RESEARCH ARTICLE

STUDENTS' MISCONCEPTIONS ABOUT THE OZONE LAYER AND THE EFFECT OF INTERNET-BASED MEDIA ON IT

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Abstract

In this study, students' misconceptions about the ozone layer were investigated, looking specifically at the effect internet-based media has on the formation of these misconceptions. Quantitative and qualitative research approaches were used to perform the research. As part of the quantitative portion of the research, the descriptive survey method, which involved a questionnaire featuring items about the ozone layer, was used to gather data. The study surveyed 95 pre-service chemistry teachers and 363 high school students. In the qualitative portion of the research, 219 local websites related to the ozone layer were analyzed. Results from this analysis showed that despite their different grade levels, both high school students and university students had similar misconceptions. Furthermore, it was found that the analyzed websites either included a good deal of information that was incompatible with scientific models or that encouraged misconceptions.

*Keywords:*The ozone layer, misconceptions, internet-based media, high school students, pre-service chemistry teachers.

Introduction

Living beings and the environment are in constant interaction with one another. The physical, chemical and biological factors that constitute any given environment have a unique impact on particular habitats (Ozkaya & Usak, 2009). Up until the 1980s, the environment had been an ordinary subject, of no great concern. Once people began to understand the seriousness of air pollution and its effects on human health, it became a popular topic in the media. For example, the wide spread attention given to the disappearance of forests in Scandinavia due to acid rain has raised public awareness about this issue in places far removed from the site of actual occurrence. The depletion of the ozone layer and the increased cases of skin cancer that have emerged as a result have caused a great deal of concern among people. Today, even young people have begun to realize that the sustainability of the environment is being threatened in various ways (Hillman, Stanisstreet, & Boyes, 1996).

Advances in technology have facilitated easy access to information. Today, the media, specifically in the form of e-information, provides the simplest means of access. Although humans are capable of potentially counteracting the negative effects of environmental change, it is still uncertain whether or not climate change can be

reversed. In terms of the printed publications, many of the misconceptions on environmental change continue to be presented in books, newspapers, and magazines, even after revisions. Coupled with the rapid sharing of information made possible with today's technology, under these circumstances, it is not surprising that students come to school with misconceptions. The proportion of individuals using the Internet increased to 38.1% of the world population in 2013 (Internet Society Global Internet Report, 2015). According to research recently conducted in Turkey, the majority of homes have an Internet connection and the number of Internet users has increased (Information and Communication Technologies Authority, 2012). It has been well-documented that today's students tend to spend most of their time on the Internet, conducting research for their homework and accessing information. However, with that said, students do not necessarily have the ability to distinguish and identify reliable information and to utilize academic sources when searching for information on websites (Acar Sesen & Ince, 2010).

Based on a poll conducted by the Australian Bureau of Statistics, 85% of participants reported that they had learned most of their environmental information from the media, such as newspapers, television, or radio (ABS, 1998 as cited in Cordero, 2000). Judging from studies like the one just mentioned, it is believed that the primary source of the misconceptions on global warming and the ozone layer is the media. To determine the role of the media in perpetuating misconceptions about the environment, the keyword "ozone" was searched in a selection of newspapers from between the years 1993-1999. In most of the environmental articles found, there were several misconceptions communicated, including among others: 'The hole in the Earth's ozone layer moves over southern Australia for about a month.' (retrieved from *The Age,* 2 June 1999); 'The effect of a large hole would lead to a decrease in ozone levels in southern Australia.' (retrieved from *The Sydney Morning Herald,* 7 October 1993) (Cordero, 2000).

The US Environmental Protection Agency (EPA) has reported that the thinning of the ozone layer creates the greatest risk among environmental problems and has the largest impact (Gardner & Stern, 1996). Given that environmental education plays a key role in bringing greater awareness and understanding about environmental issues to students, studies have begun to increasingly focus on students' understanding of environmental issues (Bahar, Bag, & Bozkurt, 2008). According to these studies, students have developed a misguided connection between the ozone layer, global warming, (Avci & Darcin, 2009; Boyes, Chuckran, & Stanisstreet, 1993; Christidou & Koulaidis, 1996; Yazdanparast et al., 2013) and the greenhouse effect (Ikonomidis, Papanastasiou, Melas, & Avgoloupis, 2012). To cite specific examples, some of the studies found that students thought there was a link between global warming and radioactive leaks from nuclear power stations. Furthermore, students were also confused about ozone layer depletion and the causes and results of global warming (Kilinc, Stanisstreet, & Boyes, 2008).

