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Evaluating Effects of an Exhibition Visit on Pre-Service Elementary Teachers' Understandings of Climate Change

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ABSTRACT

This research aims to investigate the extent to which a visit to a climate change exhibition embedded within an environmental education course affects pre-service elementary teachers' understandings about climate change. The sample comprised 58 pre-service teachers, enrolled in the environmental education course offered as part of the Elementary Education program at a private university in Turkey during the 2011/2012 academic year. The course lasted 13 weeks and was composed of various environmental issues as well as an exhibition visit and student reflections. Pre- and post-reflections written by pre-service elementary teachers' were analyzed and coded to examine the effect of the visit on their understanding of climate change. It was found that the course, and specifically the exhibition, had a positive effect on their understanding of climate change and ways in which to ameliorate the problem.

Keywords: Environmental Education; Understanding of Climate Change; Pre-service Elementary Teachers.

INTRODUCTION

Because the planet we inhabit faces serious environmental problems (Barnatt, 2012), educating citizens to be environmentally literate is increasingly important (Roth, 1992); therefore, environmental education (EE) has been added to curricula for early grades right up to higher grades of education (Blumstein & Saylan, 2007). Furthermore, there is a growing emphasis on EE research (Gayford, 2002). However, studies investigating the effectiveness of teaching programs in terms of students' understanding of environmental problems are rare (West, 2015). Although the positive and inevitable outcomes of visiting informal science settings are reported in science education literature (Rickinson et al., 2004), there are few EE researches that have studied the effect of such visits on understandings about environmental problems, in particular climate change. Investigating pre-service elementary teachers' understanding of climate change is significant because they will educate the citizens of the future.

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The climate change theme for the visit was intentionally selected because it is a dynamic and complex problem. The complexity of climate change stems from the long delay between emissions of greenhouse gases (GHGs), their accumulation in the atmosphere, their effect on temperature and climate, and the insufficient changes being made to emission policies (Moxnes & Saysel, 2009). These complexities result in misconceptions about climate change. Even graduate students from prestigious universities like Massachusetts Institute of Technology and Harvard have misconceptions about how GHGs accumulate in the atmosphere (Sterman & Sweeney, 2002).

Most recent literature focuses on perceptions, knowledge, and understandings about climate change (Bord, O'Connor, & Fisher, 2000; O'Connor, Bord, & Fisher, 1999), the gaps between environmental knowledge, environmental awareness and pro-environmental behavior (Kollmuss & Agyeman, 2002) and the actions people take in order to mitigate climate change (Whitmarsh, 2009). However, studies which investigate the impact of teaching methods on pre-service teachers' learning about climate change are rare.

The method chosen to investigate in this study was a visit because research in science education highlights the impact of visits on various learning outcomes. Visiting a science center or museum is reported to be enjoyed by students (Lucas, 2000), to foster knowledge and teaching (Bamberger & Tal, 2008), and to increase attitudes towards protecting wildlife (Hughes, Packer, & Ballantyne, 2011). There are also researches that show the benefits that visiting botanic gardens (Sellmann & Bogner, 2013) and other informal learning settings (Palmer, 2002) can have on students' understandings of environmental issues. However, there are few studies which have investigated the effect of visiting informal learning settings on students' understandings of climate change. Moreover, Yavuz-Topaloğlu and Balkan-Kıyıcı (2015) have highlighted the scarcity of studies about 'out-of-school' learning in Turkey.

The study presented here contributes to EE literature in a curricular way. The purpose of the study is to examine to what extent a visit to an exhibition embedded within an EE course affects pre-service elementary teachers' understandings about climate change. This effect will be determined by comparing reflections of the attending and non-attending pre-service teachers. By pointing out this effect, it will be possible to improve EE courses at education faculties.

