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Development of pre-service science teachers' awareness of sustainable water use*

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Water is a vital resource for sustainable development. The aim of this research was to develop and evaluate pre-service science teachers' awareness of sustainable water usage. This research was based on a mixed method. The qualitative part of the research was based on a single group pretest-posttest experimental design, and the qualitative data were collected by open-ended questions. The quantitative data were obtained through the"Water Knowledge Test","Water Consumption Behavior Scale" and "Water Attitude Scale", which were developed by the researcher. The study group consisted of 3rd year pre-service science teachers who were studying during the 2011-2012 academic year at Eskişehir Osmangazi University. Water education for the study group was provided by the researcher for 5 weeks. Quantitative data were analyzed using a t-test for dependent groups, and qualitative data were examined by descriptive analysis. Following the water awareness education, a significant difference was found in the pre-service science teachers' water knowledge, water consumption behavior and attitudes toward water (p<.05). The results of the qualitative data showed that the majority of pre-service science teachers had increased concerns about adequate water supply. Most of them experienced increased awareness and to use water more carefully. In addition, 24 of the 33 pre-service science teachers believed that future generations will experience water related problems in 20 or 30 years. The results showed that water education is effective in developing a level of water knowledge, and influencing pre-service science teachers' water consumption behavior and attitudes toward water.

Key words: Water awareness, sustainable water consumption, water education, pre-service science teacher.

INTRODUCTION

The world has witnessed a substantial increase in water and energy consumption during the last century as a direct result of rising affluence, rapid urbanization, industrialization and population growth. One of the most

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significant reasons for this increase is the unplanned industrial activities that damage the environment in the name of rising standards of life (SHW, 2011). Water is essential to life, and it heavily influences public health and living standards. However, water is unequally distributed throughout the world.The total water volume worldwide is 1.4 billion km^3. Of this amount, 97.5% is available as salt water in oceans and seas, and 2.5% is fresh water in lakes and rivers. Because 90% of the small percentage of fresh water sources is trapped at the poles and underground, the amount of fresh water that is conveniently available for human use is less than might be expected (Ergin et al., 2009). At present, approximately 1.2 billion people live in areas where water is scarce, and 1.6 billion people face economic water shortages. As a result, given the unpredictable global demand for water, serious and chronic water shortages may persist in developing countries.

In the classification of countries according to the presence of water and the determination of current water conditions, countries with an annual average usable water volume per person of 1700 to 5000 m^3 are categorized as "countries with water problems". With an annual usable water volume per person of 1735 m^3, Turkey belongs to this class of countries (Turkyilmaz, 2010). According to data from the State Statistics, the annual usable water volume per person is expected to decrease to 1120 m^3/year by the year 2030. This estimate may be accurate if current resources are transferred to 2030 without loss. Therefore, resources must be well protected and used wisely to provide the next generation with healthy and clean water (SHW, 2011). Other factors that increase the water problem include technology that develops in line with the population, the adverse effect of global climate change on water sources, and the non-homogenous distribution of water sources on earth. Therefore, attention must be paid to balancing water use with distribution and using resources wisely through new strategies (Pamuk and Akkuzu, 2008).

Water education can be important in effecting social change toward a sustainable society. The United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, agreed to a global environment and development agenda for the 21st century, called Agenda 21. Agenda 21 stated, "Education, including formal education, public awareness and education should be recognized as a process by which human beings and societies can reach their fullest potential. Education is critical for promoting sustainable development and improving the capacity of people to address environment and development issues" (Blanchard, 1995). Especially in developed countries, many programs have been developed in relation to the "conservation of water resources". Numerous projects have been conducted and books containing various activities have been prepared for at least 20 years. The Water Education for Teachers (WET, 2009) project and the Environmental Protection Agency (EPA, 2009) in the United States, Seine-Normandie Water Agency (2008) and Centre d'Education `a l'Environnement d'Amaury (2008) in France, R´eseau-Id´ee (2008) in Belgium and Helvetas (2009) in Switzerland are some examples of these projects.

Sustainability is a long-term and complex goal. Literature reviews show that, recent research on water sustainability comes from different fields, and the impact of education on water sustainability has variable significance. Research by Ergin et al. (2009) and supported by TUBITAK (The Scientific and Technological Research Council of Turkey), aimed to develop educational materials related to water and to increase water awareness among primary school undergraduates, teachers and adults. The results of the study, showed that undergraduates and teachers develop their cognitive and emotional knowledge regarding subjects such as water knowledge, water pollution, and water saving, and that their awareness of the environment increases concurrently. This study determined that the learning ability of adult participants develops in a more limited way and is not permanent.

In their study, Alas et al. (2009) aimed to determine candidate teachers' water consumption behavior and to provide recommendations for improving their erroneous behaviors. The study was conducted in the 2007-2008 spring academic year with 139 senior-class biology, chemistry and physics education students attending a secondary education program in Kazim Karabekir Education Faculty at Atatürk University. To aid in the determination of the prospective teachers' water consumption behaviors, a three-point likert type "Conscious Water Consumption Survey" consisting of 13 statements that was developed by the researchers was used in the study. The results showed that the prospective teachers did not consider water management. Furthermore, it was determined that the prospective teachers' water consumption behaviors did not differ according to their gender, age, department or place of residence.

