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Pre- and In-Service Teachers' Understandings of Atmosphere-related Environmental Issues: The Effects of Major and Gender *

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Abstract

This study aimed to investigate pre- and in-service teachers' understandings of the greenhouse effect, global warming, ozone layer depletion, and acid rain in terms of gender and major using a three-tier diagnostic test which has the potential to differentiate respondents with lack of knowledge from those with misconceptions. The data of the research in which the survey method was used were collected using "The Atmosphere-related Environmental Problems Diagnostic Test (AREPDiT)." The sample of the study consisted of 987 respondents (634 pre-service and 353 in-service teachers). The data were analyzed using a three-way ANOVA. The results revealed that although males' AREPDiT mean score was higher than that of their female counterparts, the difference between them was not statistically significant. Also, science and social studies in-service teachers' understandings of atmospheric environmental issues were significantly higher than that of pre-service teachers with the same majors, while there was no significant difference between pre- and in-service primary teachers' understandings of atmosphere-related environmental issues. It was found that the participants had some common misconceptions about atmosphere-related environmental issues. Moreover, both pre- and in-service teachers more commonly use informal sources such as the Internet and TV to access environmental knowledge than formal ones such as seminars and books.

Keywords: Atmosphere-related environmental problems, Teacher, Gender, Major

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Öğretmenlerin ve Öğretmen Adaylarının Atmosfer İle İlgili Çevre Konularını Anlamaları: Branş ve Cinsiyetin Etkisi*

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Öz

Bu çalışma kavram yanılgısına sahip olanlar ile bilgisiz olan cevaplayıcıları birbirinden ayırt etme potansiyeline sahip üç aşamalı bir tanılayıcı test kullanarak öğretmenlerin ve öğretmen adaylarının sera etkisi, küresel ısınma, ozon tabakası incelmesi ve asit yağmuru anlamalarını branş ve cinsiyet değişkenleri açısından araştırmayı amaçlamıştır. Tarama yönteminin kullanıldığı bu araştırmanın verileri "Atmosfer ile İlgili Çevre Problemleri Tanılayıcı Testi" kullanılarak toplanmıştır. Araştırmanın örneklemi 987 katılımcıdan (634 öğretmen adayı ve 353 öğretmen) oluşmaktadır. Veriler üç-yönlü ANOVA kullanılarak analiz edilmiştir. Analiz sonuçları erkeklerin test puan ortalamasının kadınlarınkinden yüksek olmasına rağmen aradaki farkın istatistiksel olarak anlamlı olmadığını göstermiştir. Bununla birlikte, fen ve sosyal bilgiler öğretmenlerinin atmosfer ile ilgili çevre problemleri anlamaları aynı branştaki öğretmen adaylarında önemli düzeyde yüksek olmasına rağmen sınıf öğretmenliği branşındaki öğretmenlerin ve öğretmen adaylarının atmosfer ile ilgili çevre problemleri anlamaları arasında fark bulunamamıştır. Ayrıca katılımcıların atmosfer ile ilgili çevre problemleri hakkında bazı yaygın kavram yanılgılarına sahip oldukları belirlenmiştir. Dahası, hem öğretmenlerin hem de öğretmen adaylarının çevre konusunda bilgiye erişmek için Internet ve TV gibi informal bilgi kaynaklarını, seminer ve kitap bilgi formal bilgi kaynaklarından daha yaygın bir şekilde kullandıkları saptanmıştır.

Anahtar kelimeler: : Atmosfer ile ilgili çevre problemleri, Öğretmen, Cinsiyet, Branş

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1. Introduction

Children struggle to understand the world around them and build concepts on a combination of their unique personal and social experiences (Driver, Guesne, & Tiberghien, 1985). Children's concepts are, at times, inconsistent with those accepted by the scientific community (Boyes, & Stanisstreet, 1997) and the term "misconception," which is one of the most common terms for these incompatible concepts, will be used in this article. Children who developed misconceptions about their world often continue to hold the majority of their misconceptions persistently during their educational life and moreover, they may construct new misconceptions in the educational environment as a result of a variety of sources such as textbooks and instructional materials (Lin, 2004; Sanger, & Greenbowe, 1997). Misconceptions are considered to be a barrier to learning more advanced science concepts (Nakhleh, 1992), and therefore, identifying their possible origins is critical for developing a better educational environment.

The intangible and complex nature of science concepts is probably one of the most important sources of student misconceptions (Nakhleh, 1992; Papadimitriou, 2004; Ratinen, 2013; Walz, & Kerr, 2007). Because imagining the untouchable and invisible is difficult for students. Therefore, students often develop misconceptions about science concepts.

Mass media is deemed another responsible factor for misconceptions (Daskolia, Flogaitis, & Papageorgiou, 2006; Groves, & Pugh, 1999). Especially the Internet, as a result of the recent advancements in computer technology, has recently become a platform where information can be spread virtually at the speed of light and, socio-scientific issues such as global warming are among the subjects shared often on the Internet. However, the information on the Internet is not always accurate, and therefore, the Internet has the potential to lead to misconceptions (Acar-Sesen, & Ince, 2010).

Teachers are also among the sources of misconceptions (Groves, & Pugh, 1999; Walz, & Kerr, 2007). In other words, good teacher knowledge is essential for the most effective teaching (Summers, Kruger, Childs, & Mant, 2000) because misconceptions held by students may arise from incorrect instruction given by teachers who do not have a correct and complete understanding of their majors (Groves, & Pugh, 1999; Khalid, 2003). To date, many studies have been performed to determine teachers' understanding of different science concepts (Kolomuc, & Tekin, 2011; Yip, 1998). Similarly, since the mid-1980s, many researchers have attempted to investigate in-service, especially pre-service, teachers' understandings of atmospheric environmental issues such as the greenhouse effect (GE), global warming (GW), ozone layer depletion (OLD) and acid rain (AR). Although in these studies a variety of methods such as interview (Summers et al., 2000), open-ended questions (Yalcin, & Yalcin, 2017), and concept maps (Rye, & Rubba, 1998) have been used to reveal misconceptions, a considerable part of the available information on misconceptions about atmosphere-related environmental issues was derived from conventional multiple-choice questions (one-tier questions) and Likert type surveys (Arsal, 2010; Michail, Stamou, & Stamou, 2007; Ocal, Kisoglu, Alas, & Gurbuz, 2011). However, traditional multiple-choice questions may not always successful in determining students understanding of concepts or in identifying their misconceptions (Tsui, & Treagust, 2010). Therefore, recently, two-tier diagnostic tests that are more successful in identifying students' understanding or misconceptions (Treagust, 1988) and three-tier diagnostic tests that have the potential to differentiate respondents with lack of knowledge from those with misconceptions (Arslan, Cigdemoglu, & Moseley, 2012) have been among the most popular instruments.