Theoratical Background

Teaching Pre-Service Teachers Climate Change

Scientists argue that climate change negatively impacts human life and natural systems and continuously leads to problems such as drought, flood, heavy precipitation, disease, and so forth (IPCC, 2001). Educating children about climate change can decrease their vulnerability while supporting them to contribute to the sustainability of the Earth (UNICEF, 2013). In this sense, as pre-service teachers will educate children, teaching them about climate change is crucial.

There are various studies that have been conducted with pre-service teachers about environmental problems related to climate change, such as their misconceptions regarding the greenhouse effect, ozone depletion, and acid rain (Groves & Pugh, 1999; Khalid, 2001) and their knowledge, beliefs, attitudes, and awareness of climate change (Boon, 2014; Dal, et al., 2015).

Liu et al. (2015) argued that teachers who were concerned about climate change generally found it necessary to teach their students about climate change and its causes and effects; however, teachers who were more skeptical about climate change did not tend to teach their students about this. These researchers noted that the more aware the teachers were of climate change the more importance they placed on teaching their students about how

human activities affect the climate. In light of this finding, the importance of investigating pre-service teachers' understandings of climate change and testing how a specific educational method affects their understandings can be inferred.

Boon (2010) showed that there were similarities between secondary school students' and pre-service teachers' understandings of climate change and that those pre-service teachers' understandings were unacceptably low. The study stressed the need to develop teacher education programs that foster pre-service teachers' knowledge and understandings about climate change. The study presented in this paper meets this need by embedding an exhibition visit within an environmental education course for the purpose of improving the course.

Informal Science Learning and Visiting Exhibitions on Climate Change

The National Science Teachers Association (NSTA) advocates for museums, zoos, nature and environmental programs, and other science-rich cultural institutions to be used as informal science learning settings by valuing different and science-rich contexts and the availability of everyday experiences (NSTA Board of Directors, 2012). Science educators agree that informal learning settings, such as science museums, zoos, and botanical gardens, provide visitors with opportunities to enrich their scientific background (Bamberger & Tal, 2006; Falk, Storksdieck, & Dierking, 2007).

Hayden et al. (2011) highlighted the significance of informal science settings when teaching *supercomplex* issues as they integrate knowledge, interaction, and communication. Environmental scientists, as well science educators, emphasize the complex structure of climate change (Lambert, Lindgren, & Bleicher, 2012; Lombardi & Sinatra, 2013) which is regarded as today's most salient socio-scientific issue (Klosterman & Sadler 2010). Hayden et al. (2011) advocate that museums can educate people about the complex structure of climate change with the use of interactive exhibits. They suggest that viewing attractive images and models about climate change in a museum is more beneficial than being bombarded with a tremendous amount of scientific data in class.

Koepfler, Heimlich, and Yocco (2010) conducted a study with visitors to two different science museums about the content of climate change exhibitions in the museums. They found that all the visitors were motivated to have a scientific conversation about climate change using proper terminology such as *mitigation*, *adaptation*, and *greenhouse gases*. During their visits, they were able to identify evidence of the human impact on climate change. The general tendency was for the visitors to be introduced to the problem and then informed about solutions that they could engage in. An important conclusion of Koepfler et al.'s study (2010) was that the visitors realized the severity of climate change, however they preferred to focus on what actions they could take to have less impact on climate change rather than on its discouraging facts.

Research Questions

This research aims to investigate the effects of an exhibition visit on pre-service elementary teachers' understandings of climate change. The study presented here addresses the following research questions:

1. To what extent did the exhibition visit embedded within the environmental education program affect pre-service elementary teachers' understandings of climate change?

2. How did the EE course affect the participants' understandings of climate change?

3. Was there any significant difference between the understandings of participants who attended the exhibition and those who did not?

