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ENHANCING TEACHERS' WATER LITERACY LEVELS THROUGH ACTION-BASED TRAINING

Ayşe AYTAR
Res. Asst., Recep Tayyip Erdoğan University, Rize, Turkey, ayse.aytar@erdogan.edu.tr
ORCID: 0000-0002-3351-9082

Nazihan URSAVAŞ
Assoc. Prof., Recep Tayyip Erdoğan University, Rize, Turkey, nazihan.ursavas@erdogan.edu.tr
ORCID: 0000-0003-2227-1015

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ABSTRACT

Understanding water and/or water-related issues more comprehensively requires people to become water literate. Even though the literature has reported several definitions on water literacy, there has still been no scientific consensus about its definition. Because ProjectWET Foundation has described water literacy with seven principles ("Water has unique physical and chemical characteristics", "Water is essential for all life to exist", "Water connects all Earth systems", "Water is a natural resource", "Water resources are managed", "Water resources exist within social constructs", "Water resources exist within cultural constructs") and suggested action-based activities on water literacy, this study aimed to enhance teachers' water literacy levels by using different activities in the light of these principles. Through a pre-experimental research methodology, 25 teachers with different expertise took part in a 7-day training project. A survey with a word association test and open-ended questionnaire (covering water definition, water reserves, water users, saving water, importance of water, and basic characteristics) was administered to the participants before and after the treatment. The findings revealed that in both tests the teachers regarded the ocean as a body holding maximum amounts of water reserve. In addition, they viewed rivers as easily accessible source of maximum potable water. Furthermore, the teachers mostly defined water as a substance composing of one oxygen and two hydrogen atoms and generally indicated its important role in vital activities. In light of the results, it can be concluded that teachers are water literate in the context of six principles, except for the principle "Water resources exist within cultural constructs". The present study suggests that further studies are needed to satisfy the principles of water literacy at different levels with various activities.

Keywords: Action-based training, teacher, water, water literacy.

INTRODUCTION

The increase of environmental issues in recent years has led researchers to focus on raising individuals more conscious and aware of the sustainability of natural sources (Dunlap & Scarce, 1991). Water is one of the most important natural resources because water is the main reason for existence and the only molecule that makes the Earth unique from molecular to the global level (Brody, 1995). Water is also an interdisciplinary concept issue in biology, chemistry, physics, geography, mathematics, art, social sciences, and other disciplines. To understand water and water-related issues more comprehensively from micro-molecular to macro-molecular level, any person should have knowledge from various aspects (McCarroll & Hamann, 2020). With this multidisciplinary perspective, individuals are expected to be water literate. A water literate person can apply this knowledge to their values and their actions, regardless of whether it is achieved consciously or subconsciously (Wood, 2014).

In recent years, there has been a trend for highlighting an awareness of the water importance in educational systems around the world in order to create a water-literate society to find solutions to the water demand lead by the population growth and other water issues (Amahmid et al., 2019; Cheng et al., 2019). These initiatives have brought water literacy concept with it. The concept of water literacy entered our lives in the 90s, but it is possible to see that more studies and definitions were made in the 2010s. According to some of these studies, water literacy is defined as follows;

…*understanding the usage of water, the health implications of water quality, and the overall impacts as a result of water shortage or extreme precipitation should all be part of the curriculum delivered effectively to students of all levels and the general society* (Su, Chen & Wang, 2011:518).

…*the ability to feel familiar with water, get actively involved in water and face the issue of water as one's own issue* (Otaki, Sakura & Otaki, 2015:36).

> …*to have knowledge and awareness about the importance of water for life, the progression of the water cycle, the recognition of resources in the near environment and globally, the right management and protection of water sustainably, the using of scientific knowledge from different disciplines to solve problems on water with a systems thinking and global point of view and take actions for this purpose* (Ursavaş, 2021).

Although the concept of water literacy is frequently used by scientists, educators, various government and non-governmental organizations, it is still seen that there is no common consensus on how to define, implement or evaluate it (McCarroll & Hamann, 2020). Besides, this makes it difficult to define sub-dimensions of water literacy or evaluating water literacy levels of individuals. In the earlier years of water-related studies, it was first handled as a sub-topic of environmental education. Studies conducted in the following years have shown that students do not have sufficient understanding of water from primary education to undergraduate level (Ewing

& Mills, 1994; Osborne & Cosgrove, 1983). It is considered that conceptual knowledge about water and water literacy is important for students to develop water awareness (Covitt, Gunckel & Anderson, 2009). Mills (1983) stated that students had more knowledge on topics such as the water cycle, the physical and chemical properties of water, and the physical effects of water on the Earth, which were commonly taught in school programs. He pointed to a lack of knowledge in the fields of current water issues, water resource management and the impact of water in shaping our past, which were rarely taught. Then, in the same year, with the Water Resources Education Project, he gave training on the subject of water resources, which students had less knowledge about.