It is important to determine the demographics that have the potential to affect environmental knowledge to design and implementation of more effective teacher education modules, which help teachers to develop a more scientific perspective of atmosphere-related environmental issues. Major was considered as one of the influential factors on the environmental knowledge of teachers. Although some majors such as primary education, social studies education, and science education have a critical role in environmental education, the number and content of the environmental-related courses provided in these majors during teacher education programs in Turkey are different. For example, although researchers pointed out the importance of environmental education at the primary school level (Michail et al., 2007), Turkish primary school pre-service teachers take only one environmental-related course during their university life, and those in the aforementioned majors receive relatively more courses containing environmental issues. However, the number of studies investigating the effect of major on Turkish teachers' environmental knowledge is limited (Arsal, 2010; Ocal et al., 2011). For example, Ocal et al. (2011) investigated pre-service teachers' understandings of GW in terms of major and found that knowledge level of pre-service social science teachers was significantly higher than that of pre-service primary school and science teachers. Gender differences in environmental knowledge are another concern that should be tackled. For several decades, environmental education researchers have been investigating gender dynamics in environmental knowledge and have been reporting inconclusive results. For example, Alp, Ertepinar, Tekkaya, and Yilmaz (2006), who investigated the effect of gender on students' environmental knowledge, found no gender difference. However, a considerable number of studies found that males' understanding of atmosphere-related environmental problems was significantly higher than that of their female counterparts (Dijkstra, & Goedhart, 2012; Ocal et al., 2011; Pekel, 2005). Thus, this study considered gender as another factor that can have an effect on teachers' environmental knowledge.

In Turkey, the majority of studies on misconceptions in atmosphere-related environmental issues have concentrated on pre-service teachers, and no studies have been dedicated to exploring misconceptions of GE, GW, OLD, and AR among in-service teachers. Similarly, the number of studies across the world investigating in-service teachers' understandings of atmosphere-related environmental issues is rather limited (Daskolia, et al., 2006; Michail et al., 2007; Summers et al., 2000). Additionally, although, in Turkey, there have been a remarkable number of studies investigating pre-service teachers' understanding of global environmental problems, none of them used a three-tier diagnostic instrument. Moreover, studies investigating gender dynamics on environmental knowledge is focused typically on pre-service teachers, and a limited number of studies examined the effect of major on environmental knowledge. Therefore, using a three-tier diagnostic test, this study aimed to investigate the following questions:

- Are there differences between pre- and in-service teachers' understandings of atmosphere-related environmental issues in terms of gender and major?
- What are pre- and in-service teachers' misconceptions about GE, GW, OLD and AR?
- What is the usage frequency of environmental knowledge resources by pre- and in-service teachers?

2. Method

This study was survey research. Surveys are used to learn about peoples' attitudes, beliefs, values, demographics, behavior, opinions, habits, desires, ideas and other types of information. Survey

research is very popular in education, primarily for three reasons: versatility, efficiency, and generalizability (McMillan, & Schumacher, 2006). In this study, the survey method was embraced because data would be collected from a large sample.

2.1. Sample

The data of the study were collected from pre- and in-service teachers with three majors (primary education - PE, social studies education - SSE, and science education - SE) based on convenience sampling in which a group of subjects is selected on the basis of being accessible or expedient (McMillan, & Schumacher, 2006). The sample of the study consisted of 353 teachers working in rural and urban schools in two cities in northwestern Turkey and 634 pre-service teachers enrolled in six universities in different regions of Turkey. The mean ages of the pre- and in-service teachers were found to be 22 (SD = 1.5) and 40 (SD = 9.5) years old, respectively. Pre-service teachers were junior (63.4%) and senior (36.2%) because they have already completed all environmental-related courses. The summary of the demographics of the participants was presented in Table 1.

Table 1. Distribution of the participants by gender and major

Variable	Number of respondents (% in parenthesis)		
	Overall (n = 987)	**Pre-service teachers (n = 634)**	**In-service teachers (n = 353)**
Gender			
Female	684 (69.3)	449 (70.8)	235 (66.5)
Male	303 (30.7)	185 (29.2)	118 (33.5)
Major			
PE	454 (46.0)	239 (37.7)	215 (60.9)
SSE	173 (17.5)	119 (18.8)	54 (12.3)
SE	360 (36.5)	276 (43.5)	84 (23.7)

2.2. Instruments

The instrument consisted of four parts. In the first part, the participants were asked for their age, gender and major. In the second part, the respondents were asked to indicate on a four-point scale how much they are interested in environmental issues. In the third part, ten sources of environmental knowledge were given, and the participants were asked to rate on 0-5 Likert scale (from 0 = never or almost never to 5 = very often) how often they use each of these sources (Michail et al., 2007).

In the fourth part, The Atmosphere-related Environmental Problems Diagnostic Test (AREPDiT) developed by Arslan, et al., (2012) was used to determine participants' understandings of GE, GW, OLD, and AR. The AREPDiT includes 13 three-tier diagnostic questions about causes, consequences, and cures of GE (two questions), GW (four questions), OLD (four questions), and AR (three questions). The first tier of each question (content tier) includes multiple-choice questions evaluating respondents' descriptive knowledge. The second tier (reason tier) contains possible reasons for the answers to the first tier. The third tier (confident tier) examines whether the respondents are sure about their responses for the first both tier.

The AREPDiT was adapted into Turkish after permission had been obtained from the corresponding author to use it, and the adaptation process was summarized in Figure 1.

