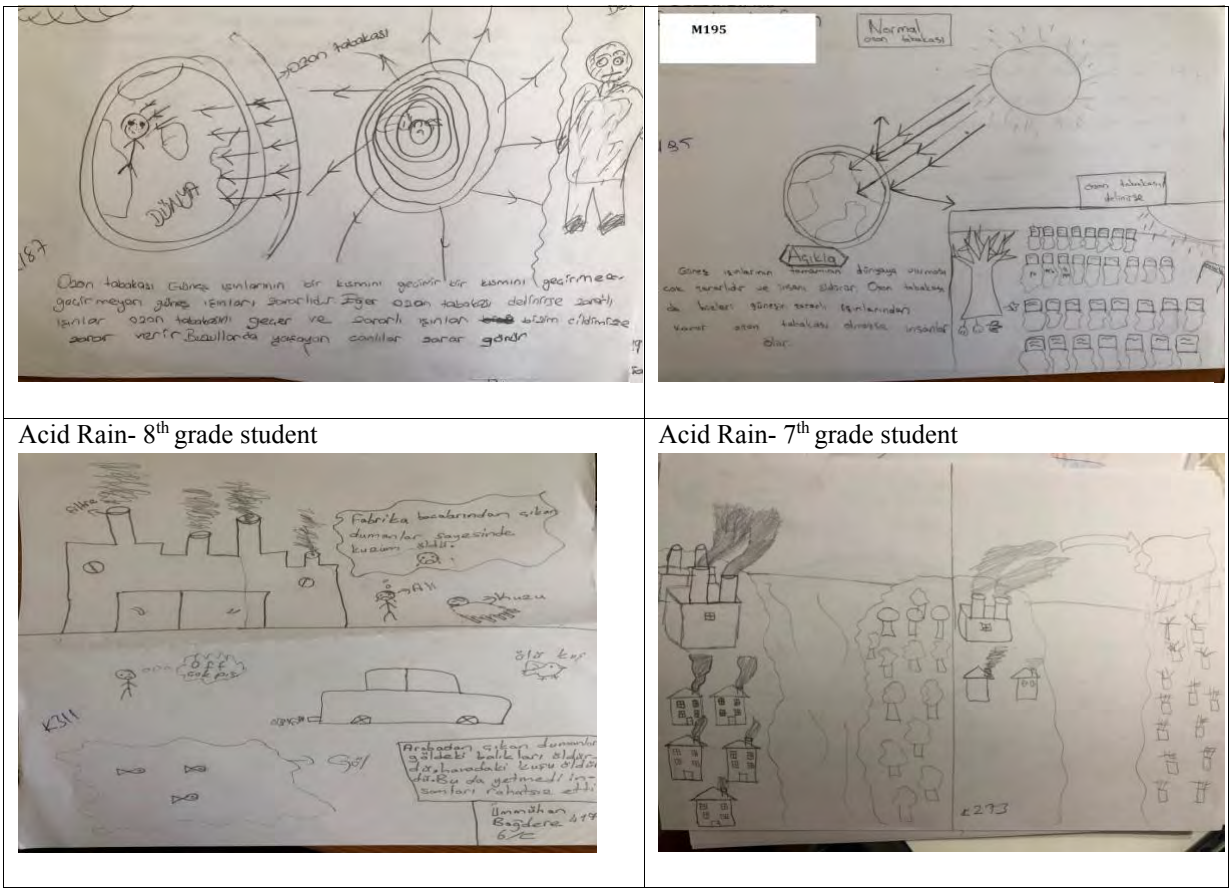


Figure 3: Some drawings of students about the effects of GW, OLD, and AR

3.1.4. What is the level of secondary school students' knowledge about how to prevent GW, AR, and OLD?
Results indicated that no students had informed views about how to prevent GW, AR, and OLD (Table 5). As shown in Table 5, it was understood that most of the 7th (%89.24) and 8th grade students (%91.61) held naïve views about how to prevent GW, while the remaining of the students had transitional views. The students with naïve views in general emphasized that global environmental problems, especially OLD must be prevented because this environmental problem is in particular responsible for GW. Some students argued that one of the best ways to prevent GW was to prohibit the missiles launched into space and nuclear tests. Few students suggested that legal regulation to reduce the use of perfumes and deodorants is essential for preventing GW. The students with transitional views mostly mentioned the planting of trees, the installation of filters on factory and vehicle exhaust, and the use of alternative energy sources. However, they couldn't give any response to the question of "what function these proposals have in preventing global warming".