In a study conducted to determine secondary school students' knowledge of the relationship between vehicle traffic and environmental problems, it was found that many of the students thought that cars harmed the ozone layer and emitted chlorofluorocarbons (CFCs) into the atmosphere (Darcin & Darcin, 2009). Additionally, some of the secondary school students believed that the cutting down of trees, cigarette smoking, smog, and even picking flowers could cause the depletion of the ozone layer. When elementary pre-service teachers were asked about what they attributed the cause of climate change to, 69.76% of them answered 'the ozone hole,' while 51.16% of them answered 'the greenhouse effect'. An important misconception was reflected in the fact that the majority of students defined the ozone layer as 'the ozone hole'. In a study conducted with 7th and 8th-grade students, students drew the

ozone layer as a layer with holes in it (Pekel & Kirik, 2016). When they were asked how climate change could be mitigated, students suggested organizing collaborative action, increasing people's awareness about environmental issues, and using environmental friendly products. Despite proposing these suitable responses, the students nonetheless held serious misconceptions about climate change, like the belief they held about the ozone layer being formed of various compounds (Papadimitriou, 2004).

The word 'layer', as used in the term 'ozone layer', is likely responsible for the misinterpretation of this region by pre-service teachers, who tended to think that the ozone–which is actually a gas–is a thin layer covering earth (Khalid, 2003).These misconceptions do not necessarily indicate a lack of understanding on the teachers' part, but rather points to how common beliefs about the relationship between the ozone layer and greenhouse gases may have led to different interpretations of these facts (Dove, 1996).

Considering the above shortcomings in the understanding of environmental issues, this study has aimed to determine high school students' and pre-service chemistry teachers' misconceptions about the ozone layer, which is one of the most critical environmental concerns. The study also has also sought to assess whether or not Internet-based media (IBM) is responsible for the students' and pre-service teachers' misconceptions. If students and educators do not strive to gain an accurate understanding of environmental issues, problems related to sustaining the environment cannot be solved. To overcome these barriers, it is necessary to determine the students' and aspiring teachers' understanding of environmental issues and to manage the dominant learning resources that impact students' learning. The present research will contribute to the body of research related to the role of the media on misconceptions. The following research questions were formulated for this study:

1. What misconceptions do university students have about the ozone layer?
2. What misconceptions do high school students have about the ozone layer?
3. Are there any similarities between the university students' and high school students' misconceptions about the ozone layer?
4. What are the misconceptions about the ozone layer seen in IBM?
5. Are there any similarities between the misconceptions of students and the misconceptions seen in IBM?

Methodology

In this study, a survey model was used. The research was carried out in two steps. In the first step, a descriptive review was conducted to determine the misconceptions students had about the ozone layer. In the second step, a document analysis was conducted to determine the misconceptions popular websites communicated about the ozone layer.

Working Group

The study was conducted in Turkey with 95 pre-service chemistry teachers attending a state university and 363 ninth-grade high school students from a public high school. Convenience sampling was used for the formation of the samples.

Gathering Quantitative Data

Both quantitative and qualitative approaches were used to collect data for the study. In the first part of the study, quantitative data was obtained, using the scale developed by Selvi (2007), to determine the participants' understanding of the ozone layer. Selvi (2007) produced this scale by recording any misconceptions on the ozone layer

present in the literature. The scale consists of 21 closed-ended questions asking respondents whether or not they agree with given statements. The questions are arranged on a 5-point Likert-type scale, with the response options of "completely disagree," "disagree," "neutral," "agree," and "completely agree."

Analyzing Quantitative Data

In order to measure the internal reliability of the test, the Cronbach's alpha (α) technique was applied. The coefficient for the scale was calculated as .748 for the university students and as .871 for the high school students. In determining the scope of validity, feedback was received from high school chemistry, biology, and geography teachers and professors in the Department of Chemistry Education at the university wherein the research was conducted.

Although the scale was a Likert-type scale, its items were nonetheless able to be used for determining students' misconceptions as a result of the scale content being created from the identification of wrong concepts in the related subject. These types of scales are commonly used in studies related to environmental chemistry (e.g. Boyes & Stanisstreet, 1993; 1998; Dove, 1996; Groves & Pugh, 1999; Kilinc, Stanisstreet, & Boyes, 2009).

Gathering Qualitative Data

In the second part of the study, qualitative data was obtained by conducting a document analysis of websites. Google, which is the most preferred search engine according to the information extracted from comScore data, was used as the search engine for IBM. A keyword search was made using the keyword "ozone layer." About 132 000 Turkish websites related to the ozone layer were retrieved. Although the first 219 of these sites were included in the study, only 190 of them were worthy of analysis, as some of the first 219 websites were not accessible. Despite the absence of time constraints for conducting the document analysis method, the document review time was limited to 1.5 months, as the popularity of the websites changed frequently due to several reasons, such as user traffic, advertisements and so on. The websites were examined several times to minimize the possibility of errors. Any statements that were deemed capable of directly or indirectly causing misconceptions were recorded.

