

## **Investigation of Secondary School Students' Knowledge Levels About Global Warming in Terms of Various Variables**

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### **Abstract**

The aim of this study was to examine the knowledge levels of secondary school students about global warming in terms of various variables. A total of 1008 students studying in secondary schools in Muş Province city center were included in the study. This study was conducted through a survey design and the Scale of Knowledge about Global Warming was used as a data collection tool. In addition to descriptive statistics, t-test, and one-way analysis of variance (ANOVA) were used to analyze the data. The results of the study suggested that the knowledge level of secondary school students about global warming was above average. The participant secondary school students' knowledge levels about global warming differed significantly according to the variables of grade, number of siblings, mother and father's education level, whether they have internet access at home, their science course grade, and the frequency of following the developments related to global warming.

**Keywords:** Global Warming, Environmental Education, Science Education, Secondary School Students

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## Introduction

Scientific and technological developments affect the environment, and the way people live, and many solutions aimed at problems cause further environmental problems (Head Council of Education and Morality of Türkiye, 2005). The effort of human beings is aimed towards making their lives easier (Avinç, 1998). While rapid developments in science and technology increase our living standards, they also cause the destruction of many parts of the environment we interact with and cause change (Yılmaz et al., 2002). Many of the environmental problems that at first glance appear to be local have global consequences. Humans and the environment have been in constant interaction, which continued in partial harmony until the industrial revolution. However, with the industrial revolution, the possibilities and conditions for humans to dominate and intervene in nature became present, and the possibilities of environmental problems posing a life-threatening danger to living things have increased with the destruction of the ecological balance (Görmez, 2007).

The use of fossil fuels emerged in the early 1800s when the industrial revolution began. As a result, the atmospheric concentrations of some gases called greenhouse gases [carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF<sub>6</sub>)] have increased. Global warming is defined as the artificial increase in the earth's temperature as a result of the intense increase in greenhouse gases in the atmosphere (Ulutaş, 2013). In addition, increasing population, deforestation, and the rapid consumption of the world's resources have not only increased the atmospheric concentrations of these gases, but also damaged the systems that remove these gases from the atmosphere. This situation, which is almost entirely the result of human activities, has resulted in global warming, the biggest environmental problem of our world today (Güley, 2009).

Global warming, which is a term that has been used widely in recent years, has caused many negative effects on our lives. Rising temperatures, an increasing number of hot days, unforeseen natural disasters, summer droughts, melting glaciers, rising sea levels, and irregular monsoon rains are some of the effects of global warming. It is likely that our lives will become more difficult, and we will face serious health problems due to global warming. Species that cannot adapt to the short-term climate changes will face the danger of extinction and this in turn will negatively impact the ecosystem (Aksay et al., 2005). Future scenarios constructed regarding this issue have shown that a catastrophe awaits all living creatures in the world if adequate and timely measures are not taken (O'Neill & Oppenheimer, 2002).

The environmental disasters in the world in recent years due to global warming have alarmed people and forced all states of the world, especially developed states, to take some measures. While environmental problems such as global warming and climate change have centuries-old roots and cannot be fully reversed, measures need to be taken to prevent further environmental impacts. Since

this global environmental problem is caused by people's attitudes and behaviors, it is a fundamental educational problem. Thus, the most effective way to combat environmental problems is to raise conscious and sensitive individuals and provide education that will cause changes in the behaviors of individuals (Uzun & Sağlam, 2006).

Children or young adults at all levels of education and future generations who have knowledge about what global warming is, what causes global warming, what the consequences of global warming can be, and how measures can be taken against these will grow up to be more sensitive towards the environment and will integrate with society as adults who fulfill their individual and social responsibilities. Hence, the first priority should be to provide proper scientific information about global warming.

When the literature was examined, various qualitative and quantitative studies examining knowledge of students at different education levels about global warming were found (Aksan & Çelikler, 2013; Atmaca Aksoy, 2022; Ay & Yalçın Erik, 2020; Aydın, 2014; Bayram, 2014; Bilgi, 2021; Boyes et al., 2008; Bozdoğan & Yanar, 2010; Dedeoğlu Demir et al., 2023; Demirkaya, 2008; Eroğlu & Aydoğdu, 2016; Gedik & Öztürk Demirbaş, 2018; Kılıçoğlu & Akkaya Yılmaz, 2021; Khalid, 2003; Koca, 2019; Mahanoğlu, 2019; Pekel & Taştan Kırık, 2016; Pruneau et al., 2003; Sever, 2013; Shepardson, et al., 2009; Summers et al., 2001; Şenel & Güngör, 2009; Toprak, 2022; Ulutaş, 2013; Yalçın, 2010). The studies in the literature suggest that students/pre-service teachers/teachers at all levels of education in Türkiye and around the world generally have limited prior knowledge about the causes and consequences of global warming and have many misconceptions regarding the issue (Bozdoğan, 2011).

