Environmental Experiments at the Primary School Level

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ABSTRACT
The focus of this paper is to demonstrate environmental experiments that were designed by pre-service teachers. Supportive lesson materials and PowerPoint presentations prepared by pre-service teachers are demonstrated along with three environmental experiments in an environmental education program. This program had been applied to 96 pre-service science teachers in a public university in Turkey. The data indicated that pre-service teachers had pro-environmental attitude and their environmental knowledge level subsequently improved.
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Introduction

The future of life on earth partly depends on the understanding of the necessity for making informed and wise decisions about the environment (Summers Kruger, & Childs, 2001). In this respect, environmental education (EE), formal or informal, plays a crucial role for developing such an understanding in children and youth. Media constitute a major informal source of knowledge that also influences children's environmental beliefs and behaviors. However, the information published or presented in the media is likely to be "ambiguous, short, fragmented, and commercialized" (Fortner, Lee, Corney, Romanello, Bonnell, Luthy et al., 2006). Moreover, EE should go beyond what popular media suggest and commercialize. Therefore, formal education plays a leading role in developing environmentally-responsible citizenship.

As an indispensable ingredient of formal education, teachers have the most important part; designing lessons including environmental content and demonstrating environmentally-responsible behaviors themselves. However, studies have shown that teachers with inadequate environmental background do not have the tendency to provide EE in their classes (Lane, Wilke, Champeau, & Shivek, 1995). In studies by Powers (2004) and McKeown-Ice (2000), teachers expressed their own deficiency in environmental knowledge. Furthermore, teacher training in EE was determined to be the weakest point in EE programs in five OECD countries: Australia, Austria, Finland, Germany, and Norway (Center for Education Research and Innovation of OECD, 1995).

Methods

Statement of the Problem

As a developing country, Turkey has been taking some of the first steps in the field of EE (Tuncer, Ertepinar, Tekkaya, & Sungur, 2005). Consistent with new emerging global problems and the need to educate students about these problems, the primary school curriculum was revised in 2005 (Doganca, 2007). However, the curriculum reform movement, that also supports inclusion of environmental content, has not yet been reflected in teacher training programs.

In Turkey, science teacher training programs involve pure science and pedagogical courses. Science classes are probably the most convenient sessions to make pre-service teachers comprehend the underlying dynamics of the planet and its problems. In addition to science classes, pre-service teachers take pedagogical courses to develop their skills to make effective lessons plans for the teaching of science. Although YOK (i.e, The Council of Higher Education of the Republic of Turkey) suggests to include environmental science courses in teacher training schedules (YOK, 2007), in practice in most education faculties, it is not possible for pre-service teachers to take environmental education courses, even as electives. Thus, there is an ongoing debate about whether or not teacher training programs in Turkey could catch up the increasing demand for informing the young population about changing dynamics of the planet.

Purpose of the Study

The aim of this paper is to present three environmental experiments, whose designs and related supporting materials were prepared by pre-service science teachers as a part of an EE program. The program has been applied in a *Science Laboratory Application Course* for two years in a public university, in Turkey. This kind of application, in which EE has been integrated into existing courses, also has been supported by the literature (Eagles & Demare, 1999).

Sample

The study included 96 junior and senior pre-service science teachers attending the science education program. The sample ranged in age from 21 to 29 years. The study was been applied to two different groups who were students of a lab course in the years 2006 and 2007 (Table 1).

Instruments

New Environmental Paradigm Scale. Environmental attitudes were measured by the Turkish translation of the New Environmental Paradigm scale (NEP). The scale included 12 items (Dunlap & Van Liere, 1978) and was translated to Turkish in Furman's (1998) study [Cronbach's alpha of the Turkish version = .61].

All attitude items were scored on a five-point Likert-type scale (from

[1] strongly disagree to [5] strongly agree). Negative items were recoded before analyses. Accordingly, higher scores represent more pro-environmental attitudes.