Analyzing Qualitative Data

The content analysis involved coding of the data, identifying the theme, organizing the codes and themes, and interpreting the findings. During this part of the research, it was found that some of the students had various misconceptions about the basis for the survey and that a number of the misconceptions they had were not directly derived from the websites. From the latter finding, it was judged that students tended to generalize environmental subjects, the concern of which prompted a scanning of the general expressions communicated on the websites. As a result, categories were developed for general expressions. For example, since the UV category covered expressions having to do with heat, temperature, UV rays, and the sun, these expressions were scanned on the websites and the findings were tabulated.

Findings

Misconceptions about the ozone layer

Answers related to the ozone layer were evaluated individually for each participant. The findings determined that students had misconceptions on 10 of the 21 items that

were conveyed to them about the ozone layer. Fifteen percent of the misconceptions were determined to be of limited value, which means that among the answers that were incorrect, more than 15% of the students were shown to have misconceptions, which were categorized under – "there are misconceptions among students." According to the results of the analysis, both university and high school students had misconceptions, and these misconceptions tended to be similar in nature (Table 1). Overall, 31.1% of the high school students and 33.2% of the university students had misconceptions on this topic.

Statistical differences were determined according to grade levels for seven out of ten misconceptions. These differences were in favor of the high school students in three questions and in favor of university students in four questions. In the other statements, there were no statistical differences between the students (Table 1).

Table 1.

Misconceptions and their total frequency and percentage distributions

Category	Misconceptions related to the ozone layer	High School Students		Pre-service Chemistry Students		X^2	p
		f	%	f	%		
The function of the ozone layer	The ozone layer keeps the Earth warm.	179	49.3	30	31.6	9.6265	<0.05
	The ozone layer consists of various gases.	286	78.7	79	83.2	0.6532	>0.05
	The ozone's benefit is to provide oxygen for people to breathe.	190	52.3	35	36.8	7.9114	<0.05
	The ozone layer protects the Earth from acid rain.	214	8.9	45	47.3	4.8498	<0.05
The reasons for the thinning of the ozone layer	The ozone layer problem is made worse by fumes from car exhausts.	269	74.1	89	93.7	15.8453	<0.05
	One reason for the thinning of the ozone layer is the increase in the greenhouse effect.	263	72.5	76	80	1.8048	>0.05
Environmental problems caused by the thinning of the ozone layer	Holes in the ozone layer allow more rays from the sun to reach the Earth, causing an increase in its temperature.	251	69.2	83	87.4	11.5432	<0.05
	Because of the holes in the ozone layer, air will escape from the atmosphere into space.	173	47.7	18	20	24.4593	<0.05
	If the ozone layer problem becomes worse, there will be changes in the Earth's ice caps, and they will shrink in size.	247	68	81	85.2	10.3585	<0.05
	If the ozone layer problem becomes worse, there will	194	53.5	520	54.8	0.0218	>0.05

be more water pollution.

Misconceptions identified in the groups of participants were divided into 3 categories: (i) the function of the ozone layer, (ii) the reasons for the thinning of the ozone layer, and (iii) environmental problems caused by the thinning of the ozone layer (Selvi, 2007). Students reported that they believed the ozone layer produces oxygen for people to breathe and consists of various gases, and that the ozone layer protects the Earth from acid rain and keeps the Earth warm. Students considered the greenhouse effect and gas emissions as the reasons for the thinning of the ozone layer. Additionally, they thought that the thinning of the ozone layer causes global warming and pollution of water resources.

Misconceptions obtained from the websites

Prior to the research, students' information sources were obtained by asking them the question, "Where did you get the information you have about environmental chemistry issues?", in the survey. The high school and university students' answers to this question are given in Table 2, in the order of their first choices to their last choices.

The most preferred sources specified by the high school students, in terms of acquiring information about the environment, were schools and teachers. They preferred the media (web-based sources) as a second source. The university students, on the other hand, used the media as their primary source. Web-based resources were therefore considered to be the most preferred sources for both grade levels.

Table 2.

Use of Sources for Environmental Knowledge

Options	High School		University	
	f	*%*	*f*	*%*
Media (Internet-based)	95	**26.2**	36	**37.9**
School / teacher	108	**29.8**	21	**22.1**
Book	22	6.1	8	8.4
Family	33	9.1	18	19
Friend	46	12.7	12	12.6
Total	363	100	95	100

Given that internet-based media was commonly used as an information resource by both groups of students (i.e. high school and university students), websites that provide information about the ozone layer were included in our study. On these websites, statements communicating misconceptions and statements that might have caused misconceptions were searched. Misconceptions related to the ozone layer and statements that might have led to misconceptions were identified in 37.9% of the 190 websites. These misconceptions, as defined in the statements made by the students, were divided into three categories: (i) the function of the ozone layer, (ii) the reasons for the thinning of the ozone layer, and (iii) environmental problems caused by the thinning of the ozone layer. Several examples for each category are given below (Table 3).