Table 5: Findings on secondary school students' knowledge level of how to prevent the GW, AR, and OLD

Level	Grade	GW	AR	OLD
Informed View	**7th**	0 (%0)	0 (%0)	0 (%0)
	8th	0 (%0)	0 (%0)	0 (%0)
Transitional View	**7th**	34 (%10,76)	26 (%8,23)	38 (%11,88)
	8th	27 (%8,39)	19 (%5,90)	65 (%20,19)
Naive View	**7th**	282 (%89,24)	290 (%%91,77)	278 (%87,97)
	8th	295 (%91,61)	303 (%94,10)	257 (%79,81)

Table 5 shows that the majority of 7th (%91.77) and 8th-grade students (%94.10) had various misconceptions or no knowledge about how to prevent AR such as harmful gases such as CO, CO_2 must be reduced. Some students had no knowledge about it. Another result of the study was that the minority of 7th and 8th-grade students had transitional views about how to prevent OLD. Results also indicated that most of 7th (%87.97) and 8th (%79.81) held various misconceptions about how to reduce or prevent OLD, which is similar to their suggestions on the topics of AR and GW. Figure 4 presents some drawings of students about how to prevent GW, OLD, and AR.

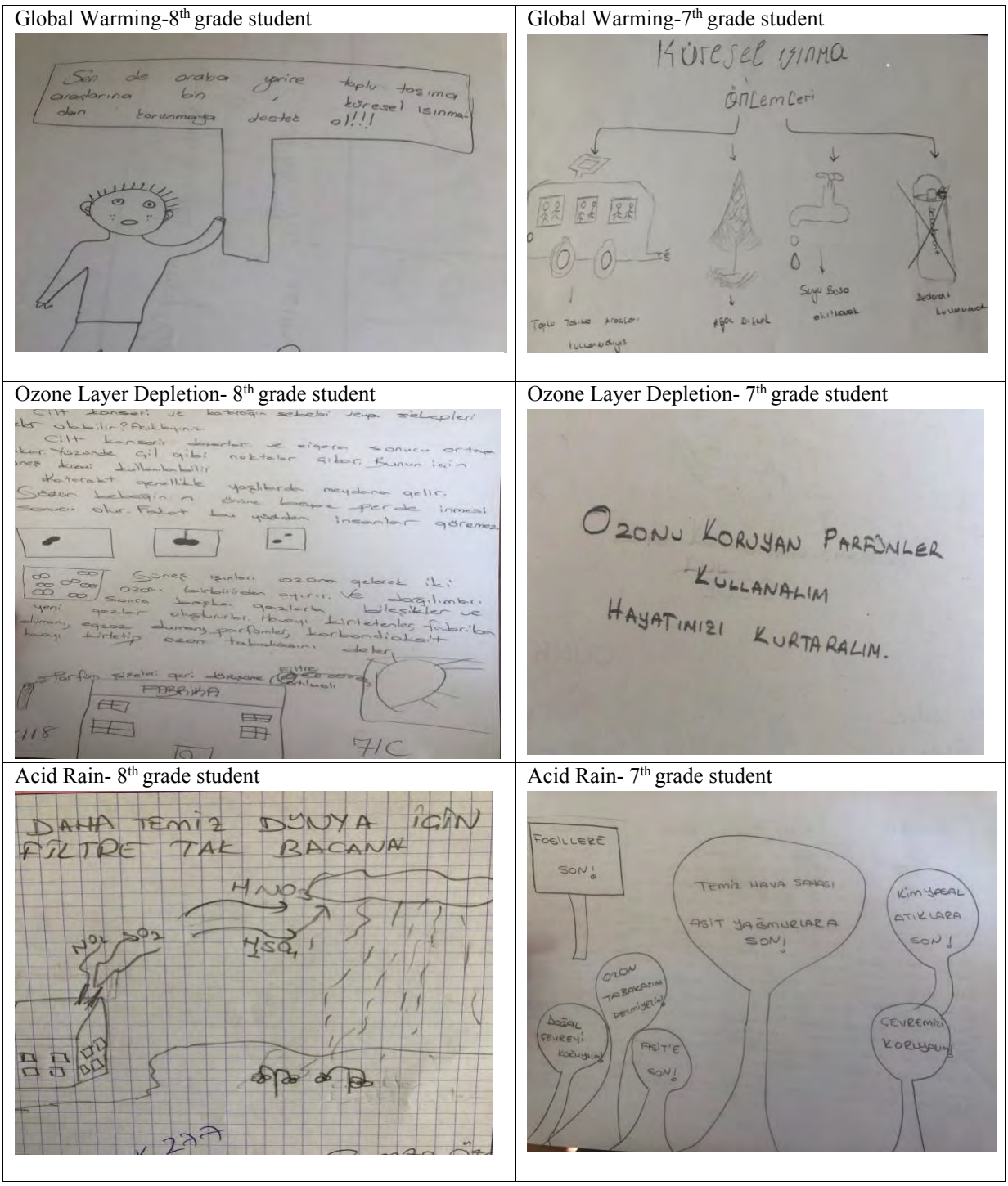


Figure 4: Some drawings of students about how to prevent GW, OLD, and AR.

3.2. Is there a statistically significant relationship among the levels of secondary school students' knowledge about the topics of GW, AR, and OLD?

Table 6 indicates that there was a weak correlation between the levels of secondary school students' knowledge about GW and OLD (r=0.146, p=0.000), while there was no significant relationship between the levels of secondary school students' knowledge about GW-AR (r=-0.009, p=0.812) and AR-OLD (r=-0.027, p=0.493).

Table 6: Relationships between the levels of secondary school students' knowledge about GW, AR, and OLD

	GW	AR	OLD
GW	--		
AR	-.009	--	
OLD	.146**	-.027	--