In their study, Havu-Nuutinen et al. (2011) analyzed the perceptions of students in the 4^{th} and 5^{th} grades of primary schools regarding water problems in the context of science, technology and community education. The students were asked to write and draw pictures about any water concept before and after water awareness education. The goal of the research was to understand the students' perceptions of water and water problems as

they relate to science, technology and community education. Initially, the undergraduates defined water as a material used for drinking, swimming and bathing. After water awareness education, however, they defined water more scientifically, and the focus of their drawings and texts was topics such as the water cycle, water pollution, and water protection.

Brace and Yoon (2011) designed a computer-aided water project to enable candidate primary education teachers to research questions on water and find solutions. The candidate teachers were asked to prepare placards and brochures and to discuss the use of e-learning software to maintain awareness of water problems. When the materials and opinions of the candidate teachers were examined, it was determined that the water project included an effective e-learning activity to increase awareness of global water problems.

A study conducted by Ay (2013) examined sustainability, which is discussed comprehensively in most national and international academic, social and strategic development meetings and is a primary global agenda issue, as well as the water potential of Turkey and its, water footprint, carbon footprint, current news and relevant links.

Sammel (2014) aimed to answer questions such as, “What does it mean to be scientifically literate in relation to water?” and “Is this understanding the same for water literacy?” An investigation by the Australian Science Curriculum and a small case study of pre-service education students highlight the degree to which one concept is preferred over the other. The 32 participating students were asked to complete a survey consisting of 13 questions to self-report their knowledge and comfort with teaching about water. The survey investigated 6 themes to assess the pre-service teachers’ comfort with teaching about water: science concepts; social, political and economic issues; sustainability and the natural environment; indigenous ways of knowing; government and community connections; and planning and emergency preparedness. The results showed that of the 32 participants, 84 % (n=27) indicated they would feel comfortable teaching scientific concepts associated with water education. Teaching the implications of water in relation to the natural environment was the next most common response, with 69% (n=22) of participants indicating their comfort. The lowest scoring aspect, indicating the participants’ lack of comfort with teaching this aspect of water education, was indigenous ways of knowing in relation to water; only 9% or 3 of the participating pre-service students affirmed their comfort with teaching this aspect.

When relevant studies are analyzed, the research is usually found to include scanning activities to determine individuals’ water saving attitudes. However, it is also important to determine the existing mindset and attitudes toward water awareness and to understand relevant cognitive and, affective developments. In this research, we aimed to develop awareness among pre-service science teachers, who will become the teachers of the future. We believe that this research may contribute to removing the water deficit addressed above through water education provided to candidate teachers and that this study may serve as a guide for further research.

Based on the water education process, answers to the following questions are analyzed:

1. Is there any meaningful difference between the knowledge level of the pre-service science teachers before and after the water education?
2. Is there any meaningful difference between the water consumption attitudes of the pre-service science teachers before and after the water education?
3. Is there any meaningful difference between the water attitudes of the pre-service science teachers before and after the water education?

After the water education:

4. What differences appear in the pre-service science teachers’ opinions about water pollution and sustainable development?
5. How have their attitudes and behaviors changed?
6. What are their opinions about any possible future water problems?

METHODS

Research mode

This research was developed using a mixed method. Mixed method is a type of research that includes the collection of quantitative and qualitative data (Punch, 2009).

Different versions of mixed method research are available. This research was designed according to the sequential descriptive mixed method based on the classification of research models used most frequently in Creswell’s (2011) education research.

The quantitative dimension of the research was performed with a one-group pre-test and post-test model. In the one-group pre-test and post-test model, an independent variable is applied to one group, and a measurement is made before and after the administration. If there is a considerable difference between the arithmetic averages of the group’s pre-test and post-test scores determined by the measurement tools, it is accepted that the administration is effective (Karasar, 2002; Balci, 2004).This study was designed to determine the effect of water education on the awareness of the pre-service science teachers in the one-group model. In Table 1, the experimental model used in the research is shown.

The qualitative dimension of the research was performed using the designed discussion form.

Table 1. One-group pre-test and post-test experimental design.

Groups	Pre-test	Experimental practice	Post-test
Study Group	Water Knowledge Test Water Consumption Behavior Scale Water Attitude Scale	Water Education	Water Knowledge Test Water Consumption Behavior Scale Water Attitude Scale

Study group

The study group was composed of 35 pre-service science teachers enrolled in the Department of Elementary Education, Faculty of Education at Eskisehir Osmangazi University during the 2011-2012 academic year. The study group was determined according to the criteria sampling method, a purposeful sampling method. The inclusion criterion of the study group was enrollment in the course "Environmental Science". Any topics related to water are included in the "Environmental Science" course in the universities. This course is taken by 3rd year pre-service teachers.

Data collection

Data collection tools

The measurement tools used to collect data from the undergraduates were as follows:

1. A "Water Knowledge Test" developed to measure the pre-service science teachers' knowledge of water;
2. A "Water Consumption Behavior Scale" developed to determine the pre-service science teachers' attitudes toward water consumption;
3. A "Water Attitude Scale" developed to determine the pre-service science teachers' attitudes toward water;
4. A structured discussion form prepared to collect qualitative data.

Water knowledge test

The Water Knowledge Test is an achievement test prepared by the researchers and developed to assess the pre-service science teachers' general knowledge of water. It consists of multiple-choice questions and was developed in accordance with the test preparation principles for this type of test.

The following steps were followed in the development of Water Knowledge Test:

Formation of the Question Basin: Gains related to water in the science curriculum and literature were examined. The Water Knowledge Test question basin consisted of 30 questions.