According to different statements found on the reviewed websites, the thinning of the ozone layer, global warming, climate change and the greenhouse effect all had the same meaning. The function of the ozone layer, as asserted in these statements, was alternately to prevent global warming or to increase global warming. Similarly,

greenhouse gases, mechanization, and global warming were accepted as the reasons for the thinning of the ozone layer, and lastly, the thinning of the ozone layer was said to result in the increase of the greenhouse effect and global warming, the occurrence of acid rain, and threats to human health. The misconceptions identified to be held by the students, the misconceptions identified to be communicated through IBM, and the statements identified as leading to the misconceptions held by students were all found to be similar with each other. For instance, students believed that the ozone layer keeps the Earth warm, as shown in the category of The function of the ozone layer (Table 1). The following statement was found in the analyzed websites: "...The ozone layer has an important function insofar as it prevents overheating of the world by absorbing harmful rays from the sun, and insofar as it also contains the heat..." (Table 3, #1).This statement supports the aforesaid misconception.

Table 3.

Misconceptions and explanations obtained from ozone layer-related websites

Category	No	Explanations selected from websites
The function of the ozone layer	1	"...The ozone layer has an important function insofar as it prevents overheating of the world by absorbing harmful rays from the sun, and insofar as it also contains the heat..."
	2	"...Efforts to close the hole in the ozone layer appear to aggravate the course of another environmental problem: global climate change. Another issue highlighted is the impact of greenhouse gases. If the hole in the ozone layer closes up, it is said that much more greenhouse gases will be trapped on the Earth's surface. As a result of this, the surface temperature may rise much more..."
	3	"...All of the abnormal weather events which are expected to happen in the future are beginning to be referred to by some general terms. These terms are generally used synonymously: "Global warming" - "Climate Change" - "Ozone thinning" - "Ozone Depletion" - "The Greenhouse Effect" and so on..."
The reasons for the thinning of the ozone layer	4	"...There is also a significant relationship between the ozone layer and global warming. The increase in global warming also reduces the self-renewal process of the ozone layer..."
	5	"Increasing the amount of these gases-greenhouse gases- in the atmosphere is causing a significant increase in the temperature of the Earth due to a variety of anthropogenic reasons. Because of these increases, the greenhouse effect, which is otherwise seen as useful for naturally occurring processes in the atmosphere, is responsible for creating the ozone hole as well as the danger of global warming..."
	6	"...Ozone depletion causes cooling in the upper atmosphere-stratosphere. In addition to carbon dioxide and greenhouse gases in the atmosphere indirectly contributing to cooling in the stratosphere by containing the world's heat below it, they also speed up the formation of the Arctic ozone hole..."
	7	"Another name for the ozone layer is the Ozonosphere; the development of mechanization in our world is damaging the ozone layer day by day due to the increasing practice of

		replacing human forces of labor with machine operations. It protects us from any threat that may come from the sun's rays from outer space and prevents our oxygen from escaping the world..."
	8	"...The ozone layer protects our planet from harmful UV rays coming from the sun. However, this protective layer has been thoroughly depleted because of greenhouse gases..."
Environmental problems caused by the thinning of the ozone layer	9	"... If the thinning of the ozone reaches dangerous proportions, the damages that may occur can be summarized as follows... Because the greenhouse effect of the atmosphere will increase, an increase in global temperature will be seen..."
	10	"...Ozone gas (O3) found in the upper layer of the atmosphere is a toxic and very malodorous gas. When the concentration of ozone in the air rises above 0.4 ppm, toxic effects, such as watery eyes and lung diseases, occur on living organisms. Also, by contributing to the formation of acid rain, ozone gas damages forests and property..."
	11	"...Experts warn that the thinning or perforation of the ozone layer may cause an increase in skin cancer and global warming..."
	12	"...What happened when the ozone layer was slightly thinned? The sun began to release its harmful rays onto the Earth through this hole. What are the consequences of this dangerous effect? Severe storms, floods, and disasters, which will immediately give rise to severe drought. Human health as well as the eco-balance will gradually be destroyed..."
	13	"...The results of this thinning (puncture) of the ozone layer: global temperature may increase worldwide due to the increase of the greenhouse effect..."
	14	"...Ultraviolet rays passing through the hole in the layer not only threaten marine life but also play an active role in global warming..."

* Statements are translated directly from the websites.