**$p < .01$

3.3. Are there significant differences in the level of secondary school students' knowledge of GW, AR, and OLD by the grade level of secondary school students?

MANOVA results are presented in Table 7. The results MANOVA, as shown in Table 7, indicated that there was a statistically significant difference between 7th and 8th-grade students for all variables (p=0.000). Based on Cohen's (1988, pp. 283–288) interpretation of the strength of partial eta squared values into three levels—0.01 (small effect), 0.06 (moderate effect), and 0.14 (large effect) —this value (η^2=0.18) indicated that the magnitude of significant difference between 7th and 8th-grade students with respect to the level of the students' knowledge about GW, AR and OLD was large.

Table 7: MANOVA Results

		Value	F	Hypothesis sd	Error df	p
Group	Wilks' Lambda	0.657	110.346	3.000	634.000	0.000

The results of ANOVA presented in Table 8 indicated that there was a statistically significant difference with respect to the students' knowledge GW (p<.001), AR (p<.001), and OLD (p<.001) between 7th and 8th grade. The post-hoc comparisons indicated that there was a significant increase (p<.001) in the mean scores of students' knowledge of GW from 8th to 7th-grade students (Table 8). With respect to the topics of AR and OLD, there was a significant difference (p<.001) in favor of 8th-grade students (see Table 9).

Table 8: Results of ANOVA for 7th and 8th grades of the students' knowledge about GW, AR, and OLD

Source of Variance	Dependent Variable	Sum of Squares	sd	Mean of Squares	F	p
Group	GW	81.493	1	81.493	197.671	0.000
	AR	2.235	1	2,235	43.737	0.000
	OLD	4.782	1	4.782	69.314	0.000
Error	GW	262.200	636	.412		
	AR	32.502	636	.051		
	OLD	43.877	636	.069		
Total	GW	505.400	638			
	AR	50.980	638			
	OLD	66.370	638			

Table 9: Descriptive statistics of the 7th and 8th grades students with *post hoc* comparisons for the students' knowledge about GW, AR, and OLD