Compiling the studies conducted over the next ten years, Brody (1993) stated that besides students' having superficial understanding of water and water resources, educators and curriculum developers had difficulties in identifying and analyzing relevant materials and preparing lessons and activities that would help students understand water and social relations. Upon this, Brody, who carried out a comprehensive curriculum study on water education, started to work on the development of a water education curriculum for educators, scientists, and resource managers. Brody (1995) sought answers to the questions of which concepts about water should be taught, what skills people should have to understand water and manage water resources correctly, and what attitudes should be emphasized while learning about water. As a result of this study, he revealed the seven basic principles of water science. With this study, Brody determined the framework of the water education curriculum for teachers. These principles were later expressed by ProjectWET as the principles of water literacy (ProjectWET, 2011). These principles are as follows: (1) Water has unique physical and chemical characteristics, (2) Water is essential for all life to exist, (3) Water connects all Earth systems, (4) Water is natural resources, (5) Water resources are managed, (6) Water resources exist within social constructs, and (7) Water resources exist within cultural constructs.

Teachers are the key element of knowledge transfer in schools or out-of-schools, except students' own learning from their experiences. As indicated in the studies, neither teachers can help children learn things they themselves do not understand (Sadler et al., 2013) nor two teachers who have same knowledge teach in the same way (Pajares, 1992) or express in similar ways of thinking (Harel, 2001). Trying to find out teachers' beliefs, conceptions, and perceptions about the subject matter is very important to improve students' knowledge of subject matter (Pajares, 1992). Besides all the findings gathered from the literature, this study is one of the first studies to evaluate teachers' water literacy level by using ProjectWET's (2011) water literacy principles. Therefore, in this study, it is aimed to reveal teachers' water literacy levels in the light of ProjectWET water literacy principles (WLP) through action-based training. With this aim, answers were sought for the following questions.

How does an action-based training affect teachers' water literacy levels on
-physical and chemical characteristics of water,
-the essentiality of water,

-the role of water in all Earth systems,

-water resources,

-water resources management,

-water resources in social and cultural constructs.

METHOD

The Research Model

This paper was the result of a project that drew on pre-experimental research to explore how teachers' water literacy level was enhanced before and after engaging in an action-based training. Since it was aimed to deal with the development of the water literacy levels that teachers had before and after the training they attended, in terms of water literacy principles this study was carried out in accordance with the pre-experimental design. Pre-experimental designs try to test treatment, and check whether it has the potential to cause a change or not (Frey, 2018).

Study Group

In this study, due to the project's limitations (26 teachers could attend the project), 25 teachers who applied for the action-based training were selected among 319 teachers from 63 different cities through purposeful sampling. One teacher was removed from the study because of lost test scores and failure to implement the activities more than once. The participants were 13 science teachers, 10 biology teachers, one geography teacher and one technology and design teacher from 21 different cities that covered almost every geographical region of Turkey. Their average age was 39, and there were 15 female and 10 male teachers in the group.

This study is a part of a project which is supported by a national science organization. In the selection of teachers, a questionnaire was used consisting of several questions to define teachers in-class activities about water-related issues, their willingness, and the number of students aimed to reach after the activity training and etc. The questionnaire was shared via the project's local website and social media accounts.

Teachers' Training and Procedures

Twenty-five teachers accepted to the study underwent a 7-day training session conducted by the authors, who were also coordinators of Turkey ProjectWET, and 10 researchers from different universities. Researchers were experts on science education, geography education, biology education, meteorological engineering and chemistry education. The teachers were trained with eight Project WET activities and various drama activities (Figure 1).

Figure 1. Photographs from Activities

All of these activities were related to seven essential principles of water science (ProjectWet, 2011). The relationships among ProjectWET water literacy principles, open-ended questions, and word association test (WAT) in the survey and activities were given in Table 1.

Table 1. The Relationships among ProjectWet Water Literacy Principles, Questions, and Activities

	ProjectWET Water Literacy Principles (WLP)	**Related question**	**Activities**	**Goals of activities**
1	Water has unique physical and chemical characteristics	What do you think about the basic characteristics of water? What comes to your mind when you hear the word water? How do you define water? What is the importance of water? What are water-related topics?	H_2O Olympics	Investigating two properties of water, adhesion and cohesion.
2	Water is essential for all life to exist	How do you define water? What is the importance of water? What comes to your mind when you hear the word water? What do you think about the basic characteristics of water? What are water-related topics?	Drama activities	
3	Water connects all earth systems	What is the importance of water? What comes to your mind when you hear the word water? How do you define water? What do you think about the basic characteristics of water? What are water-related topics?	Blue Planet	Estimating percentage of Earth's surface that is covered by water and taking a simple probability sample to check estimates.
			Incredible Journey	Simulating the movement of water within the water cycle with a roll of a cube.
			Seeing watersheds	Identifying the key parts and functions of watersheds and describing how water flows in a watershed based on elevation.