Based on the students' viewpoints, the reason for the thinning of the ozone layer was attributed to the greenhouse effect (Table 1). They presumed that the role of the ozone layer was to keep the Earth warm and likely generalized the matter by reconciling the greenhouse effect with the ozone layer. Explanations gleaned from IBM, such as *"Increasing the amount of these gases-greenhouse gases- in the atmosphere is causing a significant increase in the temperature of the Earth due to a variety of anthropogenic reasons. Because of these increases, the greenhouse effect, which is otherwise seen as useful in natural processes in the atmosphere has created the ozone hole and the danger of global warming..."* (Table 3; #5) and *"...The ozone layer protects our planet from harmful UV rays coming from the sun. However, this protective layer has been thoroughly depleted because of greenhouse gases..." (*Table 3; #8), support this misconception.

Students believed that the increased thinning of the ozone layer would lead to more rays from the sun reaching the Earth and the shrinking in size of the Earth's ice caps (Table 1). The same ideas behind the following statement were found on multiple

websites: *"...What happened when the ozone layer was a little thinned? The sun began to release its harmful rays onto the Earth through this hole. What are the consequences of this dangerous effect? Severe storms, floods, and disasters, which will immediately give rise to severe drought. Human health as well as the eco-balance will gradually be destroyed..."* (Table; #12). Other websites stated "...If the thinning of the ozone reaches dangerous proportions, the damages that may occur can be summarized as follows: *Because the greenhouse effect of the atmosphere will increase, an increase in global temperature will be seen..."* (Table 3; #9); *"...The results of this thinning (puncture) of the ozone layer: global temperatures may increase worldwide due to the increase of the greenhouse effect..."* (Table 3; #13) and *"...Ultraviolet rays passing through the hole in the layer not only threaten marine life but also play an active role in global warming..."* (Table 3; #14). These explanations may have indirectly supported this misconception.

While searching the websites related to the ozone layer for statements that were incongruent with scientific models or that supported students' misconceptions, unrelated expressions were noticed. Environmental issues that were not actually connected with the ozone layer were frequently mentioned on websites. However, events which should have been used to explain the ozone layer and its function were not mentioned on these websites. Some expressions related to environmental chemistry were scanned for on the websites under the assumption that they might have caused misconceptions for readers. The greenhouse effect or acid rain, neither of which are connected with the subject, and CFC gases, which are responsible for the thinning of the ozone layer, were several examples of these expressions. These scanned expressions were categorized (Table 4).

Table 4.

Expressions searched for on the websites related to the ozone layer

The Ozone Layer	f			%		
Scanned expressions on websites	no	yes	total	no	yes	total
Acid rain/precipitation	182	8	190	95,8	4,2	100
UV rays, sun, heat, temperature	49	141	190	25,8	74,2	100
The formation of ozone from oxygen	113	77	190	59,5	40,5	100
Chlorofluorocarbons or gases	74	116	190	38,9	61,1	100
Greenhouse effect/global warming	155	35	190	81,6	18,4	100
Pollution, water pollution, ozone pollution	159	31	190	87,7	16,3	100
The meaning of the thinning of the ozone layer (different from an ozone hole)	158	32	190	83,2	16,8	100

Incidences of the concepts of acid rain/precipitation, greenhouse effect/global warming, and pollution were present on websites related to the ozone layer (4.2%, 18.4%, and 16.3%, respectively). Since these expressions are not related to the ozone layer, they may have indirectly led to misconceptions for readers or served to reinforce the existing misconceptions. For instance, the misconception that "The ozone layer protects the Earth from acid rain", could be attributed to the fact that certain websites providing information about the ozone layer mentioned acid rain.

Similarly, because the concepts of the greenhouse effect and global warming were present on websites related to the ozone layer, this may have led to the misconception that "One reason for the thinning of the ozone layer is the increase in the greenhouse effect." Additionally, the mentioning of water pollution and ozone pollution on the websites could be responsible for the misconception that "If the ozone layer problem

becomes worse, there will be more water pollution." Moreover, it was found that the meaning of the 'thinning of the ozone layer' was not sufficiently explained in IBM and that in place of 'thinning of the ozone layer', 'ozone depletion' was frequently used on websites. Therefore, these incorrect or inadequate expressions and misapplied terms might have supported the misconception that "Because of the holes in the ozone layer, air will escape from the atmosphere into space."

When explaining the ozone layer and its function, some expressions should have been mentioned. For example, in explaining the function of the ozone layer without using the expressions of UV rays, the sun, the heat, and the temperature, might have caused incomplete modeling for readers. However, approximately 25% of the websites included in the research never used these concepts. Although the formation of ozone from oxygen and the meaning of the 'thinning of the ozone layer' should have been mentioned on the websites, approximately 60% of the websites did not have these expressions.

Consequently, the function of the ozone layer, the reasons for the thinning of the ozone layer, and the environmental problems that resulted from the thinning of the ozone layer were incorrectly explained on websites. Instead of providing explanations that describe the ozone layer in a manner consistent with appropriate scientific models, certain websites presented explanations that could lead to misconceptions.