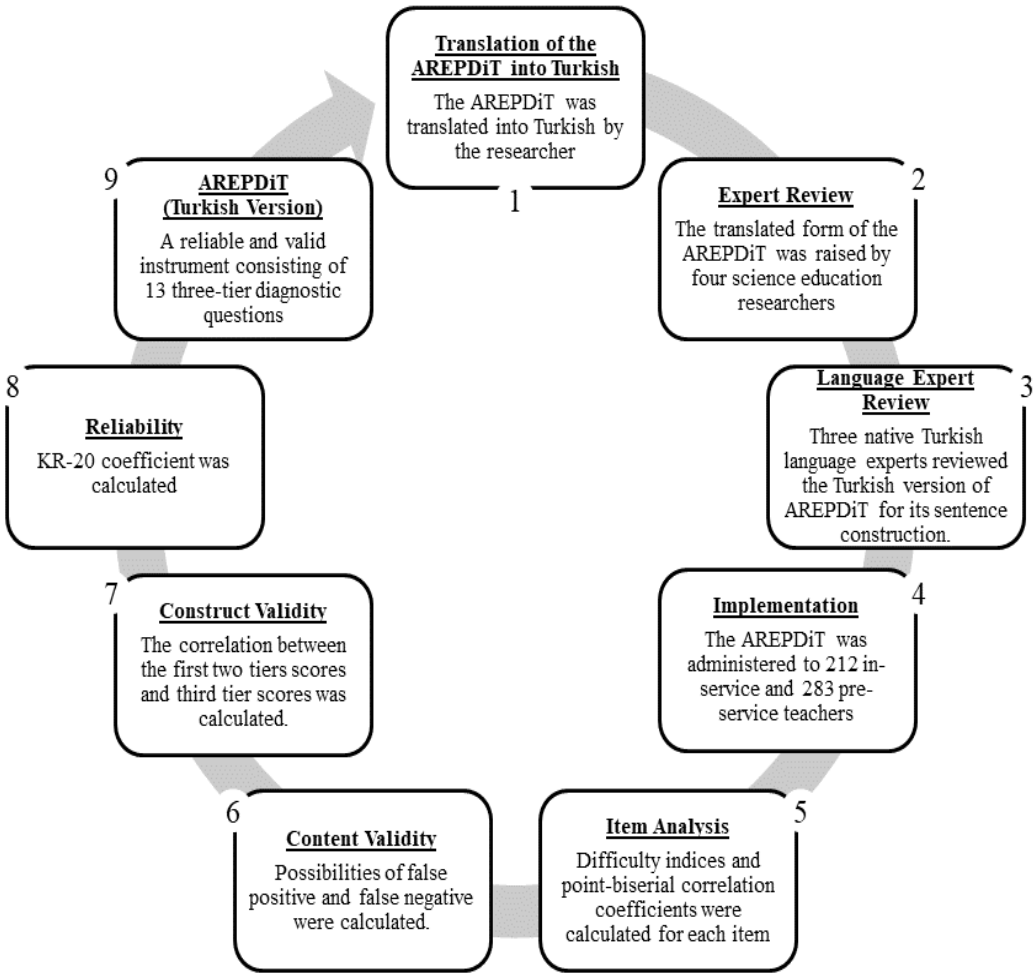


Figure 1. The adaptation process of the AREPDiT into Turkish

First, the AREPDiT was translated into Turkish by the researcher and the translated version was raised by four science education researchers who were fluent in both English and Turkish languages and three native Turkish language experts checked the linguistic and grammatical structure of the questions. To evaluate the reliability and validity of the Turkish version of the AREPDiT, the data were collected from 212 in-service teachers [128 (60%) female, 82 (39%) male and 3 (1%) undeclared] working in schools in the northwestern Turkey and from 283 pre-service teachers [224 (79%) female and 59 (21%) male] enrolled in two universities in Turkey and the results of the analysis were presented in Table 2.

Table 2. Descriptive statistics about the Turkish version of the AREPDiT

	In-service teachers				Pre-service teachers			
	N	**M**	**SD**	**KR-20**	**N**	**M**	**SD**	**KR-20**
Participants	212				283			
Items	13				13			
Reliability coefficient				.67				.68
Max/Min score	12/0				12/0			
Difficulty indices (*p*)		.30	.12				.38	.11
.50 - .60	1					2		
.40 - .50	2					3		
.30 - .40	3					5		
.20 - .30	4					2		
< .20	3					1		
Point-biserial correlation (r_{pb})		.45	.10				.46	.09
.50 - .60	6					5		
.40 - .50	3					5		
.30 - .40	3					2		
.20 - .30	1					1		

The overall difficulty indices calculated for pre- (p = .38) and in-service (p = .30) teachers indicated that the AREPDiT was a moderately difficult test for both groups as well. Point-biserial correlation coefficients calculated for each question were found to be within acceptable limits for both pre- and in-service teachers (Mitra, Nagaraja, Ponnudurai, & Judson, 2009) and the overall point-biserial correlation coefficients for pre- (rpb = .46) and in-service (rpb = .45) teachers indicated that the AREPDiT was an instrument which has the potential to differentiate those who performed well on the test from those who were doing poorly.

False positives (FPs) and false negatives (FNs) are provided as evidence for content validity and, Hestenes and Halloun (1995) emphasized that FNs should not be larger than 10%. This study found that no items in the AREPDiT had an FN of higher than 10% for either pre- or in-service teachers. To evaluate the construct validity, the correlation between the first two tier scores and third tier scores was computed. Because respondents with high confidence are expected to obtain higher score from the first two tiers (Cataloglu, 2002). The correlation calculated for pre-service teachers was weak but significant (r = .23, p = .00). However, no correlation was found for in-service teachers (r = .06, p = .36). It is estimated that in-service teachers' excessive self-confidence about their environmental knowledge might has been the reason for no correlation.

Kuder Richardson reliability coefficient (KR-20), which is suggested for items scored dichotomously, calculated for pre- and in-service teachers was found to be .68 and .67, respectively. Misconception tests with a reliability coefficient of .60 or higher could be used as a reliable instrument (Kaltakci, 2012). Consequently, the Turkish version of the AREPDiT was a sufficiently reliable and valid instrument to measure pre- and in-service teachers' understandings of atmosphere-related environmental issues.

2.3. Data Collection and Analysis

To increase the visual appeal of the AREPDiT, it was prepared in the booklet form after its validity and reliability were tested. In addition, a consent form including the purpose of the research and the procedure to be followed to fill in the instrument, was prepared. The form also included the contact information of the researcher whom the respondents can contact to ask any question about the research. The form was distributed with the AREPDiT to the respondents, and they were asked to read the consent form and then to participate in the research if they were voluntary.

The data were analyzed both descriptively and statistically using MS Excel 2013 and SPSS, respectively. The following parameters were calculated using the scoring diagram by Arslan et al. (2012):

- *All tier [AT] / Scientific Knowledge [SK]:* Respondents who marked correct response in the first two tiers and were certain about their responses were coded 1, otherwise 0.
- *Misconception [M]:* Respondents who selected an alternative concept in both first and second tiers (alternative concept selected in the second tier should be compatible with the one selected in the first tier) and were certain about their responses were coded 1, otherwise 0.

AT/SK scores were used to evaluate whether there are significant differences in respondents' understanding of atmosphere-related environmental issues in terms of service type (pre-service and the in-service teacher), major (PE, SSE, and SE), and gender (female and male). For this purpose, a three-way ANOVA was used after its assumptions had been tested. Therefore, first, to evaluate the normality of the data, skewness, and kurtosis statistics were calculated, and box plots were drawn. In addition, Levene's test was performed to determine whether the variances were equal.

3. Findings

The participants' responses regarding the question "How much are you interested in environmental issues?" were analyzed descriptively and the results were presented in Figure 2.