Considering that raising students who are well-equipped in terms of environmental issues before university is necessary since not all students can get a university education, the importance of environmental education in middle and high school is indisputable (Uzun & Sağlam, 2006). Based on the fact that the education given at a young age will be more effective, it is especially important for secondary school students to have sufficient knowledge about global warming, project this knowledge into their attitudes, and leave a livable world to the next generations. Therefore, it is important to first elucidate what secondary school students know about global warming and which factors might have an impact on what they know. It is thought that this study will provide scientists, governments, and education program developers with an overview and understanding of how to build a more detailed and more efficient base for environmental education. This study was conducted to evaluate the knowledge levels of secondary school students about global warming in terms of various variables. Within the framework of this general purpose, answers to the following questions were sought:

- (1) What are the knowledge levels of secondary school students about global warming?

(2) Does the knowledge of secondary school students about global warming change according to:

- a. Their gender,
- b. Their grade,
- c. The number of siblings they have,
- c. The average hours of TV they view per day,
- d. The educational status of their mothers,
- e. The educational status of their fathers,
- f. Whether they have internet access at home or not,
- g. Their science course grades last semester,
- h. Their overall frequency of following developments related to global warming and environmental problems,
- i. And their frequency of discussing global warming and environmental problems among their families?

### **Method**

This section includes information on the research model, the study group, the data collection tools used in the research, and the collection and analysis of the data obtained in the research.

#### **Research Design**

The aim of this study was to determine the knowledge levels of secondary school students about global warming and to examine this knowledge in terms of various variables. For this purpose, this study was conducted through a relational survey model, with a qualitative research approach. The relational survey model is a research design that aims to determine the presence and/or degree of covariation between two or more variables (Karasar, 2013).

#### **Study Group**

Since the study group was composed of volunteers, the participants were selected using a simple random sampling method. A link to the questionnaire form created on Google Forms was shared with science teachers in Muş Province city center and they were asked to send links to the student groups. Data were collected from the responding students. Thus, a total of 1008 volunteering secondary school students studying in the 5th, 6th, 7th, and 8th grades of various public schools in the city center of Muş Province were selected as participants in the second semester of the 2022–2023 academic year. Demographic information of the participating students is presented in Table 1.

**Table 1.** Demographic Information of Secondary School Students.

		Gender		Total	
		Female	Male		
Grade	5th grade	N	76	88	164
		%	7.5	8.7	16.3
	6th grade	N	134	139	273
		%	13.3	13.8	27.1
	7th grade	N	206	209	415
		%	20.4	20.7	41.2
	8th grade	N	82	74	156
		%	8.1	7.3	15.5
	Total	N	498	510	1008
		%	49.4	50.6	100

As can be seen in Table 1, of the 1008 participants, 164 (76 females, 88 males) were 5th-grade students, 273 (134 females, 139 males) were 6th-grade students, 415 (206 females, 209 males) were 7th-grade students, and 156 (82 females, 74 males) were 8th-grade students.

### **Data Collection Tools**

The questionnaire prepared to obtain the data in the study consisted of 2 forms. The Personal Information Form was used to obtain information on the independent variables of the study and the Scale of Knowledge about Global Warming (SKGW) was used to collect data on knowledge about global warming, which was the dependent variable of the study. Information on these forms is provided below.

#### ***Personal Information Form***

Within the scope of the research, a personal information form was prepared to obtain the demographic information of the participants. This form contained questions aimed at secondary school students to determine their gender, grade, number of siblings, average daily TV viewing time, mother and father's education level, whether they have internet access in their homes, their science course grade in the previous semester, their overall frequency of following developments related to global warming and environmental problems, and their frequency of discussing global warming and environmental problems with their families.

#### ***Scale of Knowledge about Global Warming***

The SKGW, developed by Mahanoğlu (2019), was used to examine the knowledge of secondary school students about global warming. The scale contains 22 True-False style questions with two options, and the KR-20 reliability of the scale was reported as 0.85. The validity and reliability of the scale was also examined by the researchers, resulting in a KR-20 reliability coefficient of 0.78.

### Data Collection

After obtaining ethical approval, the link to the questionnaire with the ethical approval attached was e-mailed to science teachers working in all secondary schools in Muş Province and they were asked to reach students who volunteered to answer the form. At the beginning of the survey, necessary information was given about the purpose of the study, where the data would be used, how long it would take, and that no identity information was requested, and data were to be collected on a volunteer basis. The survey link remained active for two months during the second semester of 2021–2022. At the end of this period, a total of 1008 secondary school students had filled out the questionnaire.