Results and Discussion

As the negative outcomes of environmental problems began to affect living conditions and the media gradually picked up on this topic, people's perceptions about environmental issues started to attract the attention of researchers. In this research, high school and university students' misconceptions about the ozone layer and the effect of IBM on the formation of these misconceptions were investigated.

According to the findings, both high school and university students had a variety of misconceptions. These were arranged under three categories: "the function of the ozone layer," "the reasons for the thinning of the ozone layer," and "environmental problems caused by the thinning of the ozone layer." The misconceptions on the ozone layer specified here are consistent with the designated misconceptions in national and international literature (Boyes & Champers, 1995; Cimer,Cimer, & Ursavas, 2011; Groves & Pugh, 2002; Selvi & Yildiz, 2009).

The first point of interest in the research findings was that high school and university students had the same misconceptions, despite the difference in their educational levels. Similar to the findings of this research, the literature has shown that students at every level, even pre-service teachers, had similar inaccurate conceptions, ones that were at odds with the scientific models (Andersson & Wallin, 2000; Boyes, Stanisstreet, & Papantoniou, 1999; Papadimitriou, 2004; Dove, 1996; Summers, Kruger, Childs, & Mant, 2001). The reason for these similar misconceptions about environmental subjects is believed to possibly be attributed to the students having made over-generalizations (Stanisstreet & Boyes, 1996) about environmental aspects, despite being at different educational levels. According to Stanisstreet and Boyes, students who over-generalized may have confused the cause-and-effect relationship of events; for example, they assume that all environmentally friendly behaviors are effective in solving environmental problems, or they assume that all pollutants contribute to all environmental problems. The over-generalization made by the students on environmental issues causes them to have faulty logic, as observed when students believed car exhaust gases to be the reason for the thinning of the ozone

layer. This type of misconception existed for both high school students and pre-service teachers (Boyes & Champers, 1995; Boyes, et al., 1999; Cimer, Cimer, & Ursavas, 2011; Darcin, Bozkurt, Hamalosmanoglu, & Kose, 2006). The logical syllogism applied by the students went something like this: since exhaust gases pollute the environment, cars must emit some kind of pollutant in the environment. At the same time, the hole in the ozone layer is also caused by the pollutants, therefore cars cause the thinning of the ozone layer. Another example is that the thinning of the ozone layer leads to environmental problems. The melting of the ice caps is an environmental problem; hence, the thinning of the ozone layer causes the melting of the ice caps. As can be understood from these two examples students' having similar misconceptions means that they have little knowledge about environmental issues and they equate many environmental factors with another factor and thereby reach illogical conclusions. Ikonomidis et al. (2012) also pointed out that students incorrectly associate certain environmental issues with one another. Likewise, Meadows and Wiesenmayer (1999) demonstrated that students tended to pair together the two major environmental problems of the ozone layer and global warming.

Another important finding derived from the research was that IBM is a source of misconceptions on environmental chemistry, given that the misconceptions identified in IBM are readily available to the students. High school and university students preferred IBM as one of the primary sources for acquiring information about environmental issues. Sachsman (1995), Selvi (2007), and Yazdanparast et al. (2013) also reported that students obtained information about environmental issues from the media (the Internet, television, or radio). Considering IBM's role in communicating potentially misleading or inaccurate information on the ozone layer, students are particularly vulnerable to entertaining misconceptions. According to research results, the common feature of these statements, the misconceptions identified on websites, and the students' misconceptions is that students associate the reason for and consequence of the thinning of the ozone layer with global warming, the greenhouse effect, and acid rain. For example, students explained the role of the ozone layer as protecting the world from acid rain and explained the reason for the thinning of the ozone layer as the greenhouse effect. When websites were searched using the keyword 'ozone layer' to acquire information, the issues of global warming, the greenhouse effect, and acid rain were all encountered in the search results. Such misrepresentations could cause students to make wrong connections between concepts. Moreover, according to the student participants in this research, holes in the ozone layer cause the Earth's temperature to increase. This opinion was also held by teachers and pre-service teachers (Selvi, 2007; Summers, Kruger, Childs, & Mant, 2001). The fact that these misconceptions exist in different countries and among different grade levels means that students lack environmental literacy (Ozgurler & Cansaran, 2014).

As environmental problems began attracting attention in the 20th century, environmental education became necessary. Based on the findings from this study, it is quite clear that environmental education courses need to be well-planned for each grade level, taking into account the primary sources students tend to use to acquire information so that proper measures may be taken to circumvent the misconceptions directly or indirectly communicated through these sources. Many websites are full of explanations that reinforce students' misconceptions. By spreading environmental education, this conveyance of incorrect information and explanations which serve to support the students' misconceptions may be avoided.