Reliability and Validity: The prepared questions were examined by nine voluntary experts, who studied primary education in general and specialized in science. Nine questions were removed from the scale because they could not satisfy content validity. As a result of the recommendations of the experts the subject of the amount of potable water worldwide was added as a question. The application of the test in the 2011-2012 academic year was conducted in various universities with 247 senior science teachers. The universities that participated in the research and the numbers of participants are given in Table 2. After the administration of the test, five questions were removed from the scale.

The average difficulty level and the KR20 safety coefficient of this 17 question test were 0.485 and 0.422, respectively. The knowledge test was administered to the study group as a pre-test and post-test.

Water consumption behavior scale

The Water Consumption Behavior Scale was developed by the researchers to determine the pre-service science teachers' attitudes toward water consumption (Cankaya and Filik Iscen, 2014). The scale is a five point Likert scale consisting of 16 questions. The internal consistency coefficient was calculated as 0.83. The water consumption attitudes scale was administered to the study group as pre-test and post-test.

Water attitude scale

The Water Attitude Scale was developed by the researchers to determine the pre-service science teachers' attitudes toward water.

The following steps were followed in the development of the Water Attitude Scale:

Formation of the Sentence Basin: A review of the literature on attitude sentences was prepared, and 17 sentences were selected for the scale.

Selecting the Scale Type: The scale was a five point Likert scale.

Reliability and Validity: The prepared questions were examined by nine volunteer experts, who studied primary education in general and specialized in science. One question was removed from the scale because it could not satisfy content validity.The application of the scale in the 2011-2012 academic year was conducted in various universities with 201 senior science teachers. The universities that participated in the research and the numbers of participants are given in Table 2. After the administration of the test, three items were removed from the scale.

The internal consistency coefficient of this 14-item scale was calculated as 0.897. The Water Attitude Scale was administered to the study group as a pre-test and post-test.

Structured discussion form

The discussion form was prepared to support the quantitative data of the research. Open-ended questions were prepared to assess the behaviors and attitudes of the candidate teachers on matters

Table 2. Distribution of participating students by university.

	Water Knowledge Test		Water Consumption Behavior Scale		Water Attitude Scale	
	n	***%***	***n***	***%***	***n***	***%***
Pamukkale University	95	0.39	97	0.39	74	37
Muğla University	100	0.40	100	0.40	75	37
Eskişehir Osmangazi University	52	0.21	52	0.21	52	26
Total	247	1.00	249	1.00	201	1.00

n=frequency.

such as water pollution, sustainable water, and potential future problems associated with water. The form consists of three questions in an open-ended question form. Two science education specialists and two science teachers were consulted for their opinions to ensure the content validity of the open-ended questions. The structured discussion form was administered to the 33 pre-service science teachers.

Water education process

The research data were obtained from the "water education", which continued for 5 weeks. The water awareness education process was prepared on a weekly basis, and the relevant content, methods, techniques and activities were as follows:

Week 1 (04/18/2012): Topics titled "Water Description and Properties", "Water Standards", and "Water Cycle" were discussed, and the discussion was visually enriched by presentations. A video containing specialists' opinions on water stiffness and the nature of potable water was shown, and the opinions of the undergraduates were obtained using discussion. Furthermore, relevant news compiled by journalists was reviewed to help the undergraduates gain awareness of water sustainability in daily life. The undergraduates actively participated in the course during the process. A microbiological analysis of drinking and potable waters supplied by the undergraduates from different places was conducted in study groups that were formed prior to the study. A microbiological analysis of water with different properties (e.g, village foundations, water taken from a treatment device, tap water, dispenser size bottled water, bottled water) was conducted by the undergraduates under the guidance of specialists working in this field at the Water Laboratory of the Faculty of Science and Arts of Eskisehir Osmangazi University, and a test report of the results was obtained.

Week 2 (04/25/2012): The topics "Importance of Water" and "Water and Health" were discussed using a conference technique with the help of a specialist invited to the faculty.

Week 3 (05/02/2012): The topics "Condition of Water and Distribution of Water Resources in the World", "Volume of Water Resources in our Country", and "Industrial Use of Water Resources in the World and in Our Country" were discussed, and the discussion was visually enriched by enriched presentations. The activity "How is Water Distributed in the World?", which aimed to describe water conditions and distribution in the world and to solidify these concepts in the undergraduates' minds was performed during this week. Furthermore, the video "Many a Little Makes a Pickle", which discusses the use of water in the architecture industry, was watched by the undergraduates, and their opinions and questions were obtained. Thus, the undergraduate's ability to think and research the subject was challenged during this week.

Week 4 (05/09/2012): The topics "Water Losses in the World and in Our Country", "Usable Water Amount Per Person in the World and in Our Country", and "Increased Water Problems in the World and in Our Country" were discussed and supported by presentations. Furthermore, the Adobe Flash Player application "Water Saving" prepared by the TEMA (The Turkish Foundation for Combating Soil Erosion for Reforestation and the Protection of Natural Habitat) was used in this step. The undergraduates actively participated in the learning process through the "Global Water Crisis" and the "We Consume Water More Than We Drink" activities. The application "Water Footprint Calculation from the website "www.waterfootprint.org" was presented. The undergraduate students calculated their own water footprints to better understand this concept and determined any possible changes in their own water use.

Week 5 (05/16/2012): The topics "Water Pollution and Waste Water Recovery" and "Water Legislation" were discussed and supported by presentations. During this week, a trip to a drinking and potable water treatment plant was arranged. The aim was for the undergraduates to learn the subject in situ and via specialists by making observations. In an activity titled "Alternative Water Sources for Drinking Water", large-group and small-group discussions were conducted.