### Data Analysis

IBM SPSS Statistics for Windows 24.0 (IBM Corp., Armonk, NY, USA) was used to analyze the data obtained in this quantitative study. The independent variables in the personal information form and the items (True = 1, False = 0) in the SKGW were coded and the data were entered. Frequency (f), percentage (%), mean ( $\bar{x}$ ), and standard deviation values were used to describe the personal characteristics and knowledge levels of secondary school students. In order to determine the statistical methods to be used before correlational data analysis, the homogeneity of the data and whether data was distributed normally were examined. The normality assumption and central distribution of the data were examined. When the histogram and Q-Q plot graphs resulting from the analyses were examined, it was observed that the data were distributed close to normal. Then, skewness and kurtosis coefficients of the data were analyzed. The skewness-kurtosis values of the scale are presented in Table 2.

**Table 2.** SKGW Skewness-Kurtosis Values.

N	$\bar{X}$	SD	Skewness	Kurtosis
1008	17.01	3.365	-0.345	-0.593

As can be seen in Table 2, the results of the normality test revealed that the skewness value of the data was  $-0.345$  and the Kurtosis value of the data was  $-0.593$ . These values being between  $-1.5$  and  $1.5$  were accepted as normal distribution (Büyüköztürk, 2012). As a result, it was found that the data were normally distributed. Thus, parametric tests were used to analyze the data. Independent samples t-test and one-way analysis of variance (ANOVA) tests were conducted to determine whether the scores of secondary school students from the scale differed significantly according to the sociodemographic variables in the personal information form. The Scheffe test was conducted to determine which groups the significance determined in the ANOVA was between. In all of the tests,  $p < 0.05$  was considered as statistically significant.

## Results

In this section, the data obtained from the research are discussed under two separate headings: descriptive findings and relational findings. In the first part, the knowledge levels of secondary school students about global warming were examined, while in the second part, their knowledge about global warming was examined in terms of some independent variables.

### Descriptive Findings

In the study, the frequencies of the answers given to the scale were analyzed to determine the knowledge levels of secondary school students about global warming. The frequency (f) and percentage (%) distributions of the answers given by the students are presented in Table 3.

**Table 3.** Findings related to secondary school students' level of knowledge about global warming.

Scale items	True		False	
	f	%	f	%
1. The increase in the world's population causes an increase in global warming.	745	73.9	263	26.1
2. Perfumes cause the ozone layer to thin.	830	82.3	178	17.7
3. The increase of carbon dioxide gas leads to an increase in global warming.	848	84.1	160	15.9
4. Global warming is causing climate change.	900	89.3	108	10.7
5. Fossil fuels are causing an increase in global warming.	668	66.3	340	33.7
6. The increase in the melting rate of glaciers is an indicator of the increase in global warming.	881	87.4	127	12.6
7. Global warming is causing the extinction of species in danger of extinction.	882	87.5	126	12.5
8. Greenhouse gases (methane, water vapor, nitrogen, and sulfur gases) cause global warming.	825	81.8	183	18.2
9. After the industrial revolution, an increase in global warming has occurred.	771	76.5	237	23.5
10. As a result of global warming, the probability of acid rains has increased.	669	66.4	339	33.6
11. There is an increase in forest fires as a result of global warming.	792	78.6	216	21.4
12. There will be an increase in health problems due to global warming.	817	81.1	191	18.9
13. Carbon dioxide is a gas necessary for the life cycle in Earth.	644	63.9	364	36.1
14. Forestation balances the world's harmful gas emissions.	782	77.6	226	22.4
15. Saving electricity reduces the impact of global warming.	694	68.8	314	31.2
16. Carbon dioxide emitted from car exhausts causes an increase in greenhouse gases.	808	80.2	200	19.8
17. The use of public transportation reduces global warming.	792	78.6	216	21.4
18. Use of recyclable (glass, paper, plastic, etc.) materials reduces global warming.	720	71.4	288	28.6
19. Reducing greenhouse gas emissions can reduce the effects of global warming.	792	78.6	216	21.4
20. Use of renewable energy sources (wind, solar, wave, etc.) can reduce the effects of global warming.	785	77.9	223	22.1
21. As a result of gases accumulated in the atmosphere, the temperature of the earth will increase more.	846	83.9	162	16.1
22. Global warming will cause an increase in the rate of disease in the world.	847	84	161	16

As can be seen in Table 3, 73.9% of the participant secondary school students answered item 1 stating that population growth causes global warming as true, while 26.1% answered it as false. Moreover, the following were also found:

Item 2: 82.3% of the participants stated that perfumes are among the causes of ozone depletion as true, while 17.7% answered it as false.

Item 3: 84.1% of the participants stated that the increase in carbon dioxide gas, one of the greenhouse gases that has a great effect on the formation of global warming, causes an increase in global warming as true, while 15.9% answered it as false.