Table 1
Sample Description

Year 2006	Female	Male	Total
Junior	26	16	42
Senior	3	10	13
TOTAL	29	26	55
Year 2007			
Junior	18	12	30
Senior	6	6	12
Total	24	18	42
2-Year TOTAL	53	44	97

Environmental Knowledge Test. The Environmental Knowledge Test was developed to measure the environmental knowledge level of the pre-service teachers (Doganca, 2007). The test contained 20 multiple-choice items with four response options per item. The questions addressed various environmental issues. Thirteen items related to environmental experiments that were part of the program. The remaining seven questions addressed other environmental issues.

Development of the Environmental Education Program for Pre-service Science Teachers

Pre-service science teachers take two laboratory courses in which they prepare lesson plans based on primary school experiments. In these lesson plans, they have the opportunity to apply both scientific knowledge and pedagogical skills. In the last two years, the theme of the laboratory course was chosen as environmental problems for two reasons. First, environmental education plays the crucial role in understanding the continuously changing environment and its problems, and educating people to produce smart solutions for environmental problems. Second even though, the revised primary school science and technology curriculum (İlköğretim Fen ve Teknoloji Dersi Öğretim Program, 2005) includes environmental content, teacher training programs do not include environmental education as a required course.

In the content of the laboratory course, various teaching techniques were demonstrated. Throughout the course, the emphasis was placed on constructivism, rather than on behaviorism and cognitivism, which equates learning with creating meaning from experience (Bednar, Cunningham, Duffy, & Perry, 1995). The revised science and technology curriculum also supports constructivism as a way paradigm for learning. During the program, constructivist lesson plans enabled pre-service teachers to deal with the given tasks in real-life contexts, to learn collaboratively (in groups), to discuss their experiences in a supportive environment, and to talk about possible solutions and outcomes of the given environmental problems.

While introducing the environmental experiments, concepts, and problems, the researcher acted as a mentor without directing the course of instruction. This approach is another aspect of constructivist theory, where the teacher facilitates learning and students are active throughout the learning process. Similarly, the presenting group assisted other pre-service teachers during experimentation. Meanwhile, the audience was the active participant of the learning process by carrying out the experiment, sharing responsibilities of their groups; completing worksheets and data sheets, and discussing their results.

The program lasted for eight weeks. At the beginning and at the end of the program, environmental attitudes and environmental knowledge level of the pre-service teachers were measured with the NEP scale and the environmental knowledge test, respectively. The design of the program is summarized in Table 2.

The laboratory course was given as two sessions. In each session, pre-service teachers were separated into groups and each group of pre-service teachers was assigned a specific environmental experiment to prepare (Table 3). They were supposed to present the experiment accompanied by lesson plans, and show the relationship and relevance to a particular environmental issue.

Table 2
Course of the Environmental Education Program

Pre-tests (1 week)	Treatment (6 weeks)	Post-tests (1 week)
NEP Scale	Introduction of the Program	NEP Scale
Knowledge Test	Preparation of the Experiments	Knowledge Test
	Presentation of the Experiments	

Table 3
Experiments and Related Issues in the Program

Section	Experiment	Related Environmental Issue
I & II	Animal Adaptations	Effect of Irreversible Environmental Changes
I	Designing a Toxicology Lab	Effects and Disposal of Toxic Matters
I & II	Holding The Water	Erosion
I	Buffering Capacity of Soil	Acid Rain
I	Identification of Hard Water	Eutrophication
I & II	Production of Recycling Paper	Recycling
II	Creating a Volcano Model	Natural Air Pollution

Content of the Environmental Experiments

There were seven environmental experiments in the program. However, three experiments will be presented in this paper. While selecting the experiments in the program, the following principles were followed:

- The experiments should be at primary school level.

- The experiments should be safe enough to apply them in primary school classes.
- The experiments should not take more than a lesson period in a primary school.
- The materials of the experiments should not be complicated to ensure that experiments may be applied in every school even with a small budget.
- The experiments should be consistent with science and technology curriculum.
- Each experiment should address a substantially different environmental issue.

Experiment # 1: Animal Adaptations. The related objectives below were taken from the 8th grade science and technology curriculum, under the unit of "Cell Division and Heredity" (İlköğretim Fen ve Teknoloji Dersi Öğretim Program, 2005):

- To give examples and explain adaptations of living things to their environment.
- To point out that living creatures that share the same habitat develop similar adaptations.
- To give examples of how adaptations contribute to biodiversity and evolution as a result of environmental changes.