4	Water is a natural resource	What reservoir contains the most water, the most potable water and the water easily accessible on earth? How do you classify Turkey in terms of water presence? What comes to your mind when you hear the word water? What do you think about the basic characteristics of water? What are water-related topics?	A Drop in the Bucket Sum of the parts	Estimating and calculating the percentage of available freshwater on Earth. Demonstrating how everyone contributes to the pollution of the river as it flows.
5	Water resources are managed	What are water users? What comes to your mind when you hear the word water? What is the importance of water? What are water-related topics?	8-4-1, One for All	Representing water users and navigating water management challenges to reach the next community.
6	Water resources exist within social constructs	What do you do to save water in your daily life? What do you think should be done to raise people's consciousness on water saving? What comes to your mind when you hear the word water? How do you define water? What do you think about the basic characteristics of water? What is the importance of water? What are water-related topics?	My water footprint	Learning about water footprints and tracking personal water use.
7	Water resources exist within cultural constructs	What comes to your mind when you hear the word water? What do you think about the basic characteristics of water?	Drama activities	

Data Collection Tools

This study is a research project designed to develop teachers' water literacy supported by the Turkish National Scientific and Technological Research Council. In order to collect the data, a survey which included a word association test (WAT) and an open-ended questionnaire was administered to 25 teachers in 2019. Based on the views of two experts in the field of biology and science education, the WAT was prepared, which relies on the individuals' answers to the stimulus word. "Water" was selected as the stimulus word due to its importance and relation to water literacy in WAT. These answers consisted of words and sentences that were retrieved from their long-term memory. The alignment of the words was considered to reveal the cognitive ties between these keywords. This test helps to reveal individuals' cognitive framework (Bahar, Johnstone & Sutcliffe, 1999). Since the sample consisted of teachers and they used word association tests in their lessons before, no preliminary study was conducted. They were given one minute to write the response words for the stimulus word (See also in Appendix 1). During the administration, each concept was written 10 times in order to prevent the risk of chain answering (Bahar & Özatlı, 2003).

During the preparation of the questionnaire, those steps were followed. The literature was surveyed according to water and water-related issues. It helped us to understand if there were any points that were overlooked.

This was followed by the examination of the ProjectWET Educator Guidebook (ProjectWET, 2011). As the book which contained water literacy principles and activities was the main guide of this study, it was a requirement on preparing open-ended questions. After completing the preparing of questions, two experts made suggestions on the questions. Before the main application, the final version of the questionnaire was piloted with 24 teachers. Based on the data gathered from pilot study, questions like "What do you think about the basic characteristics of water?", "What are water-related topics?" , "How do you classify Turkey in terms of water presence?", and "What reservoir contains the most water, the most potable water and the water easily accessible on earth?" were added to questionnaire.

There were various open-ended questions compatible with the water literacy principles which tried to find out teachers' perceptions and conceptions about water reserves, water users, water presence in Turkey, water saving, raising conscious people, water definition, the importance of water, basic characteristics of water, and so on (See also in Appendix 1).

In this article, the journal writing rules, publication principles, research and publication ethics, and journal ethical rules were followed. The research permission was obtained from Turkish National Scientific and Technological Research Council dated 20/12/2018 and numbered 77533774-115.02. The responsibility belongs to the author (s) for any violations that may arise regarding the article.

Data Analysis

In this study, it was firstly aimed to present teachers' development of water literacy levels not to find out teachers' cognitive structures. For this reason, response words were not analyzed according to content analysis or there were not any specific categories but exposed to descriptive analyses. Thus, all the response words were considered and placed under the WLP to get better understanding of teachers' water literacy development. The frequencies of the data were calculated, and a table of frequency was created for the stimulus word in order to show how many times a keyword or a concept was repeated. Therefore, in order to evaluate the results of WAT, all the answers given to the stimulus word were examined extensively. Then, the answers were identified, and a frequency table was created. Response words were listed under the water literacy principles with the cooperation and consensus of the researchers.

Data obtained via open-ended questions were analyzed using descriptive analysis techniques. The teachers' expressions were coded by two independent researchers at the same time with deep discussion thoroughly to find the relevant categories or ideas according to the answers and these categorizes were placed under the WLP which were also used as themes. Besides these, the frequencies of categories and ideas were calculated, for further evaluation and the findings were demonstrated in tables with their frequencies as pre and post-tests.

Reliability and Validity

To ensure the reliability and validity in qualitative research, Lincoln and Guba (1985) emphasize the concepts of credibility, transferability, dependability, and confirmability. In this research, demographics of study group, study group selection process, the training process, methodology and data analysis process were identified in detail and several photographs were presented to establish credibility and transferability. Also, the researchers took part in the training. For asserting dependability, the researchers conducted code-recode procedure on the data throughout data analysis for making sure that there was not anything missed in the study. Besides this, WAT was used as an alternative data collecting tool with open-ended questions by means of methodological triangulation. For enabling confirmability, findings were built on the participants' statements and presented without the researchers' bias and deceit, and some themes in the findings were formed directly from the teachers' opinions.

FINDINGS

Water Literacy Test (WLT) Findings

Findings from the water literacy test (WLT) composed of open-ended questions were given under relevant headings. Each answer was analyzed according to the WLP listed under the tables.

In Table 2, the teachers' views on the basic characteristics of water were given with their frequencies in the pre-test and post-test below.