Item 4: 89.3% of the participants stated that global warming concretely makes its presence known as the cause of climate change as true, while 10.7% answered it as false.

Item 5: 66.3% of the participants stated that the use of fossil fuels is directly related to global warming as true, while 33.7% answered it as false.

Item 6: 87.4% of the participants suggested that global warming concretely makes its presence known as true, while 12.6% answered it as false.

Item 7: 87.5% of the participants made a statement about another result of global warming as true, while 12.5% answered it as false.

Item 8: 81.8% of the participants referred to greenhouse gases as the cause of global warming as true, while 18.2% answered it as false.

Item 9: 76.5% of the participants stated that the increase in fossil fuel use causes an increase in atmospheric CO<sub>2</sub> as true, while 23.5% answered it as false.

Item 10: 66.4% of the participants remarked that global warming is a cause of natural catastrophes as true, while 33.6% answered it as false.

Item 11: 78.6% of the participants mentioned a negative consequence of global warming on living beings as true, while 21.4% answered it as false.

Item 12: 81.1% of the participants stated that global warming causes health problems as true, while 18.9% answered it as false.

Item 13: 63.9% of the participants stated that carbon dioxide is a gas essential for earth as true, while 36.1% answered it as false.

Item 14: 77.6% of the participants stated that forestation plays a role in combatting global warming as true, while 22.4% answered it as false.

Item 15: 68.8% of the participants remarked that energy savings contributes to improving global warming as true, while 31.2% answered it as false.

Item 16: 80.2% of the participants stated that car emissions play a role in global warming as true, while 19.8% answered it as false.

Item 17: 56% of the participants suggested that people should use public transportation in order to slow global warming as true, while 44% answered it as false. It was noteworthy that the numbers of true and false responses to item 17 were very close to each other.

Item 18: 71.4% of the participants stated that people need to recycle in order to slow global warming as true, while 28.6% answered it as false.

Item 19: 78.6% of the participants referred to greenhouse gases as a cause of global warming as true, while 21.4% answered it as false.

Item 20: 77.9% of the participants remarked the role of renewable energy sources in dampening the consequences of global warming as true, while 22.1% answered it as false.

Item 21: 83.9% of the participants argued that gases that accumulate in the atmosphere are a cause of greenhouse effect as true, while 16.1% answered it as false.

Item 22: 84% of the participants stated that global warming causes health problems as true, while 16% answered it as false.

### Relational Findings

In the study, the secondary school students' knowledge about global warming was analyzed separately in terms of some independent variables.

An independent groups t-test was conducted to determine whether the students' knowledge about global warming showed a significant difference according to gender. The findings obtained are presented in Table 4.

**Table 4.** Independent groups t-test results regarding gender.

Gender	N	$\bar{X}$	SD	t	P-value	Significant Difference
Female	498	17.14	3.255	1.556	0.120	NONE
Male	510	16.81	3.372			

As can be seen in Table 4, it was determined that the secondary school students' knowledge about global warming did not show a significant difference according to their gender ( $t_{(1006)} = 1.556$ ;  $p > 0.05$ ).

One-way ANOVA was conducted to determine whether the students' knowledge about global warming showed a significant difference according to grade. The findings obtained are presented in Table 5.

**Table 5.** One-way ANOVA results regarding grade.

Grade	N	$\bar{X}$	SD	F	P-value	Significant Difference
5th grade	164	16.28	3.533	9.947	0.000	7th grade > 5th grade 7th grade > 6th grade 8th grade > 5th grade 8th grade > 6th grade
6th grade	273	16.43	3.397			
7th grade	415	17.27	3.194			
8th grade	156	17.86	2.963			
Total	1008	16.97	3.317			

As can be seen from Table 5, there was a significant difference between the secondary school students' knowledge about global warming according to their grades ( $F_{(3-1004)} = 9.947$ ;  $p < 0.05$ ). There was a significant difference between the 7th graders and 5th and 6th graders with the 7th

graders having more knowledge about global warming, and between the 8th graders and 5th and 6th graders with the 8th graders having more knowledge about global warming.

One-way ANOVA was conducted to determine whether the students' knowledge about global warming showed a significant difference according to their number of siblings. The findings obtained are presented in Table 6.

**Table 6.** One-Way ANOVA results regarding number of siblings.

Number of Siblings	N	$\bar{X}$	SD	F	P-value	Significant Difference
No siblings	32	17.63	2.791			
2 siblings	190	17.59	3.336			
3 siblings	255	17.18	3.307			
4 siblings	200	16.83	3.099	3.702	0.003	2 siblings>5 siblings 3 siblings> 5 siblings
5 siblings	138	16.19	3.241			
6 siblings or more	193	16.70	3.539			
Total	1008	16.97	3.317			

When Table 6 is analyzed, it can be seen that there was a significant difference between the secondary school students' knowledge about global warming according to their number of siblings ( $F_{(5-1002)} = 3.702$ ;  $p < 0.05$ ). There was a significant difference between having 2 siblings and 5 siblings with children living in a 2-child family having more knowledge about global warming and between having 3 siblings and 5 siblings with children living in a 3-child family having more knowledge about global warming.