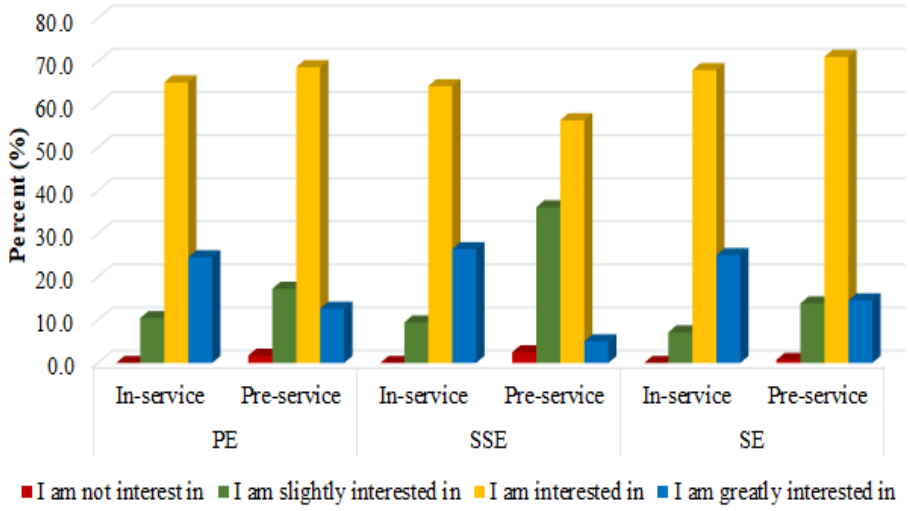


Figure 2. The participants' level of interest in environmental issues

Figure 2 showed the majority of the pre- and in-service teachers in each major had a great interest in environmental issues. However, when considering the sum percentage of the respondents who interested and greatly interested in environmental issues, a greater percentage of primary school teachers than social studies and science teachers were of high interest in environmental issues. However, although the percentages of in-service teachers with three majors who interested in environmental issues were similar to each other, especially social studies pre-service teachers were those demonstrating the lowest concern about the environmental issues among the pre-service teachers with three majors.

The participants' responses to the usage frequencies of environmental knowledge resources were descriptively analyzed and the results were presented in Figure 3.

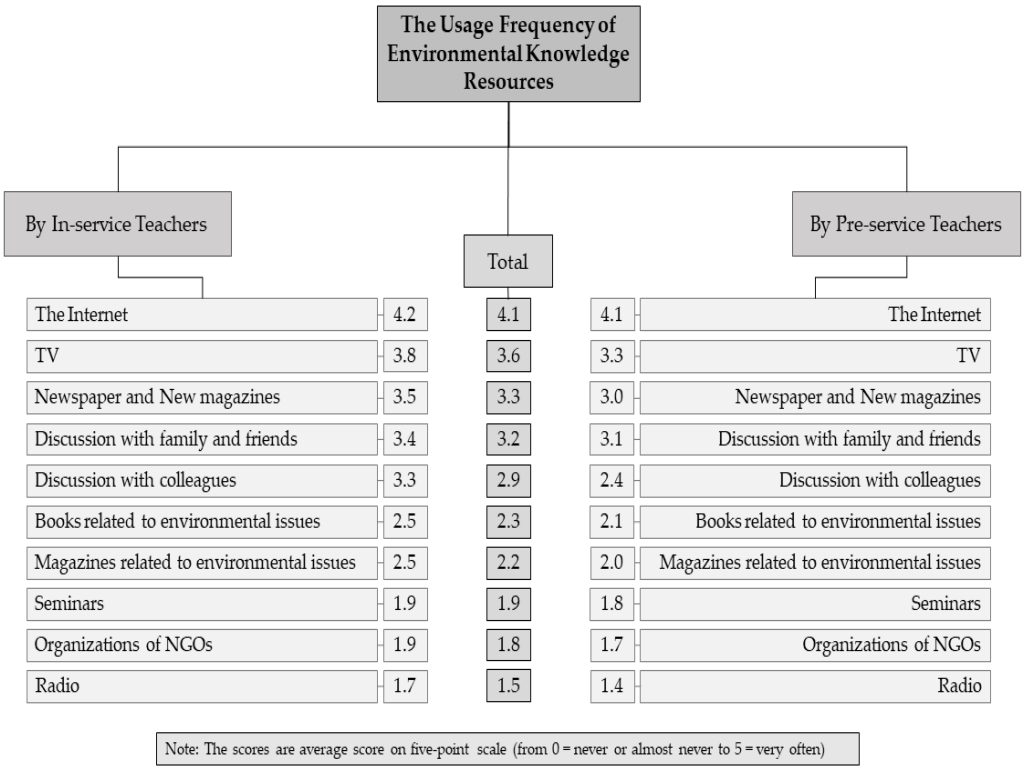


Figure 3. The usage frequencies of environmental knowledge sources by pre- and in-service teachers

According to Figure 3, mass media, except radio, was the most frequently used source to reach information about global environmental issues and the most popular environmental knowledge source among mass media tools was the Internet. Because of the advancements in computer and Internet technologies, accessing information is easier than it has ever been before and therefore, this finding was not a surprise. Discussion with family, friends and colleagues and books and magazines related to environmental issues were among resources that are moderately used to acquire environmental knowledge while seminars and non-governmental organizations were the least used sources.

3.1. The Statistical Analysis of AREPDiT Data

AT/SK scores were used to examine whether there were statistical differences in participants' understanding of atmosphere-related environmental issues according to gender, major, and

service type. First, skewness and kurtosis statistics were found to be between +1 and -1, suggesting that the data met the assumption of normality. The box plots were drawn for each sub-group also supported the skewness and kurtosis statistics. The results of the Levene's test demonstrated that the assumption of homogeneity of variances was violated ($F(11,975) = 3.975$, $p < .05$). Fortunately, SPSS uses the regression approach, and therefore, this problem was less important (Leech, Barrett, & Morgan, 2005). Three-way ANOVA was performed after the assumptions were met, and the results were presented in Table 3.

Table 3. Three-way analysis of variance for AT/SK scores as a function of service type, gender and major

Sources	Sum of squares	df	Mean of squares	F	p	η^2
Service type	318.710	1	318.710	58.723	.000*	.057
Gender	22.702	1	22.702	4.183	.041	.004
Major	869.562	2	434.781	80.109	.000*	.141
Service type*Gender	13.728	1	13.728	2.529	.112	.003
Service type*Major	268.933	2	134.466	24.776	.000*	.048
Gender*Major	6.854	2	3.427	.631	.532	.001
Service type*Gender*Major	14.719	2	7.360	1.356	.258	.003
Error	5291.680	975	5.427			

*p < .017 (the adjusted significance level)

A possible interaction among the independent variables may affect the interpretation of the separate - main effects of each independent variable (Leech et al., 2005). Thus, I first looked at the interaction and found no significant interaction between the effects of gender and the other variables on AT/SK scores. Therefore, the effect of gender on the dependent variable should be examined separately. However, statistical significance depends heavily on the sample size and effect size measures give us some indication of the importance of the relationship between independent and dependent variables (Leech et al., 2005). The η2 calculated for gender indicated that .4% of the variance in the AREPDiT could be predicted from gender. This finding suggested a small effect size (Becker, 2000). Additionally, when more than one statistical test (for example, study groups are compared with regard to two or more unrelated variables) is used in analyzing the data, some statisticians demand that a more stringent criterion should be used for "statistical significance" than the conventional $p < .05$ (Perneger, 1998). Therefore, Bonferroni adjustment was made using the formula of $(1 - (1 - \alpha)^{\frac{1}{n}})$ (Perneger, 1998), and the adjusted significance level was found to be .017. Considering this significance level, the results indicated that although the mean AT/SK score of male participants ($M = 4.28$, $SD = 2.63$) was higher than that of female participants ($M = 4.00$, $SD = 2.56$), the difference between them was not statistically significant ($F(1,975 = 4.183$, $p = .041$). Table 3 showed there was a significant interaction between the effects of service type and major on AT/SK scores ($F(2,975) = 24.776$; $p = .00$). Therefore, the variables of service type and major were recoded by combining with each other, and a new variable (includes six sub-groups) was created.