Table 2. Teachers' Views on the Basic Characteristics of Water

WLP	The basic characteristics of water	Pre-test (f)	Post-test (f)
Water has unique physical and chemical characteristics	A substance composed of one oxygen and two hydrogen atoms.	11	9
	A good solvent.	5	12
	Solid form is less dense than liquid form.	5	1
	A liquid at room temperature	3	1
	Adhesion/cohesion force	3	9
	An extinguisher	2	2
	Has surface tension.	1	6
	The bond angle is 104,5°.	1	4
	Found as a solid, liquid or gas	1	4
	A polar covalent bonded molecule	1	1
	A dipole	1	1
	High specific heat	1	1
	Has an electrical conductivity.	1	1
	The density of water is maximum at 4 °C.	1	1
	Colorless and odorless	1	1
	Expands and is denser when it freezes.	1	1
	An inorganic compound	1	-
	Used as the standard in scientific measurements.	1	-
	Freezes at 0°, boils at 100°.	1	-
	Has tetrahedral geometry.	-	2

	Viscosity is very large.	-	2
	The density of water is 1 g/cm^3.	-	1
	Upthrust of water	-	1
	Water resistance	-	1
	Plays a very important role in temperature regulation.	-	1
	Has hydrogen bonding.	-	1
	Subtotal	42	64
Water is essential for all life to exist	Essential substance for all living things	8	2
	Essential substance for the continued vitality	4	3
	Systematic activities (circulation digestion, respiration, photosynthesis, excretion etc.)	3	3
	Substance transport	2	2
	Source of life.	1	2
	Chemical reactions	1	1
	Living area	1	-
	Enzyme activity	-	2
	Subtotal	20	15
Water connects all Earth systems	Substances that make up the majority of the world	1	1
	Water cycle keeps going.	1	2
	Subtotal	2	3
Water is a natural source	Little fresh water	-	1
	A disaster	1	-
	Subtotal	1	1
Water resources exist within social constructs	Cleaning	1	4
	A strategic resource	-	1
	Subtotal	1	5
Water resources exist within cultural constructs	Sacred	-	1
	Total	66	89

The main properties of water according to the teachers are presented under six principles of principles of water science in Table 2. The most mentioned one was “Water has unique physical and chemical characteristics” with a total frequency of 42 in the pre-test and 64 in the post-test. In the pre-test, 19 qualities were stated while 23, in the post-test under this principle. Under the principle of “Water has unique physical and chemical characteristics”, water was mostly described as a substance that is composed of one oxygen and two hydrogen atoms (f:11) in the pre-test while it was referred to be a good solvent (f:12) in the post-test. Besides this, the teachers’ views were seen to fall under the principles of “Water is essential for all life to exist” (pre-:20; post-:15), “Water connects all earth systems” (pre-:2; post-:3), “Water is a natural source” (pre-:1; post-:1) and “Water resources exist within social (pre-:1; post-:5) and cultural constructs” (pre-:0; post-:1).

Table 3 shows how the teachers defined the concept of water in the pre-test and post-test. The definitions were labeled under the principles of water science.

Table 3. Teachers' Definitions of Water

WLP	Definitions	Pre-test (f)	Post-test (f)
Water is essential for all life to exist	Essential substance for all living things	6	11
	Essential substance for the continued vitality	6	3
	Source of life	5	9
	Basic building blocks of all living things	1	1
	The main factor of life	2	-
	Substances that make up the majority of the body	-	1
	Essential substance for nonliving things	-	2
	Subtotal	20	27
Water has unique physical and chemical characteristics	A substance composed of one oxygen and two hydrogen atoms	10	6
	An inorganic compound	3	1
	The density of water is 1 g/cm^3.	1	-
	A special molecule	1	-
	Subtotal	15	7
Water connects all Earth systems	Substances that make up the majority of the world	2	1
	The main factor of matter cycles.	1	-
	The continuity of Earth systems	-	1
	Subtotal	3	2
Water resources exist within social constructs	Daily routines	-	1
	Total	38	36

It could be seen from Table 3 that water was defined mostly as a substance composed of one oxygen and two hydrogen atoms (f:10) under the principle of "Water has unique physical and chemical characteristics" in the pre-test. This was followed by the definitions which were related to vitality (f:6) and living things (f:6). In the post-test, the definitions like essential substance for all living things (f:11) and source of life (f:9) were the most stated definitions of water. When WLP is examined, four of them were listed in the table. The most frequent belonged to "Water is essential for all life to exist" (pre-:20; post-:27). Teachers made seven different definitions that fitted in this principle. The teachers also defined water according to its unique physical and chemical characteristics. There were four different definitions under this principle and its subtotal frequency is 15/7. The least frequency belongs to "Water resources exist within social constructs" (pre-:0; post-:1).

The teachers' views on the importance of water with their frequencies in the pre-test and post-test were given in Table 4 below.