Data analysis

SPSS (Statistical Package for the Social Sciences) software was used to analyze the quantitative data. The significance level was set at .05. The average and standard deviations were calculated according to descriptive statistics, and a dependent sample t-test analysis was conducted to determine whether there were considerable differences between the total scores.

A descriptive analysis was used to analyze the qualitative data. Data obtained in the descriptive analysis were defined systematically and clearly according to the determined topics and these descriptions were clarified and interpreted. Their cause-effect relationship was critically assessed to obtain results (Yildirim and Simsek, 2008).

Table 3. Dependent groups of the water knowledge test, t-test results.

	n	$\overline{X}$	*Sd*	*t*	*df*	*p*
Post-test	35	75.25	13.173	-5.946	34	.000
Pre-test	35	60.20	13.367			

n=frequency; $\overline{X}$ =arithmetic average; sd=standard deviation; t=difference of difference; df=degree of freedom; p=significance; p< .05.

FINDINGS

Findings on water knowledge of the pre-service science teachers

The results of the dependent sample t-test conducted to determine whether there was a considerable difference between the scores obtained by the pre-service science teachers on a water knowledge test are presented in Table 3.

As shown in Table 3, although the post-test success score obtained by the study group on a water knowledge test was 75.25 with a standard deviation of 13.173, their pre-test success point was60.20 with a standard deviation value of 13.367. Based on the results, there was a considerable difference between the water knowledge levels of the undergraduates before and after the water education (t=-5.946; p<0.05). On the water knowledge test, the post-test score of the undergraduates ($\overline{X}$ =75.25) was higher than their pre-test score ($\overline{X}$ =60.20).

This considerable difference is in favor of the post-test scores. This effect shows that topics such as the structure of water, the distribution of water on the earth, water and health, the water cycle, and water pollution, that were taught during the five-week education program were effective in increasing the pre-service science teachers' post-test scores.

Findings on water consumption attitudes of the pre-service science teachers

The results of the dependent- sample t-test conducted to determine whether there was a considerable difference between the scores obtained by the pre-service science teachers on the Water Consumption Attitudes Scale before and after water education are presented in Table 4.

Table 4 shows that, the-post test score obtained by the candidate teachers on the Water Consumption Behavior Scale was 65.22 with a standard deviation of 7.996. The pre-test score obtained by the pre-service science teachers on the Water Consumption Behavior Scale was 59.22 with a standard deviation of 8.206. According to the results of the dependent sample t-test analysis, there a considerable difference between the water consumption attitudes of the pre-service science teachers prior to and after water education (t=-5.852; p< 0.05). This considerable difference is in favor of the post-test scores. It can be concluded that the activities performed during the education process were effective in changing the water consumption attitudes of the pre-service science teachers. In the activity "How is Water Distributed in the World?", the amount of usable water sources was demonstrated by concrete examples. Furthermore, the pre-service science teachers calculated their own water footprints, causing them to reflect on their water consumption attitudes.

Findings on the pre-service science teachers' attitudes toward water

The results of the dependent sample t-test conducted to determine whether there was a considerable difference between the scores obtained by the pre-service science teachers on the Water Attitude Scale before and after water education are presented in Table 5.

Table 5 shows that the-post test score obtained by the pre-service science teachers on the Water Attitude Scale was 63.22 with a standard deviation of 6.398.Similarly, the pre-test score obtained by the pre-service science teachers on the Water Attitude Scale was 61.68 with a standard deviation of 5.890.According to the findings, the post-test scores ($\overline{X}$ =63.22) were higher than the pre-test scores ($\overline{X}$ =61.68) on the Water Attitude Scale. According to the results of the dependent sample t-test analysis, there was a considerable difference between the water consumption attitudes of the pre-service science teachers prior to and after water education (t=-2.058; p< 0.05).

These analyses can be interpreted as indicating that a considerable difference exists in the knowledge of the pre-service science teachers regarding water, water consumption attitudes and water attitudes in favor of their post-test scores on water knowledge, and that the water education had an effect on the development of their awareness. However, these increased scores, might also reflect the effects of different variables that arise from the application of the experimental mode, including the

Table 4. Dependent group of the water consumption attitudes scale, t-test results.

	n	$\overline{X}$	*sd*	*t*	*df*	*p*
Post-test	35	65.22	7.996	-5.852	34	.000
Pre-test	35	59.22	8.206			

n=frequency; $\overline{X}$ =arithmetic average; sd=standard deviation; t=difference of difference; df=degree of freedom; p=significance; p< .05

Table 5. Dependent group of the water attitude scale, t-test results

	n	$\overline{X}$	*sd*	*t*	*df*	*p*
Post-test	35	63.22	6.398	-2.058	34	.047
Pre-test	35	61.68	5.890			

n=frequency; $\overline{X}$ =arithmetic average; sd=standard deviation; t=difference of difference; df=degree of freedom; p=significance; p< .05

maturation of the subjects, reactivity and the pre-test effect (Neuman, 2007).

FINDINGS ON QUALITATIVE DATA

Open-ended questions were posed to 33 pre-service science teachers to collect qualitative data. The topics and sub-topics of these questions are shown in Figure 1.

Opinions of the pre-service science teachers on water pollution and water sustainability

After the water education, there were seven changes in the opinions of the pre-service science teachers who participated in the research regarding water pollution and water sustainability. These changes in opinion are shown in Table 6.