Table 4. Mean, standard deviation and n for AT/SK scores as a function of service type and major

Majors	In-service teacher			Pre-service teacher			Total	
	n	M	SD	n	M	SD	M	SD
PE	215	3.38	2.39	239	3.38	1.94	3.38	2.16
SSE	54	4.56	3.08	276	3.59	2.15	3.89	2.51
SE	84	7.43	3.06	119	4.35	2.27	5.07	2.79
Total	353	4.52	3.15	634	3.84	2.17	4.09	2.58

The data were re-analyzed according to the new variable using one-way ANOVA and the contrasts command. Instead of using Post Hoc tests, I preferred to use contrasts, which compare pre-selected pairs of means rather than all possible pairs of means (Leech et al., 2005). In this case, I compared the AT/SK scores of pre- and in-service teachers in three majors and presented the results in Table 4. Simple effects analysis revealed that in-service science teachers' understanding of atmospheric environmental issues (M = 7.43, SD = 3.06) was significantly higher than that of pre-service science teachers (M = 4.35, SD = 2.27), (t(112.231) = 8.553, p = .000). Similarly, a significant difference in AT/SK scores between pre- (M = 3.59, SD = 2.15) and in-service (M = 4.56, SD = 3.08) social studies teachers was found in favor of in-service teachers (t(77.185) = 2.088, p = .040), at the significance level of .05. However, the mean AT/SK scores of pre-service (M = 3.38, SD = 1.94) and in-service (M = 3.38, SD = 2.39) primary teachers were the same and therefore, a significant difference between them was not found, t(412.413) = .003, p = .998). The values of η2 calculated for each independent variable and the interaction suggested that 14.1% of the variance of the AREPDiT was associated with major. This finding suggested a large effect (Becker, 2000). Figure 4 clearly showed the change in the AT/SK scores of pre- and in-service teachers in all three majors.

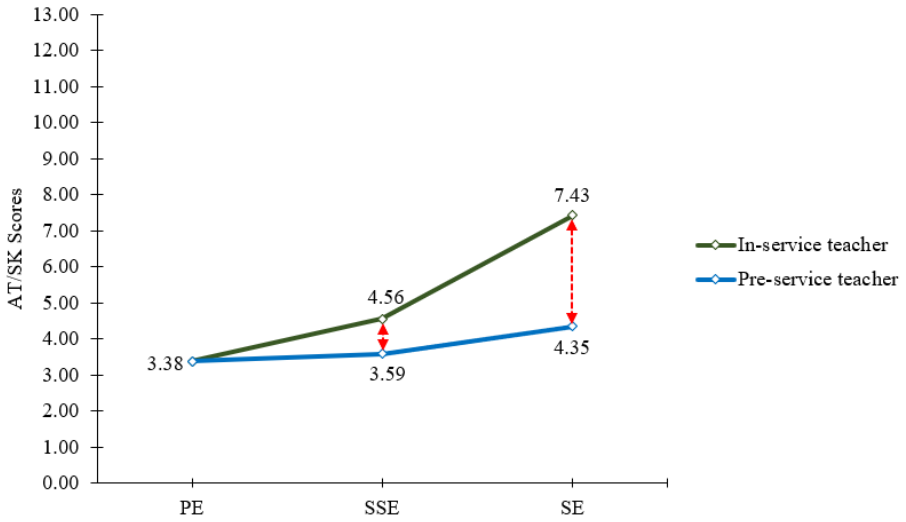
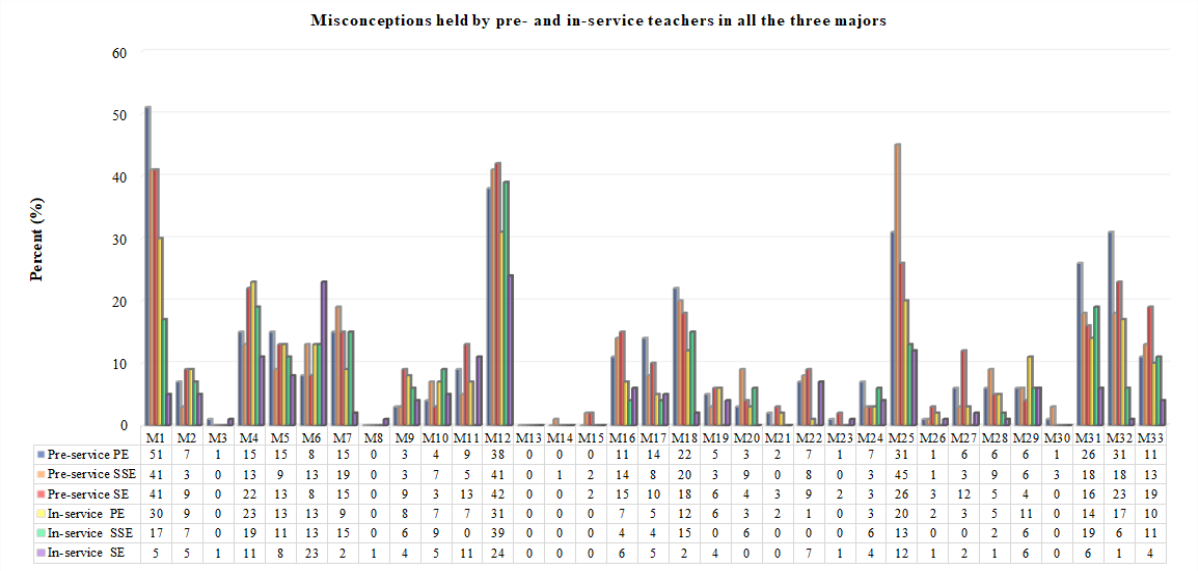


Figure 4. Interaction plot showing three simple main effects

AT/SK scores of both pre- and in-service teachers at three majors were compared using one-way ANOVA, and the results indicated that there were statistically significant differences in both pre- (F(2,631) = 14.28, p = .00) and in-service teachers' (F(2,350) = 69.19, p = .00) AT/SK scores in terms of major. Post hoc comparisons indicated that differences among the AT/SK mean scores of in-service teachers at three majors were statistically significant. However, pre-service science teachers' AT/SK mean score was significantly higher than those of both primary school and social studies pre-service teachers while there was no significant difference between the AT/SK means of pre-service primary school and social studies teachers.