Table 4. Teachers' Views on the Importance of Water

WLP	The importance of water	Pre-test (f)	Post-test (f)
Water is essential for all life to exist	Systematic activities (digestion, respiration, photosynthesis, excretion etc.)	16	16
	Essential substance for the continued vitality	12	12
	Essential substance for all living things	6	2
	Enzyme activity	2	4
	Essential substance for non-living things	1	3
	Ecosystem	1	1
	Chemical reactions	1	1
	Substance transport	1	1
	Substances that make up the majority of the body	1	1
	Source of life	2	-

	Living area	-	4
	Homeostasis	-	2
	Biodiversity	-	1
	Subtotal	43	48
Water has unique physical and chemical characteristics	A good solvent	5	1
	Osmotic balance	1	1
	pH value	1	-
	Plays a very important role in temperature regulation.	1	1
	Subtotal	8	3
Water resources exist within social constructs	Cleaning	3	1
	Technology	-	1
	Subtotal	3	2
Water resources are managed	Tourism/Recreation	1	2
	Energy	1	2
	Wildlife	-	1
	Industry	-	1
	Production	-	1
	Subtotal	2	7
Water connects all Earth systems	The continuity of earth systems	-	1
	Climate	-	1
	Subtotal	-	2
	Total	56	62

The teachers' views on the importance of water were shown in Table 4. When examined closely, the teachers generally indicated that water had an important role in vital activities (pre-:16; post-:16). Subsequently, they mentioned the importance of water for the continued vitality (pre-:12; post-:12), all living things (pre-:6; post-:2), enzyme activity (pre-:2; post-:4), and so on. The teachers view water as an essential for all life to exist (pre-:43; post-:48) like its definition. This principle was very dominant over the other categories. It was because even the sum of the other principles was not equal to this principle. According to the teachers' statements, the principle of "Water has unique physical and chemical characteristics" (pre-:8; post-:3) was expressed as one of the principles of importance of water. The same four principles were listed in the importance of water as the definitions of water. These were "Water is essential for all life to exist", "Water has unique physical and chemical characteristics", "Water resources exist within social constructs" and "Water connects all earth systems". The fifth principle, which was "Water resources are managed" in the importance of water differed from the principles of water definition.

The teachers' views on water-related topics were presented in Table 5 below.

Table 5. Topics Related with Water

WLP	Water-related topics	Pre-test (f)	Post-test (f)
Water is essential for all life to exist	Importance of water for living and nonliving things	4	13
	Ecosystem	2	2
	Ecology	1	2
	Photosynthesis /Respiration	1	1
	Plant/human physiology	1	1
	Food chain	-	1
	Biodiversity	-	2

	Subtotal	9	22
Water is a natural resource	Environmental pollution	5	9
	Causes and consequences of water pollution	-	10
	Distribution of water on the Earth's surface	-	8
	Turkey's water supplies	-	5
	Earth's water supplies	-	5
	Climate change	-	2
	Water resources	-	1
	Subtotal	5	40
Water connects all Earth systems	Matter cycles (water cycle)	5	15
	Water basin	-	2
	Subtotal	5	17
Water has unique physical and chemical characteristics	Organic and inorganic matters	2	4
	The chemical properties of water	1	6
	Pressure	1	-
	States of matter	1	-
	Properties of potable water	-	5
	Subtotal	5	15
Water resources exist within social constructs	Water saving	1	13
	Human and environment	1	5
	Water footprint	1	2
	Domestic waste and recycling	1	2
	Subtotal	4	22
Water resource are managed	Sustainable development (using resources efficiently)	2	3
	Renewable energy	1	-
	Water transportation managed	-	1
	Subtotal	3	4
	N/A	3	4
	Total	34	124

Table 5 showed the topics related to water according to the teachers' views under the six principles of water science except "Water resources exist within cultural constructs". The most stated topics were matter cycles (pre-:5) and environmental pollution (pre-:5) gathered under the principles of "Water connects all earth systems" and "Water is as natural resource" respectively in the pre-test. In the post-test, the matter cycle was also the first water-related topic. After that, the topics of water-saving and the importance of water for living and nonliving things came with the same frequency of 13. There was a massive increase in the principle of "Water is as natural resource" from 5 to 40. It was the most frequent principle followed by "Water resources exist within social constructs" (post-:22) and "Water is essential for all life to exist" (post-:22). In particular, the total frequency of water-related topics rose up to 124 in the post-test.

The answers to the question of what reservoir contains the most water, the most potable water and the water easily accessible on earth were presented in Table 6 below.