One-way ANOVA was conducted to determine whether the students' knowledge about global warming showed a significant difference according to the average daily TV viewing hours. The findings obtained are presented in Table 7.

**Table 7.** One-way ANOVA results regarding average daily TV viewing hours.

Average Hours	N	$\bar{X}$	SD	F	P-value	Significant Difference
I don't watch TV	111	17.36	3.413			
0 to 1 hour	362	16.84	3.180			
1 to 2 hours	308	17.11	3.296			
2 to 3 hours	144	17.14	3.641	1.468	0.198	NONE
3 to 4 hours	37	15.97	3.193			
4 hours and above	46	16.48	3.230			
Total	1008	16.97	3.317			

As seen in Table 7, no significant difference was found between the secondary school students' knowledge about global warming according to their average daily TV viewing hours ( $F_{(5-1002)} = 1.468$ ;  $p > 0.05$ ).

One-way ANOVA was conducted to determine whether the students' knowledge about global warming showed a significant difference according to the educational status of their mothers and fathers. The findings obtained are presented in Table 8.

**Table 8.** One-way ANOVA results regarding educational status of mothers and fathers of participants.

	Educational status	N	$\bar{X}$	SD	F	P-value	Significant Difference
<b>Mother's Educational Status</b>	Illiterate	132	16.63	3.337	8.020	0.000	Undergraduate and higher > Literate (did not attended school)
	Literate (did not attended school)	158	16.18	3.452			
	Primary school	290	16.96	3.205			
	Secondary school	181	16.70	3.244			
	High school	167	17.31	3.315			
	Associate degree	29	18.86	2.748			
	Undergraduate and higher	51	19.22	2.618			
	Total	1008	16.97	3.317			
<b>Father's Educational Status</b>	Illiterate	22	15.36	2.804	7.343	0.000	Undergraduate and higher > High School
	Literate (did not attended school)	78	15.87	3.443			
	Primary school	250	16.99	3.386			
	Secondary school	209	16.62	3.309			
	High school	269	16.89	3.204			
	Associate degree	59	17.58	3.445			
	Undergraduate and higher	121	18.45	3.834			
	Total	1008	16.97	3.317			

As can be seen in Table 8, there was a significant difference between the secondary school students' knowledge about global warming according to the education status of their mothers ( $F_{(6-1001)} = 8.020$ ;  $p < 0.05$ ) and fathers ( $F_{(6-1001)} = 7.343$ ;  $p < 0.05$ ). There was a significant difference between the children with parents who had undergraduate and higher education and all of the other children with children with parents who had undergraduate and higher education having more knowledge about global warming.

An independent groups t-test was conducted to determine whether the students' knowledge about global warming showed a significant difference according to their having internet access at home. The findings obtained are presented in Table 9.

**Table 9.** Independent groups t-test results regarding internet access at home.

Internet access at home	N	$\bar{X}$	SD	t	P-value	Significant Difference
Yes	711	17.23	3.271	3.866	0.000	Yes > No
No	297	16.35	3.350			

As seen in Table 10, it was determined that the knowledge of the secondary school students about global warming differed significantly according to whether they had internet access at home ( $t_{(1006)} = 3.866$ ;  $p < 0.05$ ). Students who had internet access at home had significantly more knowledge about global warming.

One-way ANOVA was conducted to determine whether the students' knowledge about global warming showed a significant difference according to their last semester's science course grades. The findings obtained are presented in Table 10.

**Table 10.** One-way ANOVA results regarding the students' last semester science course grades.

Science course grade	N	$\bar{X}$	SD	F	P-value	Significant Difference
1	16	14.81	3.209	13.836	0.000	5 > 4 5 > 3 5 > 2 5 > 1
2	47	16	3.303			
3	212	16.06	3.420			
4	322	16.79	3.112			
5	411	17.79	3.226			
Total	1008	16.97	3.317			

When Table 10 is examined, it is seen that there was a significant difference between the secondary school students' knowledge about global warming according to their last semester's science course grades ( $F_{(4-1003)} = 13.836$ ;  $p < 0.05$ ). Students who had a grade of 5 had significantly more knowledge about global warming than students with grades between 1 and 5.

One-way ANOVA was conducted to determine whether the students' knowledge about global warming showed a significant difference according to the overall frequency of following up with developments related to global warming and environmental problems. The findings obtained are presented in Table 11.