	Group	N	Mean	Post-hoc
Global Warming	7th grade (1)	316	0.86	2<1
	8th grade (2)	322	0.14	
Acid Rain	7th grade (1)	316	0.10	1<2
	8th grade (2)	322	0.21	
Ozone Layer Depletion	7th grade (1)	316	0.08	1<2
	8th grade (2)	322	0.25	

4. Discussion

The results indicated that the levels of students' knowledge about GW, AR, and OLD were low and most of the students had various misconceptions about these three topics such as especially "CO_2 is one of the harmful-toxic gases and responsible for AR and OLD as well as GW" ozone layer is the physical layer that protects around the earth", "there was a hole in the ozone layer in a physical meaning", "GW, AR, and OLD directly affect each other and any of these environmental problems cause the other two to occur" etc. There are several reasons why the students have misconceptions regarding these common environmental problems. First, the fact that the topics of GW, AR, and OLD are both complex and abstract makes it difficult for these topics to understand and teach (Boyes, Chambers, and Stanisstreet, 1995; Dove, 1996). It can be said that one of the reasons for these misconceptions may be the animations, videos, and visuals on the internet, magazines, and books (Shepardson, Niyogi, Choi, and Charusombat, 2011) or environmental information from unofficial and unreliable sources. For example, the visuals of the ozone layer in these resources evoke the concept of "layer" in the minds of students in the physical meaning. Khalid (2003) claimed that the media influences the students' views and thinking about these environmental problems and there is an important role of media on the students' misconceptions. For example, CO_2 is mentioned as a 'bad or toxic' gas in the media, which causes the students to think of it only as a harmful gas rather than one of the greenhouse gases. It was also determined that the students explained the environmental problems with only a few concepts. For example, they stated that CO_2 gas was one of the main reasons for all environmental problems, or installing a filter to chimneys, and planting a tree would solve all three environmental problems. The fact that those topics are commonly included under the heading of "environmental pollution" or "environmental problems" in textbooks may be shown as a reason for this result, which may cause the students to confuse these topics. In a study of the levels of students' knowledge about GW, Boyes and Stanisstreet (1993) found that students had a general awareness of environmental issues, but had difficulty in establishing cause-effect relationships among these environmental problems. With respect to the effects of GW, AR, and OLD, the students were found to be more informed compared to other dimensions of these topics, which is due to the fact that these environmental issues are up-to-date is more likely and more concrete for students to encounter in daily life (TV, internet, magazines, documentaries, etc.). The findings of some research (e.g., Boyes and Stanisstreet, 1994; 1997) support these results. Contrary to this finding, the results indicated that the students' knowledge about how to prevent the GW, AR, and OLD was more inadequate than the other dimensions of these three environmental problems. They commonly considered that installing filters in chimneys, planting trees is the ones of the best ways to prevent these issues. The results of Pearson Correlation indicated that there was a statistically relationship between GW and OLD, however there was no relationship between AR-OLD and AR-GW, which can be explained by the fact that students confused the topics of OLD and GW more than acid rain. This means that the students who had more appropriate knowledge in any of the topics of GW and OLD had a better understanding of another topic or vice versa. These statistical results were further supported by evidence from qualitative analyses of the data obtained from drawings and open-ended questions. The results of MANOVA also indicated that there was a significant increase in the mean scores of students' knowledge of GW from 8th to 7th-grade students, while there was a significant difference in favor of 8th-grade students with respect to the topics of AR and OLD.

Consequently, the results of this study provide evidence that Turkish secondary school students have not developed an appropriate conceptual understanding of the topics of GW, AR, and OLD. In the light of this study's findings, we may suggest that there is a need for more studies for exploring and developing the secondary school students' knowledge about these global environmental problems, especially for providing our students to be sensitive to the environment and to actively engage them in decisions regarding environmental issues. The results of this study also imply that environmental science courses dealing with current and future environmental problems such as the GW, AR, and OLD should be comprehensively added to science curricula as compulsory courses.

4.1. Limitation of the Study

In this study, in order to determine the students' knowledge level of these environmental problems, only open-ended questions and drawings were used as data collection tools. Also, the sample of this study is limited to only 7th and 8th-grade students.

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