Table 6. Teachers' Views on Water Reserves

WLP	Water reserve		Pre-test (f)	Post-test (f)
Water is a natural resource	with maximum water	Ocean	19	16
		Glacier	3	5
		Sea	1	3
		Groundwater	1	1
		N/A	1	-
		Total	25	25
	with maximum potable water	Groundwater	9	2
		Glacier	8	17
		River	3	1
		Lake	1	1
		Dam	1	
		N/A	1	1
		Freshwater resources	2	3
		Total	25	25
	with maximum potable water and easily accessible	River	10	10
		Groundwater	4	1
		Spring water	4	2
		Lake	3	3
		Freshwater resources	-	3
		Surface water	-	3
		Dam	2	2
		N/A	2	1
		Glacier	-	1
		Total	25	25

As seen in Table 6, findings from these questions were listed in the principle of "Water is as natural resource". The table showed the teachers' views on water reserves with maximum water, with maximum potable water, and with maximum potable water that was easily accessible on earth. The most stated water reserve holding maximum water was ocean in both of the tests (pre-:19; post-:16). The teachers generally said that groundwater (f:9) was with maximum potable water in the pretest but glacier (f:17) in the post-test. Additionally, rivers contained maximum potable water and were easily accessible according to the teachers both in the pre-test and in the post-test with the frequency of 10.

The teachers' classifications of Turkey in terms of water presence with their frequencies in the pre-test and post-test were given in Table 7 below.

Table 7. Teachers' Classifications of Turkey in Terms of Water Presence

WLP	Water presence	Pre-test (f)	Post-test (f)
Water is a natural resource	Water rich	6	2
	Water poor	7	3
	Water stressed	12	20
	Total	25	25

In Table 7, the teachers stated that Turkey was a water-stressed country in both the pre-test (f:12) and the post-test (f:20) under the principle of "Water is as natural resource". However, two teachers considered Turkey as a water rich country while three of them considered it as a water poor country in the post-test.

The teachers' views on water users with their frequencies in the pre-test and post-test were given in Table 8 below.

Table 8. Teachers' Views on Water Users

WLP		Water users	Pre-test (f)	Post-test (f)
Water resources are managed	1	Soil	16	16
	2	Plants	14	16
	3	Animals	13	16
	4	All of them	12	8
	5	Microorganisms	9	13
	6	Fungi	7	12
	7	Air	6	5
	8	Human beings	5	7
	9	Stones	4	5
	10	All of them	3	3
	11	Rock	3	1
	12	Cloud	2	3
	13	Shipping	1	4
	14	Glacier	1	1
	15	Lake	2	-
	16	Sea	2	-
	17	Construction	2	-
	18	River	1	-
	19	Weather events	1	-
	20	Industry	-	5
	21	Transportation	-	2
	22	Recreation	-	2
	23	Tourism	-	1
	24	Agriculture	-	1
	25	Energy	-	1
	26	Ecosystems	-	1
	27	Climate	-	1
	28	Mineral	-	1
	29	Enzyme	-	1
		Total	104	126

As understood from Table 8, water users were gathered under the principle of "Water resources are managed". Soil (f:16), plants (f:14), animals (f:13), all of the living things (f:12), microorganisms (f:9), fungi (f:7), air (f:6), and human beings (f:5) were top water users in the pre-test according to teachers. In the post test, the same views appeared as soil, plants and animals with the frequency of 16. After these microorganisms (f:13), fungi (f:12) and all of the living things (f:8) came. In the post-test, there were 24 replies, 10 of them were new. These could be listed as industry (f:5), transportation (f:2), recreation (f:2), tourism (f:1), agriculture (f:1), energy (f:1), ecosystems (f:1), climate (f:1), mineral (f:1), and enzyme (f:1).

The answers given to the question of "What do you do to save water in your daily life" by teachers were stated in Table 9 below.

Table 9. Ways to Save Water

WLP		Ways to save water	Pre-test (f)	Post-test (f)
Water resources exist within social constructs	1	Minimize water consumption (while tooth brushing, hand and face washing, taking a shower and bath, shaving)	14	19
	2	Do not waste water	13	3
	3	Use leftover water while watering plants (in bottled water, leftover vegetable water, leftover shower water)	8	2
	4	Put a bottle in the reservoir	4	3
	5	Run full dishwasher and washing machine	3	7
	6	Close the taps tightly	3	5
	7	Use dishwasher	3	3
	8	Do not wash car frequently	3	3
	9	Sweeping the balcony's floor instead of washing	2	2
	10	Warn students/children	2	1
	11	Repair the leaky taps	2	1
	12	Use drip irrigation system	1	2
	13	Do not swill out dishes before placing dishwasher	1	1
	14	Share the stuff	1	1
	15	Choose A+++ rated dishwasher and washing machines	4	-
	16	Use water efficient taps	1	-
	17	Be conscious consumer	-	5
	18	Use public transport	-	1
	19	Do recycling	-	1
	20	Avoid polluting water resources	-	3
		Total	26	63

As seen in Table 9, what the teachers did in their daily lives for water-saving were listed under the principle of "Water resources exist within social constructs". According to these, teachers generally minimized water consumption while tooth brushing, hand and face washing, taking a shower and bath, shaving to save water in daily lives with the frequency of 14 in the pre-test and 19 in the post-test. Following this, they did not waste water (pre-:13) and run a full dishwasher and washing machine (post-:7). Most of the teachers used leftover water while watering plants (pre:8). In the post test, they considered closing the taps tightly (f:5) and being conscious consumers (f:5) to conserve water. Also, in the post test four new suggestions had occurred like using water efficient taps, being conscious consumers, using public transport, recycling and avoiding polluting water resources. Besides, the total suggestions for water-saving increased from 26 to 63 in the post-test.