Table 6 shows that eight of 33 pre-service science teachers stated that water pollution is a critical problem, and another eight pre-service science teachers stated that water saving would be effective for water sustainability. Seven pre-service science teachers stated that their concerns about water pollution and water sustainability increased. Six pre-service science teachers stated that water pollution is partly responsible for current and future water shortages. Only two pre-service science teachers, stated an increased belief that water shortage is hindered through measures taken; this item received the lowest frequency of responses.

One pre-service science teacher (Student -S23-), who perceived the severity of the water shortage, addressed the importance of water for life and stated, *"At the end of this study, I notice that we use water subconsciously. I'm worried that water, which is highly valuable for life, is used casually. If human beings continue to mishandle water so much, there is a high likelihood that we will experience a water shortage in the future*". Participant S16 stated that he/she knew that there was global water shortage and that, the activities and tests in this study improved his/her understanding of water footprints and the condition of water resources. Nonetheless, participant S18 stated that prior to the study, he/she was unaware that the water shortage likely that was to occur was so critical. Furthermore, this participant said that he/she noticed the severity of the water shortage more clearly, when he/she examined the water conditions and management of other countries. When participant S18 stated his/her opinions, he/she also talked about the concept of "water management".

Eight of the pre-service science teachers, who participated in the research, perceived the importance of water saving through water education. Water saving is fairly important for sustainable water. The understanding of this need by the pre-service science teachers is fundamental for changes in their attitudes. One of the pre-service science teachers, (S11) stated, *"We already said that we had to pay attention, but never made an effective effort. However now we are more conscious and we know that water will never suffice in this way".* Therefore, this participant began to use water more economically. Another pre-service science teacher (S17) emphasized that he/she was more aware of water pollution and water shortage and added *"My opinions changed. I used to leave the water tap on for a long time, but now I use water more carefully. Each time I turn the tap on in the kitchen and bathroom, I remember*

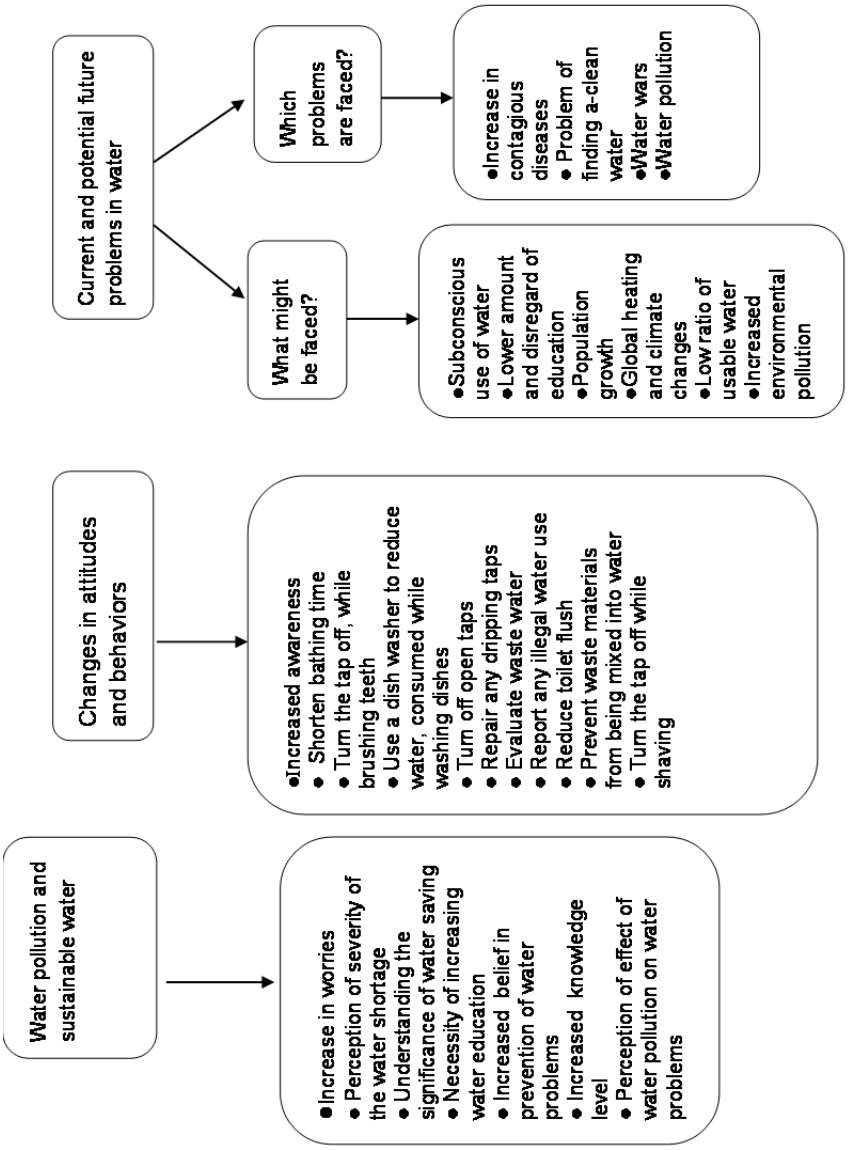

Figure 1. Topics and sub-topics obtained from interpretation of qualitative data

Table 6. After water education changes in opinions on water pollution and water sustainability of the pre-service science teachers.

Sub-topics	***(f)***
Increase in concerns	7
Perception of severity of the water shortage	8
Understanding the significance of water saving	8
Necessity of increased water education	3
Increased belief in the prevention of water shortage	2
Increased knowledge	3
Perception of the effect of water pollution on water shortage	6

everything I have learned and watched in the environmental science course".