**Table 11.** One-way ANOVA results regarding the overall frequency of following up with developments related to global warming and environmental problems.

Frequency of following up with developments	N	$\bar{X}$	SD	F	P-value	Significant Difference
Always	56	16.16	3.520	3.656	0.006	Often > Never Sometimes > Never
Often	82	17.54	3.112			
Sometimes	508	17.09	3.254			
Rarely	257	17.11	3.297			
Never	105	16.08	3.540			
Total	1008	16.97	3.317			

As can be seen in Table 11, a significant difference was found between the secondary school students' knowledge about global warming according to their overall frequency of following up with developments related to global warming and environmental problems ( $F_{(4-1003)} = 3.656$ ;  $p < 0.05$ ). There was a significant difference between the children who often followed up with developments and those who did not with children who often followed up with developments having more knowledge about global warming, and between children who sometimes followed up with developments and those who did not with children who sometimes followed up with developments having more knowledge about global warming.

One-way ANOVA was conducted to determine whether the students' knowledge about global warming showed a significant difference according to their frequency of discussing global warming and environmental problems with their families. The findings obtained are presented in Table 12.

**Table 12.** One-way ANOVA results regarding the frequency of the students discussing global warming and environmental problems with their families.

frequency of discussing environmental problems	N	$\bar{X}$	SD	F	P-value	Significant Difference
Always	40	16.75	3.447	1.998	0.093	NONE
Often	71	16.83	3.602			
Sometimes	409	17.18	3.359			
Rarely	272	17.15	3.052			
Never	216	16.45	3.406			
Total	1008	16.97	3.317			

As can be seen from Table 12, there was no significant difference between the secondary school students' knowledge about global warming according to their frequency of discussing global warming and environmental problems with their families ( $F_{(4-1003)} = 1.998$ ;  $p > 0.05$ ).

### Discussion and Conclusion

In this section, the data obtained from the research were discussed under two separate headings: results regarding descriptive findings and results regarding relational findings.

#### Results regarding the descriptive findings of the Scale of Knowledge about Global Warming

The responses given by the students to the SKGW were evaluated under the headings of the causes and consequences of global warming and the measures to be taken against global warming.

The responses to the scale items related to the causes of global warming were analyzed and the following were concluded from the results.

It was observed that the secondary school students participating in the study had a great amount of knowledge about the causes of global warming. Most of the secondary school students participating in the study (81.8%) established the correct relationship between global warming and the greenhouse effect and agreed that greenhouse gases cause global warming. Koulaidis and Christidou (1999) and Aydın (2010; 2014) reached conclusions similar to those presented above in their studies. In addition, a great majority of the participants stated that industrialization played a role in global warming (76.5%). This finding supports prior studies conducted with different student groups (Eroğlu & Aydoğdu, 2016; Orbay, Cansaran & Kalkan, 2009). The majority of the students thought that CO<sub>2</sub> is a necessary gas for the life cycle (63.9%); however, the increase in this gas causes an increase in global warming (73.9%). This finding also supports the findings of some prior studies with different student groups (Eroğlu & Aydoğdu, 2016; Mahanoğlu, 2019; Ulutaş, 2013). However, some studies

have reported that some students think that CO<sub>2</sub> is a greenhouse gas, but they have misconceptions that it damages the ozone layer (Boyes & Stanisstreet, 1992; Kılınç et al., 2008; Rye et al., 1997; Şenel & Güngör, 2009).

In addition, the majority of the participating students considered human-induced factors such as population growth (73.9%), fossil fuels (66.3%), accumulation of gases due to vehicle exhausts (80.2%), etc., in the atmosphere (83.9%) among the causes of global warming. This finding supports the studies conducted with different student groups (Aydın, 2014; Eroğlu & Aydoğdu, 2016; Jeffries, Stanisstreet & Boyes, 2001; Mahanoğlu, 2019; Ulutaş, 2013).

The responses to the scale items related to the consequences of global warming were analyzed and the following were concluded from the results.

It was observed that the secondary school students participating in the study had a great amount of knowledge about the consequences of global warming. The students believed that due to global warming, climates will change (89.3%), glaciers will melt faster (87.4%), endangered species will go extinct (87.5%), more acid rain will occur (66.4%), forest fires will increase (78.6%), health problems will increase (81.1%), and disease rates will increase (84%). This finding supports the results of some studies conducted with different student groups (Freije et al., 2017; Kılınç et al., 2008; Şenel & Güngör, 2009; Yalçın, 2010), which also showed that students had appropriate knowledge about the consequences of global warming. On the other hand, some studies have found that students have incomplete knowledge regarding the consequences of global warming. For example, Eroğlu and Aydoğdu (2016) found in their study that pre-service teachers had misinformation regarding this subject and that they did not have knowledge about the fact that global warming causes storms and floods. In a study by Mahanoğlu (2019), conducted with secondary school students, it was determined that roughly half of the students (41.2%) did not have knowledge about the decreasing availability of potable water, which is one of the consequences of global warming. In their study, Boyes and Stanisstreet (1992) found that only a small proportion of undergraduate students thought that the number of pests would increase with global warming. In a study conducted by Ulutaş (2013) with secondary school students, it was determined that some students did not have information about the strong winds and storms that may occur as a result of global warming, and some of them had misinformation about this issue.