In Table 10, things to do to raise people's consciousness of water saving were presented with the frequencies in the pre-test and the post-test, respectively below.

Table 10. Teachers' Views about Raising People's Consciousness of Water Saving

WLP		Things to raise people's consciousness	Pre-test (f)	Post-test (f)
Water resources exist within social constructs	1	Organize training (adult education, teacher education, family involvement education)	11	12
	2	Use digital media (video, advertising, social media campaign)	6	3
	3	Give water education at schools (water course, water literacy, ProjectWET activities)	5	19
	4	Public service announcement	5	8
	5	Organize projects	5	4
	6	Organize activities, seminars, workshops, interviews	4	5
	7	Ministry of water	1	-
	8	Develop water policy	-	2
	9	Punitive sanctions	-	1
	10	Use drip irrigation system	-	1
		Total	37	55

The teachers' views on what to do as a way to raise people's consciousness of water saving were shown in Table 10 under the principle of "Water resources exist within social constructs". The first one was organizing training in the pre-test (f:11) and giving water education in the post-test (f:19). The second view that was mostly stated was using digital media (f:6) in the pre-test while organizing training in the post-test (f:12). In total, seven things were thrown out in the pre-test, however nine things were stated in the post-test. The different views in the pre-test were developing water policy (f:2), punitive sanctions (f:1), and using drip irrigation systems (f:1).

Word Association Test (WAT) Findings

The teachers' views about the water acquired from word association tests were gathered under seven principles. The principles and words along with their respective frequencies obtained from the pre-test and post-test were presented in Table 11 below.

As it could be seen in Table 11, WAT findings were categorized under seven principles of water science named as "Water has unique physical and chemical characteristics", "Water is essential for all life to exist", "Water connects all Earth systems", "Water is a natural source", "Water resources are managed", "Water resources exist within social and cultural constructs". In the both pre-test (f:21/54) and the post-test (f:26/51), the principle of "Water resources exist within social constructs" was the first among the others in terms of new entries/total frequency. Then the principle of "Water connects all Earth systems" (pre-:17/27; post-:21/39) and "Water is essential for all life to exist" (pre-:14/49; post-:15/49) came after respectively. The number and total frequency of new entries of all these four principles increased in the post-test.

In particular, a total of 79 new entries figured out with a total frequency of 174 in the pre-test. In the post-test, this increased to 96 with a total frequency of 199. This could also be expressed as 79/7=11.29 words per principle in the pre-test; while the average value increased to 96/7=13.71 in the post-test. Based on these

numbers, the average frequency per theme was found as 174/7=24.86 in the pre-test and 199/7=28.43 in the post- test.

First of all, three principles had an increase in terms of the number and total frequency of new entries. The principle of "Water connects all Earth systems" had a rise in different new words such as basin (f=1), Antarctica (f=2), underground sources (f=2), ocean (f=2), evaporation (f=1), transpiration (f=1), and etc. with the number of new entries (f:21) in the post-test. This principle was followed by "Water is a natural source" (pre-:7/10; post-:10/19) and "Water resources are managed" (pre-:6/9; post-:7/20). Also, "Water resources exist within cultural constructs" (pre-:5/7; post-:7/9) was the other principle that showed a higher frequency in the post-test than in the pre-test.

Secondly, two of them rose in the number of new entries while decreased in terms of the total frequency of new entries. They were "Water has unique physical and chemical characteristics" (pre-:10/19; post-:13/16 and "Water resources exist within social constructs" (pre-:21/54; post-:26/51). Besides, the principle of "Water resources exist within cultural constructs" was stable (pre-:4/6; post-:4/5) in terms of new entries. However, there was no change through "Water is essential for all life to exist" (pre-:14/49; post-:15/49) in the number of the total frequency of new entries in the post-test except the word of nonliving things (f=1), metabolism (f=1), cell (f=1), digestion (f=1), and etc.