Seven of the pre-service science teachers, who participated in the research-, expressed increasing concern regarding whether the water supply would be adequate. When the statements made by the pre-service science teachers were reviewed, it was noted that they stated having incorrect knowledge of the condition of water resources in the world and in the country prior to water education. The developments observed in their knowledge levels also support findings obtained in the Water Knowledge Test. The statements of some pre-service science teachers, who expressed their opinions, were as follows.

Three of the pre-service science teachers,-who participated in the research-, stated that water education must be provided to prevent water pollution and to ensure water sustainability. S5 stated that, if water sustainability education began during pre-school, this might prevent a possible future water shortage. Another pre-service science teacher (S31) stated his/her opinion:*"If people around me never raise awareness of this, water will continue to be polluted and consumed. The conferences must not only reach schools, but also the people. As teachers of the future, we must do our best*".

Two of the pre-service science teachers,-who participated in this research-, expressed their belief that although the water shortage might be compromised, water sustainability might be ensured through any measures taken. However, the number of pre-service science teachers, who expressed this opinion, was fairly low. These pre-service science teachers (S2 andS8) stated that, if individual awareness of water sustainability develops, the amount of water will be adequate. One of these pre-service science teachers (S8) stated,

"If everybody saves water individually, water suffices, but if, water consumption continues, a water shortage will occur in the future. People must be more aware of this".

Six pre-service science teachers,-who participated in this research-, stated that water pollution triggers water problems. The participants believed that this problem will have an adverse effect on the water use of the next generations. They believed that is it important to understand that water sustainability is not only ensured by water saving. One of these pre-service science teachers stated his/her opinion, as follows:

"This has enabled me to know the causes of water pollution in more detail. The methods I used in water education have enabled me to realize this. I think that, although it seems as if there is an unending supply of adequate water, when people continue to consume it subconsciously, one day it will run out".(S1)

"Turkey is a rich country in terms of water resources. However, the fact that water is not treated and made reusable by using advanced technology causes major water shortages. Because water is polluted quickly, it might not be enough in the future. It is very sad that most lakes and rivers fight against water pollution in our country. This affects other creatures".(S26)

Three of the pre-service science teachers,-who participated in this research-, stated that no change occurred in their opinion on water pollution and the fact that the water supply will never suffice. However, they attributed this belief to their sensitivity to this matter. Based on the statements of the pre-service science teachers, it is clear that family plays a critical role in awareness of the environment. One of the pre-service science teachers, S25, stated, *"Obviously, any major change never occurs. My relevant opinions are already strong maybe due to my education department, but mostly due to my family".*

Changes in attitudes and behaviors of the pre-service science teachers after water education

Twelve attitudes and behaviors of the pre-service science teachers that were expected to change after water education are shown in Table 7.

Thirteen of the pre-service science teachers, who participated in the research, stated that it is important to make people aware of water use and that they would make an effort to this end. The responses that the pre-service science teachers gave mostly reflected the need to make people aware of the water problem. This might be associated with the pre-service science teachers' professional missions. Some pre-service science teachers stated the following about this matter:

"….*Primarily, we must make people aware of water pollution and water insufficiency. In our teaching life, we talk about environmental pollution in the science and technology courses".* (S30)

"….I realize that I scrimp and save while using water. Because I live with my family, I will tell them this information".(S15)

"….I think that I will pay more attention to water saving , and when I become a teacher, I will make my students and their guardians aware of this matter".(S10)

The second most common answer by the participants (five pre-service science teachers) was to shorten bathing time. One pre-service science teacher stated that one of the areas, in which water is mostly consumed, is showers. Furthermore, this participant talked about the

Table 7. Attitudes and behaviors expected to change/changed by the pre-service science teachers after water education.

Sub-topics	*(f)*
Increasing other people's awareness of the problem	13
Shortening bathing time	5
Turning off the water tap while brushing teeth	3
Using dish washer or reducing the amount of water consumed while washing dishes	2
Turning off open taps	3
Repairing any dripping taps	2
Recycling waste water	4
Reporting illegal water use	2
Saving water during toilet flushing	2
Preventing waste material from being mixed into water	3
Turning the tap off, while shaving	3

utilization of water by the next generations. A pre-service science teacher stated,

"I intend to use water more economically and to ensure that the next generations also make use of it. I will be more sensitive about the water problem to prevent Turkey from experiencing the shortages that are seen today in Africa. I frequently take a bath and I notice that much more water is consumed while having a bath. From this, one of the first things I've done is to shorten very long shower times".(S26)

Two of the pre-service science teachers, - who participated in the research-, stated that after the water education, they tried to turn off open taps. One of the pre-service science teachers (S17), -who used water carefully, stated that, when he/she noticed water dripping or running in the school or in another place, he/she turned it off. Another pre-service science teacher stated,

"….I paid attention not turning the tap on excessively while using water. However, after this education, I began to turn off the tap when I notice that it's open, but sometimes I don't care about it and I'm too lazy to turn it off ".(S29)

Two of the pre-service science teachers, -who participated in the research-, stated that they would report illegal water use to the authorities. Pre-service science teacher S18 stated,

"I will never turn a blind eye to people who consume water subconsciously and use it illegally".(S18)

Three of the pre-service science teachers, -who participated in the research-, stated that they endeavored to recycle waste water. The first pre-service science teacher stated,

"…I will try to use dish water and dirty, but usable water for washing the balcony".(S1)

Six of the candidate science teachers, -who participated in the research-, mentioned that there was no change in their attitudes and behaviors concerning water use. Of the pre-service science teachers, S31 and S4 stated that they had sufficient sensitivity to this matter and would continue to act positively. Participant S4 stated,

"Actually, I already use water more economically. Therefore, I will continue to act positively".(S4)

Opinions of the pre-service science teachers on whether the next generations will experience problems associated with water in 20 to 30 years

Twenty-four of the pre-service science teachers, -who participated in the research-, believed that the next generations will experience problems involving water in 20 to 30 years. Seven participants believed that under some circumstances, there will be future water problems, and two believed that the next generation will have no water problems.