METHODOLOGY

a) Research Design

This study comprises an experimental design in two ways. Firstly, the research incorporates a one group pre-test–post-test design by collecting reflections at the beginning and end of the EE course. This allows for the effectiveness of the treatment implemented in the study, in terms of participants' understandings of climate change, to be tested. This design is also known as *repeated measures* of experimental design. In this design, the participants take part in the same treatment (the independent variable) (McLeod, 2007). Secondly, in order to investigate whether there was a significant difference between the understandings of participants who attended the exhibition and those who did not, *independent measures* of experimental design were utilized. In this design, different participants take part in each condition of the independent variable (McLeod, 2007). In this research, both quantitative and qualitative analyses were implemented to enable deeper insight and more comprehensive comparisons to be made between the pre- and post-reflections.

b) Sample

The sample comprised 58 students (8 males and 50 females) enrolled in an EE course in the Elementary Education program at a private university in Turkey in the spring semester of 2011/2012. When asked about their hometown, 71% described it as metropolitan, 22% as rural, 3% as a small town, 2% as a village, and 2% did not respond. When asked about the education level of their parents, 10% described their mothers as university graduates, 31% as high school graduates, 16% as middle school graduates, 38% as primary school graduates, and 5% did not respond. Two percent described their fathers as doctoral graduates, 19% as university graduates, 39% as high school graduates, 17% as middle school graduates, 21% as primary school graduates, and 2% did not respond.

c) Procedure

The treatment was implemented in the EE course that lasted 13 weeks. During the first five weeks, basic concepts and information about ecology and the historical development and causes of environmental problems were introduced. During the next five weeks, the pre-service teachers worked in groups (with three or four members) to prepare and deliver presentations about current environmental problems as listed below.

1. Water pollution
2. Air pollution
3. Soil pollution and erosion
4. Radioactive pollution
5. The depletion of the ozone layer
6. The loss of biological diversity
7. Waste
8. Energy
9. Hormone-injected foods and genetically modified organisms
10. Global warming

At the beginning of the term, the pre-service teachers submitted pre-reflections on the issue of climate change. After the presentations, the participants attended an exhibition about climate change. Participation in the exhibition visit was voluntary, but all participants were required to submit their post-reflection on climate change at the end of the term. 33 pre-service teachers volunteered to participate in the visit, while 25 did not.

The exhibition was located for a few months in Santral Istanbul at the Bilgi University campus. The main purpose of the exhibition was to increase attendees' awareness and

knowledge about climate change. The participants visited the exhibition for two hours. The exhibition included a half-hour seminar and a one-and-a-half hour presentation of models, videos, posters, and a graph showing the increase in atmospheric CO_2 and global temperature. Various models were exhibited, including those representing floods in some cities, (e.g. Manhattan after a sea level rise triggered by pressing buttons), bleached coral reefs, polar bears and polar foxes that lost their habitats, and so forth. The duration of each video was about five minutes and they were presented on monitors throughout the exhibition. These videos gave brief information about the changes taking place in some regions because of global warming and climate change. The posters were about various environmental problems, such as pollution (air, water, soil, and radioactive), erosion, the depletion of the ozone layer, the loss of biological diversity, waste, renewable and non-renewable energy sources, genetically modified foods, and global warming. It took approximately 45 minutes to read all of the posters. The posters also gave information about green buildings, energy saving bands in roads, and recycling. There were also employees giving information about these posters and models. The CO_2 and temperature graph was presented on a large wall and in front of each year there was a model representing a phenomenon that happened during those years. For example, there were peaks in both CO_2 level and temperature in the 1880s and in front this there was a model of a steam engine to represent the Second Industrial Revolution. The graph showed another peak in the 2000s in front of which there was a computer to represent their common usage in homes. The visitors to the exhibition were divided into two groups. One group listened to the seminar first and then visited the presentation and the other group visited the presentation first and then listened to the seminar.

d) Instruments

Pre-and post-reflections were the instruments used in this study. In their reflections, the participants were asked to write about the definitions, causes, and possible consequences of climate change, as well as their suggestions for preventing climate change. These constituted the categories for the coding. In their post-reflections, visitors were asked to write about their impressions of the exhibition, including what most attracted their attention. The reflections were coded and evaluated by the first and the second authors of this paper. Agreement percentages for each code were calculated and the two experts were found to be in 75–99% agreement. After separate coding, the two raters discussed their discrepancies and eventually reached total agreement (100%) in order to determine the codes listed in Tables 2–5.

e) Data Analysis

Various codes emerged from the participants' explanations for the definitions, causes, and consequences of climate change, and their suggestions for possible solutions (as listed in Tables 2–5). In addition to these four categories, the visitors' impressions of the visit were also coded by the researchers.