3.2. The Misconceptions Held By Pre- and In-Service Teachers

The percentages of pre- and in-service teachers who had the misconceptions identified by Arslan et al. (2012) were calculated separately for each major, and the results were presented in Figure 5. Total scores indicated that the participants held almost all the misconceptions reported in the misconception list (includes 33 misconceptions). Therefore, the misconceptions with a mean score of 15% or more were discussed here.



	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33
Pre-service PE	51	7	1	15	15	8	15	0	3	4	9	38	0	0	0	11	14	22	5	3	2	7	1	7	31	1	6	6	6	1	26	31	11
Pre-service SSE	41	3	0	13	9	13	19	0	3	7	5	41	0	1	2	14	8	20	3	9	0	8	0	3	45	1	3	9	6	3	18	18	13
Pre-service SE	41	9	0	22	13	8	15	0	9	3	13	42	0	0	2	15	10	18	6	4	3	9	2	3	26	3	12	5	4	0	16	23	19
In-service PE	30	9	0	23	13	13	9	0	8	7	7	31	0	0	0	7	5	12	6	3	2	1	0	3	20	2	3	5	11	0	14	17	10
In-service SSE	17	7	0	19	11	13	15	0	6	9	0	39	0	0	0	4	4	15	0	6	0	0	0	6	13	0	0	2	6	0	19	6	11
In-service SE	5	5	1	11	8	23	2	1	4	5	11	24	0	0	0	6	5	2	4	0	0	7	1	4	12	1	2	1	6	0	6	1	4

Figure 5. The percentages of pre- and in-service teachers with misconceptions by major

This study indicated that pre- and in-service teachers in all the three majors had almost all the misconceptions determined by Arslan et al., (2012). However, some misconceptions were more common than the others. For example, M12 (GE is a totally harmful phenomenon for mankind) is one of the most common misconceptions held by the participants (37%). The other prevalent misconception encountered in the same percent of the participants was that GW is caused by OLD (M1), and especially, this misconception was more common among pre-service teachers than among in-service teachers. However, the percentage of in-service teachers who believe that stopping the usage of CFCs is not a cure for GW (M6) was higher than that of the pre-service teachers. These misconceptions indicated that both pre- and in-service teachers confuse GW with OLD. Similarly, %20 of the participants believe that activities that damage the ozone layer should be avoided to reduce AR (M32). This misconception showed that the respondents linked OLD with AR. The other prevalent misconceptions are as following:

- Using filters for smoke from factories and cars reduces OLD (M25)
- Recycling more paper is not an effective cure for GW (M4)
- GE leads to OLD (M18)
- AR can burn everything that it comes in contact with (M31)
- CO is the main culprit of AR (M33)

4. Discussion and Conclusion

The aims of the study were threefold: (1) to investigate pre- and in-service teachers' understandings of atmosphere-related environmental issues in terms of gender and major (2) to

identify pre- and in-service teachers' misconceptions of GE, GW, OLD and AR, and (3) to determine the usage frequency of environmental knowledge resources by pre- and in-service teachers.

This study found that although male teachers scored higher in the AREPDiT than their female counterparts, the difference between them was not statistically significant. This finding was surprising when considering the related literature and stereotypical relationship between females and science. In other words, the literature has many studies reporting a significant difference in environmental knowledge in favor of males (Dijkstra, & Goedhart, 2012; Ocal et al., 2011; Pekel, 2005; Salehi, Nejad, Mahmoudi, & Burkart, 2016). For example, Ratinen (2013), who investigated primary student-teachers' understanding of the greenhouse effect using both open- and close-ended questionnaire, found that females had more misconceptions about the subject matter than males did. Similarly, Xiao and Hong (2017) reported that Chinese women had less environmental knowledge than did Chinese men even if they received the same training. On the other hand, female students' interest in science is generally less than that of male students (Jones, Howe, & Rua, 2000), and they feel less confident about their mathematics and science abilities than their male counterparts (McCright, 2010). Moreover, females tend to have a more negative attitude towards science (Weinburgh, 1995) and perceive science as more difficult than males (Jones et al., 2000). NEETF (2005) hypothesized that males outperform females in environmental knowledge as they are more likely to have a career in science- and/or technology-related fields. Korkut-Owen and Mutlu (2016), who investigated gender differences in the tendency to choose a career that involves the fields of STEM (Science, Technology, Engineering, and Mathematics) reported that although the gender gap in Turkey has narrowed in recent years, females continue to be underrepresented in fields of STEM. Thus it is clear that more research will confirm the current study's finding in which the gender gap in environmental knowledge is narrowing are needed.

This study found that although primary school teachers declared higher environmental interest than those in the other majors, both pre- and in-service primary teachers' knowledge of atmosphere-related environmental issues were found to be disappointingly low. This finding was similar to that of the previous studies in different nations, which explored primary teachers' understanding of atmosphere-related environmental problems (Arsal, 2010; Papadimitriou, 2004; Ratinen, 2013). Turkish primary teachers take only one environmental-related course during their undergraduate education. In earlier studies in our country (Ocal et al., 2011; Kisoglu, Gurbuz, Erkol, Akar, & Akilli, 2010), pre-service teachers expressed that one of the reasons for their poor environmental knowledge was traditional teaching methods used in their classrooms. Ratinen (2013) pointed out that traditional teaching methods that are based on the transmission of knowledge are not an appropriate way to teach atmospheric environmental issues such as the greenhouse effect and so on, which are abstract and complex in nature. The same factor may be one of the reasons underlying poor environmental knowledge of primary teachers participating in this study. On the other hand, a statistically significant difference between pre- and in-service primary teachers' understanding of the subject matter was not found. Primary teachers in Turkey do not teach GW, OLD, and AR in their classrooms as a part of the curriculum (MEB, 2018), and therefore, they may not actively follow the related literature. This claim may be an explanation of why there was no difference in environmental knowledge between pre- and in-service primary teachers. However, although primary school teachers do not give a course containing GW, OLD, and AR, their environmentally friendly behaviors have an important influence on students' behaviors. Because students may gain environmentally friendly behaviors not only from the

environmental-related courses but also from the behaviors of teachers who are role models for them (Sivek, 2002). Therefore primary school teachers play an important role in developing students who are knowledgeable about the environment and feel responsible themselves for the environment. Accordingly, the number and content of the environmental-related courses given in the primary school teacher education program may be revised. In addition, educational activities such as in-service training and workshops that will help primary school teachers recall their environmental knowledge they obtained in their undergraduate life can be organized.