The present study focused only on the topic of the ozone layer under the subject of environmental chemistry. Such research should be repeated in other environmental chemistry subjects. Furthermore, this study only looked at IBM and its role in presenting environmental issues. Future studies should consider also examining

television news as a primary source of information and analyze how they present these same issues, especially since it can be assumed that virtually everyone has televisions in their home.

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References

AcarSesen, B., & Ince, E. (2010). Internet as a source of misconception: "Radiation and radioactivity". *Turkish Online Journal of Educational Technology - TOJET, 9*(4), 94-100.

Andersson, B., & Wallin, A. (2000). Students' understanding of the greenhouse effect, the societal consequences of reducing CO2 emissions and the problem of ozone layer depletion. *Journal of Research in Science Teaching, 37(*10), 1096-1111

Avci D., & Darcin E.S. (2009). Investigation of eight grade students' knowledge level about global environmental problems. *Eurasian Journal of Physics and Chemistry Education, 1*(2), 93-98.

Bahar, M., Bag, H., & Bozkurt, O. (2008). Pre-service science teachers' understandings of an environmental issue: Ozone layer depletion. *Ekoloji*, 18(69), 51-58.

Boyes E., & Chambers W. (1995). Trainee primary teachers' ideas about the ozone layer. *Environmental Education Research, 1*(2), 133-145.

Boyes, E., Chuckran, D., & Stanisstreet, M. (1993). How do high school students perceive global climatic change: What are its manifestations? What are its origins? What corrective action can be taken? *Journal of Science Education and Technology, 2*(4), 541-557.

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

Boyes, E., & Stanisstreet, M. (1998). High school students' perceptions of how major global environmental effects might cause skin cancer. *The Journal of Environmental Education, 29*(2), 31-36

Boyes, E., Stanisstreet, M., & Papantoniou, V.S. (1999). The ideas of Greek high school students about the ozone layer. *Science Education, 83*(6), 724-737.

Christidou, V., & Koulaidis, V. (1996). Children's models of the ozone layer and ozone depletion. Research in Science Education, 26(4), 421-436.

Cordero, E. (2000). Misconceptions in Australian students' understanding of ozone depletion. *Melbourne Studies in Education, 41*(2), 85-97.

Cimer, S. O., Cimer A., & Ursavas, N. (2011). Student teachers' conceptions about global warming and changes in their conceptions during pre-service education: A cross sectional study. *Academic Journals, 6*(8), 592-597.

Darcin, E. S., & Darcin, M. (2009). Ortaöğretim öğrencilerinin araç emisyonlarından kaynaklanan çevre problemleri hakkındaki bilgi seviyeleri. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, *29*(2), 485-512.

Darcin, E.S., Bozkurt, O., Hamalosmanoglu, M., & Kose, S. (2006). İlköğretim öğrencilerinin sera etkisi hakkındaki bilgidüzeylerinin ve kavram yanılgılarının tespit edilmesi. *International Journal of Environmental and Science Education, 1*(2), 104-115.

Dove, J. (1996). Student teacher understanding of the greenhouse effect, ozone layer depletion and acid rain. *Environmental Education Research, 2*(1), 89-95.

Gardner, G. T., & Stern, P. C. (1996). *Environmental problems and human behavior.* Allyn & Bacon.

Groves, F. H., & Pugh, A. F. (1999). Elementary pre-service teacher perceptions of the greenhouse effect. *Journal of Science Education and Technology, 8*(1), 75-81.

Groves, F. H., & Pugh, A. F. (2002). Cognitive illusions as hindrances to learning complex environmental issues. *Journal of Science Education and Technology, 11*(4), 381-390.

Hillman, M., Stanisstreet, M., & Boyes, E. (1996). Enhancing understanding in student teachers: The case of auto-pollution. *Journal of Education for Teaching, 22*(3), 311-325.

Ikonomidis, S., Papanastasiou, D., Melas, D., & Avgoloupis, S. (2012). The anthropogenic 'greenhouse effect': Greek prospective primary teachers' ideas about causes, consequences and cures. *Journal of Science Education and Technology, 21*(6), 768-779.

Information and Communication Technologies Authority.(2012). *Geniş bantHizmetlerindeŞeffaflıkDüzenlemeleriveHizmetKalitesiUygulamaları. Retrieved May 22, 2015, from https://www.btk.gov.tr/File/?path=ROOT%2F1%2FDocuments%2FSayfalar%2F Arastirma_Raporlari%2FTeknoloji_Hizmetler_Duzenleme_ve_Dunyadaki_Gelis melerle_Genisbant*.pdf

Internet Society Global Internet Report. (2015). *Mobile Evolution and Development of the Internet.* Retrieved June 24, 2016, from http://www.internetsociety.org/globalinternetreport/assets/download/IS_web.pdf .