The McNemar test was used to analyze the codes that emerged from the participants' pre- and post-reflections. This test was used to investigate whether there were significant differences in dichotomous variables for the dependent samples (Laerd Statistics, 2013). Chi-square testing was used to compare the data of exhibition visitors and non-visitors. This test can be applied when there are two categorical variables within a single population (Stat Trek, 2016).

FINDINGS

The reflections were analyzed according to four categories: definitions, causes, and consequence of climate change, and suggestions for solutions to the problems of climate change. Specified codes, their frequencies, and percentages are reported in separate tables according to category. Tables 1–4 provide a general overview for the four categories. Further statistical analyses are included in the following pages.

Table 1. *Frequency distributions for definitions of climate change*

		CODES		
		Change	Long-term	Weather Conditions
Pre-Reflection	Frequency	16	6	17
	Percentage (%)	27.5	10.3	29.3
Post-Reflection	Frequency	46	34	47
	Percentage (%)	79.3	58.6	81

Table 5 shows the statistically significant results of the changes in pre-service elementary teachers' understandings of climate change throughout the course for those who attended the exhibition and those who did not, with a .05 confidence interval. It was found that the EE course resulted in significant changes in specified categories for both visitors and non-visitors to the exhibition.

Table 2. *Frequency distributions for causes of climate change*

		CODES								
		GHGs	Name of GHGs	Source of GHGs	Natural Causes	Defores-tation	Industry	Global Warming	Ozone Depletion	Irreg. Urban.
Pre-Ref.	Fre.	31	13	12	4	5	13	10	9	5
	Perc. (%)	53.4	22.4	20.6	6.8	8.6	22.4	17.2	15.5	8.6
Post-Ref.	Fre.	51	36	41	24	28	31	6	9	11
	Perc. (%)	87.9	62	70.6	41.3	48.2	53.4	10.3	15.5	18.9

Table 3. *Frequency distributions for consequences of climate change*

		CODES								
		Melting of Glaciers	Rising Sea Level	Global Warming	Droughts	Floods	Famine	Diseases & Deaths	Extinction of Species	Disc. about Turkey
Pre-Ref.	Fre.	18	18	26	24	22	11	18	22	8
	Perc. (%)	31	31	44.8	41.3	37.9	18.9	31	37.9	13.7
Post-Ref.	Fre.	40	38	41	37	33	13	30	34	12
	Perc. (%)	68.9	65.5	70.6	63.7	56.8	22.4	51.7	58.6	20.6

Two groups were formed according to participation in the exhibition; the visitors group (n=33) and the non-visitors group (n=25). For deeper analyses between visitors and non-visitors, a Chi-square test was used to compare the data for each. At the beginning of the course, the number of students who did not attend the exhibition identified the importance of the role of organizations, foundations, and governments in finding solutions to climate change as significantly higher than those who attended the exhibition ($p<0.05$) (Table 6). These students might attribute the solving of environmental problems to be the role of organizations, foundations and governments and underestimate individual efforts. This result can be accepted as an indication of their unwillingness to act environmentally. No significant difference was found between the two groups in terms of the other categories ($p>0.05$).