Although pre-service social studies teachers receive more environmental-related courses (General Physical Geography-compulsory; The Current World Problems-compulsory; Geographical Ecology and Environmental Problems-selective) than pre-service primary teachers, no a significant difference between their AT/SK scores was found. However, in-service social studies teachers were more knowledgeable about the examined content than pre-service teachers. It is estimated that social studies teachers follow the developments in environmental education because they teach some of the atmosphere-related environmental issues (e.g., GW) to their students (MEB, 2018). This may be evidence of why there was a significant difference between pre- and in-service social studies teachers, but not between pre- and in-service primary teachers.

Unsurprisingly, pre- and in-service science teachers' understandings of atmosphere-related environmental issues were higher than that of pre- and in-service teachers with other majors. However, although pre-service science teachers receive a variety of courses which are directly (Special Issues in Chemistry-compulsory; Environmental Science–compulsory; Ecology and Environmental Consciousness-selective) and indirectly (General Chemistry-I and II–compulsory; General Chemistry Lab-Compulsory; Organic and Analytical Chemistry-compulsory) related to environmental issues, their AT/SK score was still poor (M = 4.35). It is clear that the quality of the college-level environmental courses should be assessed because an increasing number of courses is not enough to increase students' achievement. Pre-service teachers in Turkey reported that environmental knowledge provided by formal information resources such as instructors and textbooks was insufficient (Ocal, et al., 2011; Kisoglu et al., 2010). Science education researchers reported that students in the science classrooms where traditional teaching methods were used had an inadequate understanding and some common misconceptions of science concepts (Yalcin, 2012). It is estimated that one of the possible reasons for students' poor understanding and misconceptions of atmosphere-related environmental issues may be the teaching methods used in the teaching of environmental issues. Therefore, a revision of the traditional teaching methods used in environmental education and alternative teaching methods may be considered to enhance students' understanding of environmental issues.

This study found that both pre- and in-service teachers had some common misconceptions about GE, GW, OLD, and AR, and some of these misconceptions were compatible with those held by students in different grade levels. For example, some participants in the current study believed that the ozone layer helps to keep the Earth's temperature stable to make it livable. A similar misconception was also encountered in high school students in the study by Pekel and Ozay (2005). Furthermore, some of the respondents believed that using filters for smoke from factories and cars reduces OLD. Similarly, Boyes, Stanisstreet, & Papantoniou (1999) found that some high school students believed that OLD is caused by smoke from factories. The finding may be evidence

that teachers may be a source of misconceptions held by students because teachers who have misconceptions have the potential to transfer them to students.

Another finding was that both pre- and in-service teachers more commonly use mass media such as the Internet and TV to acquire information about environmental issues rather than formal sources such as seminars and books related to environmental issues. The influence of electronic and printed media seems to be an important factor in developing the environmental knowledge of students, the general public, and even teachers (Dove, 1996; Khalid, 2001). For example, Michail et al. (2007) found that primary teachers in Greece generally obtain their environmental knowledge through mass media such as newspapers and TV. A similar finding was also reported by Kisoglu et al. (2010) and Ocal et al. (2011). However, whether the information shared on mass media is scientific and correct is debatable. For example, Gungordu, Yalcin-Celik, and Kilic (2017), who investigated the effect of Internet-based media on Turkish students' understanding of the OLD, analyzed 219 local websites and found that these websites contained incorrect information or statements supporting misconceptions. Thus, the Internet, which is often the first choice to reach information, has the potential to develop new misconceptions or to reinforce old ones (Acar-Sesen, & Ince, 2010; Ocal et al., 2011). Incorrectness in the reporting of atmosphere-related environmental issues may confuse issues that are already abstract and complex in nature (Cordero, 2000). Therefore, in a scientific framework, programs that will help the society to enhance their awareness of environmental issues can be organized through mass media. According to the results of the current study, the least-used source by pre- and in-service teachers was seminars. Pre- and in-service teachers may be encouraged to participate in scientific activities such as seminars and symposiums, where scientific discussions about the environment are carried out. Furthermore, in-service training programs and workshops may be organized to eliminate the misconceptions held by in-service teachers. Moreover, both pre- and in-service teachers may be given training, including how to use the Internet to reach scientific knowledge effectively.

The study had some limitations, but the most important one was that the data of the study were collected using convenience sampling in which a group of subjects is selected on the basis of being accessible or expedient. The generalizability of results is limited because of the non-random nature of the sampling, and therefore, similar studies may be repeated a sample, which will be determined using a random sampling method. Second, for the purpose of this research, a factorial ANOVA approach was adopted to determine teachers' understanding of atmospheric environmental issues in terms of three independent variables. The use of quantitative methods may be effective in determining relationships between variables but is considered insufficient in lightning the factors underlying those relationships (Chisnall, 1997). Future research may enable researchers to explore more insight into the possible relationships among variables by integrating qualitative approaches with quantitative ones.

References

Acar Sesen, B., & Ince, E. (2010). Internet as a source of misconception. *Turkish Online Journal of Educational Technology*, *9*(4), 94-100.

Alp, E., Ertepinar, H., Tekkaya, C., & Yilmaz, A. (2006). A statistical analysis of children's environmental knowledge and attitudes in Turkey. *International Research in Geographical and Environmental Education, 15*(3), 210-223.

Arsal, Z. (2010). İlköğretim öğretmen adaylarının sera etkisi ile ilgili kavram yanılgıları [The greenhouse effect misconceptions of the elementary school teacher candidates]. *Elementary Education Online, 9*(1), 229-240.

Arslan, H. O., Cigdemoglu, C. & Moseley, C. (2012). A Three-tier diagnostic test to assess pre-service teachers' misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain. *International Journal of Science Education, 34*(11), 1667-1686.

Becker, L. A. (2000). Effect size. Retrieved from https://www.uv.es/~friasnav/EffectSizeBecker.pdf

Boyes, E., & Stanisstreet, M. (1997). The Environmental impact of cars: children's ideas and reasoning. *Environmental Education Research, 3*(3), 269-282.

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.

Cataloglu, E. (2002). *Development and validation of an achievement test in introductory quantum mechanics: the quantum mechanics visualization instrument*. (Unpublished doctoral dissertation) The Pennsylvania State University

Chisnall, P. (1997). Marketing Research, 5th edition. McGraw-Hill, Berkshire, UK.

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

Daskolia, M., Flogaitis, E., & Papageorgiou, E. (2006). Kindergarten teachers' conceptual framework on the ozone layer depletion. Exploring the associative meanings of a global environmental issue. *Journal of Science Education and Technology, 15*(2), 168-178.

Dijkstra, E. M., & Goedhart, M. J. (2012). Development and validation of the ACSI: measuring students' science attitudes, pro-environmental behaviour, climate change attitudes and knowledge. *Environmental Education Research, 18*(6), 733-749.