Sixteen of twenty-four pre-service science teachers stated their opinions on this issue. Six believed that the next generations will experience problems involving water in 20 to 30 years. Six opinions obtained from the analysis are shown in Table 8.

As seen in Table 8, the pre-service science teachers

Table 8. Reasons for the pre-service science teachers' belief that the next generations will experience water problems in 20 to 30 years.

Sub-topics	*(f)*
Subconscious use of water	3
Less amount or disregard of education	4
Population growth	3
Global warming and climate change	2
Low ratio of usable water	2
Increase in environmental pollution	2

believed that population growth, increased environmental pollution, global warming and climate change, subconscious use of water, a low ratio of usable water, and a lower amount or disregard of relevant education would result in future water problems.

Three of the pre-service science teachers, who participated in the research, stated that, because water is consumed subconsciously, the next generations will experience water problems. One pre-service science teacher mentioned that humans act selfishly, because humans want to achieve dominance in nature. This participant stated, *"Because we use water without thinking about it and in general we never think of anything but ourselves, this will cause problems later".*(S4)

Four of the pre-service science teachers, -who participated in the research-, stated that because water education is disregarded and not expanded to the public, the next generations will experience water problems. One of the pre-service science teachers (S33) complained that there is not a significant amount of education on this matter. He/she also stated that the significance of water is not discussed sufficiently in relevant school courses. This pre-service science teacher stated,

"*I think that the topics are described superficially to children in school. Even if matters related to water are discussed, they are only for information. Nobody cares to increase awareness on this and to arrange the relevant activities. Furthermore, I think that such education projects should not be limited to schools. Any necessary activities related to the current value of water must be increased".*

Three of the pre-service science teachers, who participated in the research-, stated that the next generations will experience water problems in line with population growth. Some teachers, -who noted that the amount of water resources remains constant in spite of population growth-, stated,

"Of course, the population growth rate is not proportional to the volume of used water and recycled water. Delays may occur in the water cycle. I think that the water supply will gradually reduce for this reason".(S28)

"….Water resources are constant and don't increase. We cannot produce water. Maybe, if salty water is treated and fresh water requirements are met. But, this time, equilibrium is disrupted. However, the population increases quickly in the country. Both balance each other. Thus, these types of problems occur".(S12)

Two of the pre-service science teachers, -who participated in the research-, stated that the next generations will experience water problems due to a low ratio of usable water. Participant S23 stated,

"They may experience these problems. Before, we might use only 3% of water as fresh water in the world. If we continue to consume much more water, we may experience shortages. The fact that we have already experienced water shortages in the last years is an indication that it will happen again in the future".(S23)

Two of the pre-service science teachers, who participated in the research, stated that the next generations will experience water problems due to global warming and climate change. The 10thteacher stated,

"…Inconsistent use of the water resources by most of us and changes due to global warming of the earth cause us to experience problems involving water. Ices melt and rain decreases due to the effect of global warming. These changes in climates and seasons cause people to experience problems involving water". (S10)

Two of the pre-service science teachers, -who participated in the research-, stated that the next generations will experience water problems due to increased environmental pollution. One teacher expressed her belief that, even if water is not exposed directly to pollution, other types of pollution will affect water. She stated,

"...Increased industrialization affects water use adversely. Air pollution and wastes discharged into rivers affect water use indirectly and directly. I think that, because attention is given to industrialization in our country, water pollution will increase in the future. This will become a problem for the next generations".(S8)

DISCUSSION AND RECOMMENDATION

This research aimed to provide pre-service science teachers with water education on sustainable water use

and to develop their awareness. Through the scales developed before and after this water education, the pre-service science teachers' awareness, water knowledge, water consumption attitudes and attitudes toward water were examined under three dimensions and with the support of qualitative data derived from answers to open-ended questions.

This study determined that there is a considerable difference between the water consumption attitudes of the pre-service science teachers prior to and after water education in favor of the post-tests ($p< 0.05$). This finding indicates that water education positively affected the pre-service science teachers' water knowledge, water consumption attitudes and attitudes toward water.

Ergin et al. (2009) concluded that level 2 of the Water School workshop activity of the Education Material Development Project for the water education implemented by the researchers is effective for teachers and students in learning the concepts related to awareness of water, water pollution and water saving. In this study, there was a large difference between the average scores and a considerable difference between the knowledge levels of the pre-service science teachers after the water education. The pre-test scores of the pre-service science teachers, who participated in the study, were good ($\overline{\times}$ =60.20). Environmental topics are also discussed in courses such as General Biology and Special Matters in Chemistry. Therefore, basic information related to water sustainability is available. No other information was added to the information given in the five-week education process, and a score increase of approximately 15 was obtained. This increase is fairly important in the field of science.