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

Kilinc, A., Stanisstreet, M., & Boyes, E. (2008). Turkish students' ideas about global warming. *International Journal of Environmental & Science Education, 3*(2), 89-98.

Kilinc, A., Stanisstreet, M., & Boyes, E. (2009). Incentives and disincentives for using renewable energy: Turkish students' ideas. *Renewable and Sustainable Energy Reviews, 13*(5), 1089-1095

Meadows, G., & Wiesenmayer, R. (1999). Identifying and addressing students' alternative conceptions of the causes of global warming: The need for cognitive conflict.*Journalof Science Education and Technology, 8*(3), 235-239.

Ozgurler S., & Cansaran A. (2014). Graduate students, study of environmental literacy and sustainable development. *International Electronic Journal of Environmental Education, 4*(2), 71-83.

Ozkaya, A., & Usak, M. (2009). *Çevre Kavramı ve Çevre Biliminin Tarihsel Gelişimi.* Aydoğdu, M. (Ed.) Ankara: Pozitif Matbaacılık.

Papadimitriou, V. (2004). Prospective primary teachers' understanding of climate change, greenhouse effect, and ozone layer depletion. *Journal of Science Education and Technology*, *13*(2), 299-307.

Pekel, F., & Kirik, O. T. (2016). Middle school students' cognitive structures about global warming and ozone layer depletion. *Eğitimde Kuram ve Uygulama, 12*(1), 308-357.

Sachsman, D. B. (1995, April 25). *Communicating Environmental Issues in the 21st Century: Teaching Journalists and the Public about Environmental Risk and Setting the Environmental Agenda.* Paper presented at the International Interdisciplinary Conference on Environmental Issues for the 21st Century, Lehman College, New York.

Stanisstreet, M., & Boyes, E. (1996). Young people's ideas about global environmental issues. In G. Harris, & C. Blackwell (Eds.), *Monitoring Change in Education 2: Environmental Issues in Education, (pp. 37- 52).* Aldershot, England: Ashgate Publishing Limited.

Selvi, M. (2007). *Biyoloji Öğretmen Adaylarının Çevre Kavramları ile İlgili Algılamalarının Değerlendirilmesi*. Yayımlanmamış Doktora Tezi, Gazi Üniversitesi *Eğitim Bilimleri Enstitüsü*, Ankara.

Selvi, M., &Yildiz, K. (2009). Biyoloji Öğretmen Adaylarının Sera Etkisi ile ilgili Algılamaları. *Türk Eğitim Bilimleri Dergisi, 7*(4).

Summers, M., Kruger, C., Childs, A., & Mant, J. (2001). Understanding the science of environmental issues: Development of a subject knowledge guide for primary teacher education. *International Journal of Science Education, 23*(1), 33-53.

Yazdanparast, T., Seyedmehdi, M. S., Salehpour, S., Masjedi, M. R., Boyes, E., Stanisstreet, M., et al. (2013). Global warming: Knowledge and views of Iranian students. *Acta Medica Iranica, 51*(3), 178-184.

Stanisstreet, M., & Boyes, E. (1996). Young people's ideas about global environmental issues. In G. Harris, & C. Blackwell (Eds.), *Monitoring Change in Education 2: Environmental Issues in Education,* (pp. 37- 52). Aldershot, England: Ashgate Publishing Limited.

Öğrencilerin Çevre Kimyası Konularındaki Yanlış Kavramalarına İnternet Tabanlı Medyanın Etkisi

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Özet

Bu çalışmada öğrencilerin ozon tabakası ile ilgili yanlış kavramaları ortaya çıkarılmıştır. İnternet tabanlı medyanın bu yanlış kavramaların oluşumundaki etkisi belirlenmiştir. Araştırma, nicel ve nitel araştırma yaklaşımları ile yürütülmüştür. Nicel araştırmada; durum tespiti yapmak için betimsel tarama yöntemi kullanılmıştır. Betimsel taramada veriler, ozon tabakası ile ilgili maddeler içeren ölçme aracı ile toplanmıştır. Çalışmanın katılımcıları 95 kimya öğretmen adayı ve 363 lise öğrencisidir. Nitel araştırmada ise ozon tabakası ile ilgili yerel ilk 219 internet sitesi analiz edilmiştir. Sonuç olarak hem lise hem de üniversite öğrencilerinde farklı öğrenim düzeyinde olmalarına rağmen benzer yanlış kavramaların mevcut olduğu tespit edilmiştir. Ayrıca ilgili websitelerin birçok yanlış bilgiye yerverdiği, bilimsel modellere uygun olmayan ya da yanlış kavramaları destekleyen ifade ve açıklamalar içerdiği belirlenmiştir.