Dove, J. (1996). Student teacher understanding of the greenhouse effect, ozone layer depletion and acid rain. *Environmental Education Research, 2*(1), 89-100.

Driver, R., Guesne, E., & Tiberghien, A. (1985). *Children's ideas and the learning of science*. In: Driver R, Guesne E, Tiberghien A (eds) Children's ideas in science (pp. 1-9). Open University Press, Buckingham.

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.

Gungordu, N., Yalcin-Celik, A., & Kilic, Z. (2017). Students' misconceptions about the ozone layer and the effect of Internet-based media on it. *International Electronic Journal of Environmental Education*, *7*(1), 1-16.

Hestenes, D., & Halloun, I. (1995). Interpreting the force concept inventory. *Physics Teacher*, 33, 502–506.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, ınterests, and attitudes toward science and scientists. *Science Education, 84*(2), 180-192.

Kaltakci, D. (2012). *Development and application of a four-tier misconception test to assess pre-service students' misconceptions about geometric optics*. Unpublished Doctoral Thesis, Middle East Technical University, Institute of Educational Sciences, Ankara, Turkey.

Khalid, T. (2001). Pre-service teachers' misconceptions regarding three environmental issues. *Canadian Journal of Environmental Education, 6*(1), 102-120.

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

Kisoglu, M., Gurbuz, H., Erkol, M., Akar, M. S., & Akilli, M. (2010). Prospective Turkish elementary science teachers' knowledge level about the greenhouse effect and their views on

environmental education in university. *International Electronic Journal of Elementary Education*, *2*(2), 217-236.

Kolomuc, A., & Tekin, S. (2011). Chemistry teachers' misconceptions concerning concept of chemical reaction rate. *Eurasian Journal of Physics and Chemistry Education, 3*(2), 84-101.

Korkut-Owen, F., Mutlu, T. (2016). Türkiye'de fen bilimleri, teknoloji, mühendislik ve matematik alanlarının seçiminde cinsiyetler arası farklılıklar [Gender differences on selecting STEM Areas in Turkey]. *Education for Life, 30*(2), 53-72.

Leech, N. L., Barrett, K. C. & Morgan, G. A. (2005). *SPSS for Intermediate Statistics, Use and Interpretation*. (2nd ed.). Lawrence Erlbaum Associates Inc., Mahwah.

Lin, S.-W. (2004). Development and application of a two-tier diagnostic test for high school students' understanding of flowering plant growth and development. *International Journal of Science and Mathematics Education, 2*(2), 175-199.

McCright, A. M. (2010). The effects of gender on climate change knowledge and concern in the American public. *Population and Environment*, 32, 66-87.

McMillan, J. H., & Schumacher, S. (2006). *Research in education: Evidence based inquiry* (6th ed.). New York, Pearson Education.

MEB (Ministry of National Education) (2018). Programmes of instruction. Retrieved from http://mufredat.meb.gov.tr/Programlar.aspx

Michail, S., Stamou, A. G., & Stamou, G. P. (2007). Greek primary school teachers' understanding of current environmental issues: An exploration of their environmental knowledge and images of nature. *Science Education, 91*(2), 244-259.

Mitra, N. K., Nagaraja, H. S., Ponnudurai, G., & Judson, J. P. (2009). The levels of difficulty and discrimination indices in type a multiple choice questions of pre-clinical semester 1, multidisciplinary summative tests. *IeJSME, 3*(1), 2-7.

Nakhleh, M. B. (1992). Why some students don't learn chemistry. *Journal of Chemical Education, 69*(3), 191-196.

NEETF (2005). *Environmental literacy in America: What ten years of NEETF/roper research studies say about environmental literacy in the US.* Retrieved from https://files.eric.ed.gov/fulltext/ED522820.pdf

Ocal, A., Kisoglu, M., Alas, A., & Gurbuz, H. (2011). Turkish prospective teachers' understanding and misunderstanding on global warming. *International Research in Geographical and Environmental Education, 20*(3), 215-226.

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. O. (2005). High school students' and trainee science teachers' perceptions of ozone layer depletion. *Journal of Baltic Science Education, 1*(7), 12-21.

Pekel, F. O., & Ozay, E. (2005). Turkish high school students' perceptions of ozone layer depletion. *Applied Environmental Education and Communication*, *4*(2), 115-123.

Perneger, T. V. (1998). What's wrong with Bonferroni adjustments. *British Medical Journal, 316*, 1236-1238.

Ratinen, I. J. (2013). Primary student-teachers' conceptual understanding of the greenhouse effect: a mixed method study. *International Journal of Science Education*, *35*(6), 929-955.

Rye, J. A., & Rubba, P. A. (1998). An exploration of the concept map as an interview tool to facilitate the externalization of students' understandings about global atmospheric change. *Journal of Research in Science Teaching, 35*(5), 521-546.

Salehi, S., Nejad, Z. P., Mahmoudi, H., & Burkart, S. (2016). Knowledge of global climate change: view of Iranian university students. *International Research in Geographical and Environmental Education, 25*(3), 226-243.

Sanger, M. J., & Greenbowe, T. J. (1997). Students' misconceptions in electrochemistry: Current flow in electrolyte solutions and the salt bridge. *Journal of Chemical Education, 74*(7), 819.

Sivek, D. J. (2002). Environmental sensitivity among Wisconsin high school students. *Environmental Education Research*, *8*(2), 155-170.

Summers, M., Kruger, C., Childs, A., & Mant, J. (2000). Primary school teachers' understanding of environmental issues: An interview study. *Environmental Education Research, 6*(4), 293-312.

Tsui, C. Y., & Treagust, D. (2010). Evaluating secondary students' scientific reasoning in genetics using a two-tier diagnostic instrument. *International Journal of Science Education, 32*(8), 1073-1098.

Treagust, D. F. (1988). Development and use of diagnostic tests to evaluate students' misconceptions in science. *International Journal of Science Education, 10*(2), 159-169.

Walz, K. A., & Kerr, S. C. (2007). "Holes" in student understanding: addressing prevalent misconceptions regarding atmospheric environmental chemistry. *J. Chem. Educ., 84*(10), 1693-1696.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching*, 32, 387-398.

Xiao, C., & Hong, D. (2017). Gender differences in concerns for the environment among the Chinese public: An update. *Society & Natural Resources, 30*(6), 782-788.

Yalcin, F. A. (2012). Pre-service primary science teachers' understandings of the effect of temperature and pressure on solid–liquid phase transition of water. *Chemistry Education Research and Practice, 13*(3), 369-377.

Yalcin, F. A., & Yalcin, M. (2017). Turkish primary science teacher candidates' understandings of global warming and ozone layer depletion. *Journal of Education and Training Studies, 5*(10), 218-230.

Yip, D. Y. (1998). Teachers' misconceptions of the circulatory system. *Journal of Biological Education, 32*(3), 207-215.

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