Table 4. *Frequency distributions of suggestions for climate change*

		CODES						
		Saving Energy	Renew. Energy	Public Transport	Green Buildings	Foresta-tion	Organi-zations	Waste Man.
Pre-Ref.	Fre.	15	7	5	1	11	13	0
	Perc. (%)	25.8	12	8.6	1.7	18.9	22.4	0
Post-Ref.	Fre.	29	38	30	8	28	23	8
	Perc. (%)	50	65.5	51.7	13.7	48.2	46.5	13.7

Table 6 also shows Chi-Square analyses of the categories that emerged from the participants' post-reflections. Pearson Chi-square value was used to analyze the data for the categories of names of the gases and individual efforts. Continuity correction value was utilized to interpret the result of the category of irregular urbanization because in one of the cells the observed value was less than five. Table 6 reveals that the participants who attended the exhibition visit scored significantly higher than those who did not in terms of knowing the names of greenhouse gases, knowing irregular urbanization to be a factor affecting climate change and for suggesting individual efforts as solutions to environmental problems.

Apart from the quantitative findings, the reflections include some indicative phrases that enable comparisons between the pre- and post-reflections to be made. Firstly, it should be noted that the pre-service teachers were free to utilize any reliable information found in print or on the Internet. As indicated by the results of statistical tests, the participants seemed to learn from the EE course, and their essays reflect their learning. The pre-reflections include several direct and in-direct quotations from various resources, while the post-reflections mostly contain the participants own statements and fewer references. The post-reflections of the visitor group referred to the exhibition while giving information on climate change.

In addition to their selection of references, the designation of the four categories also differed between the pre- and post-reflections. Definitions, causes, consequences, and suggestions could be identified clearly in the post-reflections. This clarity, or lack of it, might underlie the frequency differences shown in Table 5. Because it is a complex environmental problem, understanding the structure of climate change and identifying its causes and consequences is difficult. In the post-reflections, there were clear statements like 'global warming is not a cause, but a consequence of climate change' that might represent understandings about climate change. The terminology used in the pre- and the post-reflections differed. For example, some participants referred to GHGs as 'harmful gases' in their pre-reflections, while this phrase was not used in the post-reflections.

Table 5. *McNemar test results for the reflection categories wrt visitors and non-visitors*

		Visitors		Non-Visitors	
		N	Sig. (2-tailed)	N	Sig. (2-tailed)
Definition	Change	33	0.00*	25	0.01*
	Weather conditions	33	0.00*	25	0.01*
	Long time	33	0.00*	25	0.00*
Causes	Name of gases	33	0.00*		
	Sources of gases	33	0.00*	25	0.02*
	Natural causes	33	0.03*	25	0.00*
	Forest de.	33	0.01*	25	0.02*
	Industrialization			25	0.03*
Consequences	Glacier melting	33	0.04*		
	Destroying habitats	33	0.02*		
Solutions	Renewable energy	33	0.00*	25	0.01*
	Saving natural sources	33	0.02*		
	Individual efforts	33	0.00*	25	0.00*
	Public transport.	33	0.00*	25	0.04*
	Green buildings	33	0.03*		
	Forestation			25	0.02*
	Organizations			25	0.00*

*p<0.05

Table 6. *Chi-square test results between visitors and non-visitors*

Reflection	Codes	Category	Pearson Chi-Square Value	df	Asympt. Sig. (2 sided)
Pre-reflection	Solution	Organizations	5.25	1	0.02
Post-reflection	Cause	Name of the gases	9.54	1	0.00
Post-reflection	Cause	Irregular Urbanization	9.15	1	0.00
Post-reflection	Solution	Individual Efforts	4.58	1	0.03

*p<0.05

Table 7. *Impressions about exhibition*

Themes	Visitors (%)
Polar bears	63.64
Models	48.48
Green buildings	18.18
Energy platforms	15.15
Polar fox	12.12
Recycled materials	12.12
CO_2 graph	9.09
Pressing the button	9.09
Other	33.33
Not identified	12.12

DISCUSSION and CONCLUSION

Today we all know that EE plays a crucial role in educating environmentally literate citizens. To achieve this, most teacher education curricula have incorporated EE courses into their programs (Doğança, 2007; Powers, 2004). While there is a growing body of research about EE, there is also a need for more research into the effectiveness of the methods and activities used in these courses (Loubser, 2015). The study presented here addresses this need.