This experiment consisted of two parts. In the first part, models of different animals were created with simple materials. Four beakers having 100ml. of boiled water (having the exact temperature) were closed with aluminum foil. Thermometers were put into each beaker. One beaker was placed into a wool sock; representing an animal with heavy coat of fur. Second beaker was placed inside a flower pot containing sand. The second beaker represented an animal living in the desert. The third beaker was located into a flower pot without sand. Learners were asked to relate this model to an animal. The last beaker served as a control specimen. Then, students recorded temperature changes of water in four beakers for about 15 minutes (Environmental Health and Toxicology Community Outreach and Education, Basic Toxicology Laboratory Procedure and Worksheet, 2007).

In the second part, learners plunged their two fingers into icy water, one bare and the other covered with oil. Afterwards, they compared the temperature felt by both fingers in icy water. The same procedure was repeated with two thermometers, one covered with oil. The purpose of the experiment was to understand how animals adapt to different weather conditions.

After experimentation, there was an activity in which learners drew pictures of animals that were taken to habitats other than their own. At the end of the term, pre-service teachers in this study organized a science fair and primary school students were invited to the fair. This experiment also took place in the fair. In Figure 1, there is a picture drawn by a fifth-grade student. The drawing was about a camel which develops different adaptations to survive at the North Pole.

The rationale for placing this experiment into the program was to draw attention to the flexible characteristics of adaptations to various conditions. The emphasized environmental problem was oil spills. Although, living creatures have the ability to adapt to certain changes in their environment, there are some incidents that cause extinction of species. Most of these incidents arise from human activities. In such cases, extinction of a species takes place before suitable adaptations can be developed. Oil spills are examples of such incidents. The fur and feathers of aquatic animals and birds contain water repellent oil and fats that help them to resist cold water. These are chemically quite different than oil and tar found in crude oil. Spilled oil dissolves away bird's normal oil in its feathers and then the toxic crude oil penetrates to the skin and is absorbed into the blood and kills the bird. During the presentation, the group emphasized the drastic effects of oil spills to aquatic life and encouraged the class to discuss the consequences of oil spills.

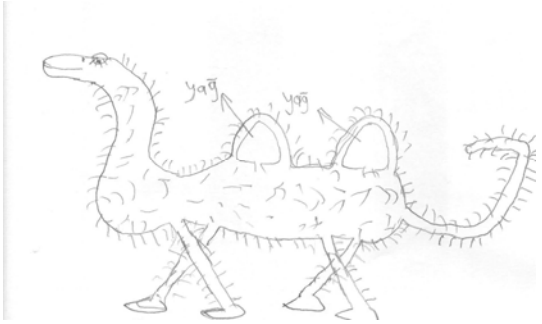
Experiment # 2: Designing a Toxicology Lab. Among the seven environmental experiments, only the toxicology lab exercises were not related directly to the topics in the science and technology curriculum. Nevertheless, stations required and evaluated solubility and acid-base knowledge that are the ingredients of the curriculum. Other than objectives related to these subjects, this experiment addressed some acquisitions that take place in the curriculum (İlköğretim Fen ve Teknoloji Dersi Öğretim Program, 2005):

- To understand that the management of wastes, the end-products of any technological system, is a crucial social and environmental problem.
- To give examples of expected and unexpected effects of scientific and technological advances to individuals, society, and the environment.
- To appreciate scientific studies and scientists.

This experiment also requires some science process skills like measuring, drawing graphs, gathering and interpreting data. The main objectives of this experiment were to make students:

- familiar with some toxicology terms,
- capable of identifying some toxic materials that are part of their lives, and
- aware of different effects of toxic materials to organisms.

Figure 1
Imaginary Adaptation Drawing



This experiment consists of four stations. In the first station, they learned the term "threshold limit" by tasting different amounts of salt

solutions. They drew graphs and pointed out where they felt they drank salty water on the graphs.

In the second station, learners added drops of food coloring to 100ml and 500ml of water and observed the resulting hues. This station was related to body size; the 100ml beaker represented a small child and the 500ml beaker represented an adult.