The responses to the scale items related to the measures to be taken against global warming were analyzed and the following were concluded from the results.

It was observed that the secondary school students participating in the study had a great amount of knowledge about measures to be taken against global warming. The students participating in the study stated that in order to reduce the effects of global warming, the earth should be further forested (77.6%), renewable energy sources that do not harm the environment should be used (77.9%)

and recycling should be conducted (71.4%), greenhouse gas emissions should be reduced (81.8%), and public transportation should be used (78.6%). These findings were found to be in line with the results of Boyes and Stanisstreet (1992), Pruneau et al. (2001), Khalid (2003), Kılınç et al. (2008), Yalçın (2010), Malandrakis et al. (2011), Ambusaidi et al. (2012), Ulutaş (2013), Eroğlu and Aydoğdu (2016), Durkaya and Durkaya (2018), and Mahanoğlu (2019).

### **Results regarding the relational findings of the Scale of Knowledge about Global Warming**

In this part of the study, the results of the comparison of the secondary school students' knowledge about global warming according to some demographic characteristics were discussed.

In the study, it was determined that the secondary school students' knowledge about global warming differed significantly according to the grade variable. The 7th and 8th graders had higher levels of knowledge about global warming than the 5th and 6th graders. However, there was no significant difference between the 7th and 8th grades and between 5th and 6th grades in terms of knowledge about global warming. This may be due to the fact that global warming is discussed in the textbooks of both the 7th and 8th grade level. In a study by Ulutaş (2013), it was found that 8th grade students had higher levels of knowledge about global warming than 6th and 7th grade students, while there was no significant difference between 6th and 7th grade students in terms of knowledge about global warming. In a study conducted by Aydın (2014), a significant difference was found between 9th grade students' knowledge about global warming and that of students at higher grades (10th, 11th, and 12th grades) with the latter having more knowledge. Mahanoğlu (2019) also observed a significant difference between the knowledge about global warming levels of secondary school students according to their grade levels. The results of that study suggested that students studying in the 7th grade had more knowledge about global warming. Bilgi (2021) and Eroğlu and Aydoğdu (2016) did not find a significant difference between the knowledge levels of pre-service science teachers about global warming, and Ay and Yalçın Erik (2020) did not find a significant difference between knowledge levels of university students and their grade levels.

In the current study, it was determined that the knowledge of the secondary school students about global warming differed significantly according to the number of siblings in their family. Students living in 2-child and 3-child families had significantly more knowledge about global warming than students living in 5-child families. When the averages of the groups were analyzed, it was observed that the averages of only children and children living in 2-child and 3-child families were similar to each other and higher than those living in families with 3 or more siblings. This may be due to the fact that those with fewer siblings have to divide their families' attention and economic support among fewer children. No other studies in the literature investigating the effect of the number of siblings on knowledge about global warming were found.

In the present study, it was determined that the secondary school students' knowledge about global warming differed significantly according to the educational status of their parents. Children of parents with a bachelor's degree or higher were found to have more knowledge about global warming than children of parents with other education statuses (illiterate, literate and did not attend school, primary school, secondary school, high school). Thus, it can be suggested that as a result of the increase in the level of education of the parents, the environmental sensitivity of students increases, they have awareness of environmental problems, and that children take their parents as role models or parents contribute to the children's environmental sensitivity. Similarly, Gülsoy and Korkmaz (2020) found that university students with higher family income and education levels had higher levels of knowledge about global warming and climate change. On the other hand, in their study conducted with university students, Ay and Yalçın Erik (2020) did not find a statistically significant difference between students regarding their perceptions of the causes of climate change, its effects on our lives, or ways to combat climate change according to the variables of their mother and their father's education status.

In the current study, it was determined that the secondary school students' knowledge about global warming differed significantly according to whether they had internet access at home. Students who had internet access at home had significantly more knowledge about global warming than those who did not. This may be due to students getting information regarding current environmental issues from the internet. No other studies in the literature investigating the effect of internet access at home on knowledge about global warming were found.

In this study, it was determined that the secondary school students' knowledge about global warming differed significantly according to their last semester's science course grades. Students who received the highest grade of 5 in the science course were significantly more knowledgeable about global warming than other students who had received grades of 4, 3, 2, or 1. This finding revealed the importance of the effect of science courses on students' knowledge about global warming. There were no other studies found in the literature that investigate the effect of science course grades on knowledge about global warming.