Elementary teacher education programs in the universities of Turkey include EE courses. These courses enable pre-service teachers to be informed and aware of environmental problems facing the world. In addition, there is a growing amount of literature about pre-service teachers and EE. Tuncer, et al. (2009) found that pre-service teachers' environmental background is positively related to their environmental literacy and attitude. The results of a study by Saribas, Teksoz, and Ertepinar (2014) showed that pre-service elementary teachers do not have sufficient environmental knowledge and self-efficacy beliefs related to EE. Saribas (2015) emphasized the importance of teacher education programs leading the cooperation between Turkish authorities, schools, and education faculties. The study presented in this paper contributes to teacher education literature on EE by revealing the impact of an intervention implemented in the EE course of a pre-service elementary teaching program.

The results of this study revealed that the EE course, with its focus on various environmental problems, seems to have had an impact on pre-service elementary teachers' understandings of climate change. Throughout the course they also improved their understandings about reducing and coping with climate change, including the use of renewable energy sources, public transportation, and the importance of individual effort. This result is consistent with literature that has examined the impact of EE on various learning outcomes (Doğança & Saysel, 2013; Grotzer & Basca, 2003; Hungerford & Volk, 1990).

The most distinctive aspect of the study presented here is organizing an exhibition visit and asking the volunteer visitors to write reflections after the visit, with all the pre-service elementary teachers writing reflections before and after the course. The exhibition, which included a seminar and presentations of models, videos, posters, and a graph showing the increase in atmospheric CO_2 and global temperature, seems to have had an influence on the pre-service teachers' understandings and awareness about environmental issues. This is evidenced as they show more knowledge about the definitions, causes, and consequences of climate change, and suggestions for solutions to the problems of climate change compared to their pre-reflections and the non-attendees.

A comparison of the reflections of the visitors and non-visitors reveals that the visitors were able to name more greenhouse gases and identify the negative effect of irregular urbanization and the importance of individual effort in solving environmental problems than non-visitors. Koepfler, Heimlich, and Yocco (2010) also concluded that the participant visitors in their study were able to select appropriate climate change terminology and were eager to take part in solutions to climate change. These findings were in line with the content of the climate change exhibition. Hence, it is appropriate to conclude that the exhibition visit had a positive impact on the visitor groups' understandings of climate change.

Another finding of this study relates to the tendency of students to assign the responsibility for solving environmental problems to organizations, foundations, and governments. This evasion of responsibility could have a negative influence on students' desire to take individual action. In consequence, students' beliefs should also be taken into account when designing EE curricula. Similarly, continuing efforts must be taken to overcome students' tendencies to be reluctant about solving environmental problems.

The pre-service elementary teachers' reflections indicate that affective appeals in the climate change exhibition attracted more attention than intellectual appeals. This result shows, as previously suggested by Hayden et al. (2011), that informal learning environments such as exhibitions presenting models and pictures with dramatic content can be more instructive than purely intellectual content. This finding can also be explained by the backgrounds of the participants in this study. These participants had limited backgrounds in science and EE and most of them chose to answer the questions about social sciences during the university entrance exam. The effectiveness of different affective and intellectual appeals on different samples of students warrants further investigation.

This study presents an alternative design for an EE course for pre-service teachers with the inclusion of a visit to an exhibition. Okur-Berberoğlu (2015) suggests the construction of outdoor education centers and outdoor education programs within universities. Having an informal learning environment within a university would probably increase the integration of these environments into teaching courses. A comparison of pre-service teachers studying in universities with and without informal learning environments in terms of specific content knowledge (e.g. climate change) and based on the theme of the centers or affective domains (e.g. self-efficacy in science teaching or attitudes towards informal learning, environmental attitudes) could be further research topics.

The data of this study were reflections written by pre-service elementary teachers at the beginning and end of an EE course. Interviews with some participants have resulted in deeper insight into understandings of climate change. Further research examining the effect of implementing different methods in EE courses on various outcomes at different grade levels is still required.

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