In the third station, drops of red cabbage extract, which is the raw material of acid-base indicators, were added to vinegar solution (a mild acid solution). Learners filled out a chart as the color of solution turned into red. Red color indicated that the organism died. During this station, students learned about dose-response relations.

In the last station, there were four beakers that appeared to be full of water. However, one beaker contained an acidic solution. As they poured droplets of red cabbage extract, only one solution gave a different response. This station emphasized the concept of individual susceptibility.

All of the stations were demonstrations of toxicology experiments (Environmental Health and Toxicology Community Outreach and Education, Basic Toxicology Laboratory Procedure and Worksheet, 2007). These demonstrations were safe to be handled in the classroom environment. Moreover, all the stations were easy to construct and students were successful in completing the tasks at each station. This experiment also enabled learners to work collaboratively in laboratory.

Before the experiment, the presenters played a little drama about scientists working in a toxicology laboratory. While students were doing the experiments, the presenters created an inquiry-based atmosphere by asking them questions related to the experiments. After completing the stations, each station was compared to real-life situations and students discussed the possible consequences of these real-life situations, such as prescribing the same amount of medicine to both children and adults. The PowerPoint presentation prepared by the pre-service teachers would be shared with the audience during the workshop.

Experiment # 3: Identification of Hard Water. The related objectives below were taken from the 8th-grade science and technology curriculum, under the unit of "Structure and Characteristics of Matter" (İlköğretim Fen ve Teknoloji Dersi Öğretim Program, 2005):

- To differentiate soft and hard water.
- To explain why hardness is not a preferable feature of water.
- To search for methods of reducing hardness of water.

The aim of this experiment was to test and to compare hardness of a variety of liquids. The testing method was simple and enjoyable for the primary school level; pouring the same amount of detergent into each liquid, shaking the liquids five times and measuring the thickness of foam with a ruler (Walker, 2001).

The presenting group focused on the consequences of using hard water for domestic purposes, discharging detergents, and the problem of lake "euthrophication" during the experiment. Although, euthrophication may be a new term for 8th-graders and even for pre-service teachers, the aim was to raise awareness about discharging excessive amount of detergents that affect all life forms and the environment.

This experiment also took place in the science fair and the presenting group had prepared a poster that could help call the attention of others to this problem (Figure 2).

Results

When the data of the years 2006 and 2007 were analyzed, it could be concluded that environmental knowledge level of pre-service teachers changed significantly in a positive way after the EE program in both years respectively ($t\ [n = 47] = -3.21$, $p < .05$; $t\ [n = 54] = -6.11$, $p < .05$).

Although there was a significant change in environmental attitudes (EA) of pre-service teachers in the year 2006, no significant difference was observed in the year 2007. This absence of change might be related to the difference in the inputs of the years 2006 and 2007 in terms of EA mean scores. In other words, pre-test EA scores were higher in the year 2007 compared to 2006. Moreover, the pre-test EA scores in 2006 were almost equal to the post-test EA scores in 2007 (Table 4).

Figure 2
Poster Prepared by the Pre-Service Teachers

Table 4
Descriptive Statistics of the Instruments

	NEP		EK	
Year 2006	I	II	I	II
Mean	42.82	44.49	9.29	11.55
SD	5.35	6.19	2.26	2.53
Year 2007	I	II	I	II
Mean	44.68	43.85	9.59	11.39
SD	5.59	8.71	2.71	2.86

Discussion

An encouraging finding of this study for a developing country, which is at the early stages of EE, was that: pre-service science teachers have pro-environmental attitudes (Doganca & Mugaloglu, 2007). This finding is encouraging in the sense that one of the goals of EE was developing an environmentally concerned population (UNESCO-UNEP, 1976). Moreover, a significant difference was found in the EK of prospective teachers before and after the treatment. So, in terms of EK, the program seemed to be working for the sample. The study

also supported the idea of inclusion of EE in teacher training curriculum rather than opening EE electives (Powers, 2004).

However, to generalize the results of the study, it would need to be carried out with a larger number of pre-service science teachers, science teachers, and primary school students. In addition, a comparison group would be necessary. Primary school students will be the ultimate target group, and teachers and pre-service teachers have a crucial role in facilitating a pro-environmental attitude and in developing an appropriate level of environmental knowledge.

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