In the present study, it was determined that the secondary school students' knowledge about global warming differed significantly according to their overall frequency of following up with developments related to global warming and environmental problems. Students who sometimes and often followed up with developments related to global warming and environmental problems had more knowledge about global warming than those who never followed up with issues regarding global warming. This finding suggests that students with environmental awareness have increased knowledge about global warming. There were no other studies found in the literature that investigate the effect of

overall frequency of following up with developments related to global warming and environmental problems on knowledge about global warming.

Additionally, it was also determined in this study that the knowledge of the secondary school students about global warming did not show a significant difference according to the variables of gender, average daily TV viewing hours, or frequency of discussing global warming and environmental problems with their families. In their studies conducted with secondary school students, primary school students, pre-service science teachers, and university students, other researchers have also reached similar conclusions (Ay & Yalçın Erik, 2020; Aydın, 2014; Bilgi, 2021; Eroğlu & Aydoğdu, 2016; Mahanoğlu, 2019; Yalçın, 2010). In contrast, some studies found that female students have a higher level of knowledge about global warming (Gülsoy & Korkmaz, 2020; Şenyurt et al., 2011; Ulutaş, 2013). On the other hand, Boyes and Stanisstreet (1992) found that female students were less knowledgeable about the mechanisms and consequences of global warming than male students. There were no other studies found in the literature on the effect of other remaining variables on knowledge about global warming.

### **Recommendations**

Considering that education starts in the family environment, comprehensive environmental awareness may be created by including children and families in environmental education programs. Activities should be organized as part of "environment days" to involve students and families in environmental education on topics such as recycling, energy saving, and protection of the natural environment.

A Ministry of National Education and the Ministry of Energy joint protocol should be prepared through which environmental projects prepared by students can be presented at the end of semesters to raise public awareness.

In this study, only the knowledge levels of secondary school students about global warming were investigated. Further research utilizing similar data collection tools should be conducted with students studying in primary school, high school, and university. In these studies, students could be compared in terms of their level of knowledge about global warming according to different variables.

The present study can be extended further with qualitative data collection tools. The reasons for the responses of the secondary school students to the statements in the scale used as a data collection tool in this study could be investigated.

The greenhouse effect and global warming are not sufficiently explained in 7th and 8th grade science textbooks and the subject is mentioned through only a few sentences. Current environmental issues such as global warming, the greenhouse effect, etc., should be included to a larger extent in secondary school curricula.

In the current study, only the knowledge levels about global warming of students in secondary schools in Muş Province city center were examined. Further studies utilizing similar data collection tools should be conducted with secondary school students studying in different provinces to compare their knowledge about global warming according to different variables.

### **Policy Implications**

It can be said that environmental education has emerged with the concept of global warming in many countries and in Türkiye. With global warming, the impact of environmental problems on the world has increased. Therefore, countries have focused their education policies on the solution of environmental problems. When we look at the world, it is seen that many countries are faced with environmental problems. At the beginning of solving environmental problems, it is emphasized that it is important to educate people, therefore, it is seen that they start by placing environmental awareness in their education policies. Because if environmental awareness is formed, environmental awareness will increase and environmental problems will begin to decrease. In our country, it is seen that environmental education has been included in our education programs more intensely in recent years. The reason for this is the increasing pollution rates around the world, the effects of global warming, various waste problems, etc. In addition, it is seen that environmental issues are gradually added to the education programs in order to raise the awareness of teachers and students and to inform them about the environment (Yılmaz et al., 2002). The most important role in the formation of environmental awareness is to give environmental education to individuals (Stife, 2010). In other words, education is the basis for the society to have knowledge and awareness about the environment, to create sensitive and positive behavioral changes, to protect the natural environment and to regain the damaged environment (Uzun & Sağlam, 2005). is to train. From this point of view, it is of great importance for people to acquire the right behaviors in environmental issues and to be educated on this issue (Kızılaslan & Kızılaslan, 2005). One of the important aims of environmental education is to reveal environmental literacy in individuals (Loubser, Swanepoel, & Chacko, 2001). It is believed that when environmentally literate individuals are raised, the damage to the environment will be minimal (Erdoğan, Kostova, & Marcinkowski, 2009). As a result of the study, it was revealed that secondary school students have knowledge about global warming. Therefore, the conclusions of this study will anticipatngly contribute to the change and development of education strategies and policies.

### **Conflict of Interest**

The author declares that she has no conflicts of interest.

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### **Ethical Statement**

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### **Credit Author Statement**

The author confirms that she had all responsibilities for the following: conceptualization of the study and design, data collection, data analysis and interpretation of the findings, and preparation of the manuscript.

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