Although there was a considerable difference between the pre-test and post-test scores of the pre-service science teachers on water attitudes, the difference between the average scores was not very high. Whereas the pre-test score was 61.68, the post-test score was 63.22. Considering that time is required for the pre-service science teachers to change their attitudes, more education is also required to improve the attitudes of the undergraduates (Sülün and Güven, 2012). According to Güler and Afacan (2011), an attitude is an action that prepares for a behavior. The principal purpose is to ensure that pre-service science teachers present the same attitudes as behaviors. In this study, a considerable difference between the pre-test score ($\overline{\times}$=59.22) and the post-test score ($\overline{\times}$=65.22) of the pre-service science teachers on water consumption attitudes and any changes specified by the pre-service science teachers in the qualitative data on the topics of attitude and behavior changes might be defined as an indicator of positive developments. After the water education, the pre-service science teachers stated that they would endeavor to make people around them aware of the water problem, shorten their bathing time, turn the tap off while brushing their teeth and shaving, begin to turn open taps off and reuse waste water. In this context, the qualitative findings of the study support the quantitative findings.

In a study conducted to determine the water consumption attitudes of pre-service science teachers, Gürbüz et al. (2009) stated that 22.3% of the respondents wiped spaces such as doorsteps, balconies and terraces instead of washing these spaces with a hose, whereas 28.8% shortened bathing times, and 31.7% washed fruits and vegetables in a container filled with water rather than in running water. Similarly, our research shows that, 15% of the pre-service science teachers claimed to shorten their bathing time.

When the opinions of the pre-service science teachers on water pollution and sustainable water are reviewed, it can be seen that a large majority think that the water supply will not suffice. An analysis of the sub-topics shows that the pre-service science teachers perceive the severity of the water shortage, understand the significance of saving water, increasingly worry about water sustainability, and perceive the effects of water pollution on the water problem. A review of the relevant literature shows that data support the opinions of the pre-service science teachers. According to research, the annual water consumption per person is approximately 800m³ worldwide. Approximately 20% of the global population (1.4 billion people) is deprived of sufficient drinking water, and 2.3 billion people are deprived of healthy water. Some estimates indicate that more than 3 billion people will face a water shortage by 2025. In 1995, the percentages of the global population that experienced water shortage and water stress were 29 and 12%, respectively. According to FAO, these percentages will increase to 34 and 15%, respectively by 2025 (Demir, 2009).

According to Tomanbay (2008), a rapid increase in the global population means a decrease in the annual water volume per person. This population growth is one of most important factors causing water problems worldwide. Güler (1996) states that as a result of current attitudes concerning water use, the existing water resources will not suffice for people in the future. Measures must be taken to save and use existing water wisely, and to manage resources to ensure water sustainability. If necessary measures are not taken in light of such information, it is believed that stress on existing resources will increase and water will not be adequate for people in the future. The pre-service science teachers, -who participated in this research-, draw attention to the subjects mentioned in the literature.

In their study, Ergin et al. (2009) found that after the administration of water education known as “water school” 70% of undergraduates believed that the water supply will be inadequate, compared with 90% prior to the administration of “water school”. This finding indicates that pre-service science teachers and undergraduates have realistic knowledge about water conditions in the world and in our country, and change their opinions after receiving water education.

According to the research findings of this study, a large majority of the pre-service science teachers stated that the next generations will experience water problems due to a low ratio of usable water, a lower amount or disregard of relevant education, subconscious use of water and population growth. Furthermore, the pre-service science teachers identified an increase in contagious diseases, difficulty finding clean water; and water shortages among the future water-related problems.

Among the research participants in this study, many believed that if the subconscious use of water continues and if necessary measures are not taken, water-related problems may occur. These pre-service science teachers think that the water problems that may be experienced by the next generations may be worsen. A smaller number of the pre-service science teachers stated that problems might be encountered over a longer timeframe.

Research results by Akın (2007) address the fact that Turkey, which is in a position experience water shortages for reasons including an increase in population and industrialization and, the expansion of the use of agricultural fertilizers and drugs, will face irreparable and irrevocable water problems in 20 to 30 years. In this study, the pre-service science teachers addressed topics such as the increase in the human population and environmental pollution that might lead to future water-related problems.

The following recommendations are submitted based on the results of the research which aimed to develop awareness among pre-service science teachers through water education,

Research Recommendations

1. This study was implemented using a one-group post-test and pre-test mode. The execution of the study with test and control groups in the pre-test and post-test research model would increase its intrinsic validation.
2. This research was implemented with the participation of pre-service science teachers. Activities should be designed according to the ages and levels of undergraduates, and research and practices should be performed with different ages of undergraduate groups. The variety of this type of research should be increased, and similar research should be compared and evaluated.
3. This research should be applied to more homogenous groups, and the effects of demographic variables should be examined.

Practical Recommendations

1. Topics such as the significance of water, water and health, water conditions in the world and in our country, and attitudes during water use must be described more clearly and in more detail in textbooks. Because water gains are discussed primarily in science and technology courses, water should also be discussed primarily in those courses.
2. In this course, practical activities must be included to cause pre-service science teachers to change their attitudes toward water saving. Laboratory activities, trips and projects related to water saving will make their learning and awareness more permanent.
3. In universities, projects may be prepared to enhance awareness of water sustainability in the community service application course given to pre-service science teachers.
4. A Water Knowledge Test, Water Consumption Behavior Scale and Water Attitude Scale have been developed by the researchers to determine the efficiency of water education. The scales developed for this research could be used for future research.

Conflict of Interests

The author(s) has not declared any conflict of interests.

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