Table 11. Distribution of Associated Words According to the WLP

Water has unique physical and chemical characteristics		**Water is essential for all life to exist**		**Water connects all Earth system**		**Water resources exist within social constructs**	
Pre-test (f)	Post-test (f)	Pre-test (f)	Post-test (f)	Pre-test	Post-test	Pre-test (f)	Post-test (f)
Blue (6)	Blue (2)	Life (22)	Life (23)	Nature (5)	Water cycle (6)	Cleaning (16)	Cleaning (10)
Pureness (3)	Pureness (2)	Vitality (6)	Photosynthesis (6)	Earth (3)	Earth (4)	Peace (7)	Water footprint (4)
Dissolvent (2)	Dissolvent (2)	Greenery (4)	Living things (5)	Sea (3)	Glacier (4)	Health (4)	Happiness (4)
Green (2)	Fluid (1)	Plentifulness (4)	Vitality (2)	Rain (2)	Sea (2)	Happiness (3)	Peace (3)
Fluid (1)	Beauty (1)	Biodiversity (3)	Plant (2)	Indispensable (2)	Nature (2)	Future (2)	Health (3)
Beauty (1)	Inorganic (1)	Photosynthesis (2)	Fish (2)	Humidity (1)	Basin (2)	Fun (2)	Awareness (3)
Originality (1)	Cohesion (1)	Plant (1)	Ecosystem (1)	Temperature (1)	Underground sources (2)	Need (2)	Fun (2)
Transporter (1)	Adhesion (1)	Child (1)	Non-living things (1)	Habitat (1)	Ocean (2)	Roominess (2)	Need (2)
Balancer (1)	Hydrogen bond (1)	Living things (1)	Metabolism (1)	Climate (1)	Antarctica (2)	Wealth (2)	Right (2)
Hot (1)	Proton-ion (1)	Flower (1)	Cell (1)	Wetland (1)	Balance (2)	Infinity (2)	ProjectWet (2)
10/19	H2O (1)	Yield (1)	Brain (1)	River (1)	River (1)	Swimming (2)	Watering (1)
	Chemistry (1)	Respiration (1)	Digestion (1)	Lake (1)	Climate (1)	Sustainable development (1)	Wealth (1)
	Move (1)	Cytoplasm (1)	Respiration (1)	Glacier (1)	Mild climate (1)	Comfort (1)	Justice (1)
	13/16	Beginning (1)	Essential (1)	Water cycle (1)	Transpiration (1)	Coolness (1)	Infinity (1)
		14/49	Refreshing (1)	Melting (1)	Evaporation (1)	Journey (1)	Injustice (1)
			15/49	Main component (1)	Freezing (1)	Joy (1)	Water-saving (1)
				Balance (1)	Snow (1)	Name (1)	Water literacy education (1)
				17/27	Indispensable (1)	Drink (1)	Conscience (1)
Water is a natural source		**Water resources are managed**			Magnificent (1)	Bath (1)	Hope (1)
Pre-test (f)	Post-test (f)	Pre-test (f)	Post-test (f)		Everything (1)	Tea (1)	Science (1)
Pollution (2)	Pollution (4)	Hygiene (3)	Energy (5)		Important (1)	Enthusiasm (1)	Future (1)
Disaster (2)	Source (3)	Food (2)	Industry (4)		21/39	21/54	Value (1)
Thirst (2)	Life source (3)	Potable water (1)	Agriculture (3)	**Water resources exist within cultural constructs**			Prosperity (1)
Drought (1)	Pollution agents (2)	Agriculture (1)	Hygiene (3)	Pre-test (f)	Post-test (f)		Enthusiasm (1)
Child mortality in Africa (1)	Point source pollution (2)	Transportation (1)	Recreation (2)	Culture (3)	Scream (2)		Drink (1)
Waste (1)	Disaster (1)	Project (1)	Food (2)	Soul (1)	Soul (1)		Coffee (1)
Source (1)	Drought (1)	6/9	Fishery (1)	Gratitude (1)	Culture (1)		26/51
7/10	Neediness (1)		7/20	History (1)	Voice (1)		
	Nonpoint source pollution (1)			4/6	4/5		
	Africa (1)						
	10/19						

CONCLUSION and DISCUSSION

The results showed that the teachers had sufficient knowledge about the principle "Water has unique physical and chemical characteristics". Analyzing their views, it was found that the number of characteristics rose up from a total frequency of 42 in the pre-test to 64 in the post-test. It was not surprising that the teachers already knew so much about the properties of water due to the fact that they knew and thought these at school. In addition, the considerable increase in this principle could be evaluated as a result of the activities, especially the "H_20 Olympics" that was related with characteristics of water like being a good solvent, adhesion/cohesion force, and surface tension.

According to the teachers' views about the definitions, importance of water, and water-related issues, they particularly considered "Water is essential for all life to exist" principle in terms of living things, which was the expected way of thinking. However, the striking part of their views was that they had mentioned non-living things with increasing frequency in the post-tests. This was satisfying because water was not just related to living things but also non-living things. They also mentioned water as a living area, a need for biodiversity and homeostasis. Although the drama activities contributed to the development of those thoughts in the post-test, it was believed that different activities like "8-4-1 One for all" and the "Incredible Journey" reinforced this situation.

The water cycle is the basis of the "Water connects all Earth systems" principle. The knowledge of the teachers about the water cycle was revealed in the basic characteristics of water, importance of water, water-related topics, and the WAT. In particular, there is a remarkable change in the water-related topics and the WAT test. It was thought that this might be due to the "Incredible Journey" as well as the fact that it was supported by the "Blue Planet" and "Seeing Watershed" activities.

The results showed that the teachers had sufficient knowledge about the principle "Water is a natural source". Under this principle, it was seen that the teachers cited the oceans as the water resources with the maximum water reserve in both tests. It indicated that teachers already had this knowledge which was in accordance with these studies' results (Kalaycı & Çağlarer, 2021; Shiklomanov & Rodda, 2003). Such a result from the teachers' post-test findings was closely related to the "Blue Planet" and "A Drop in the Bucket" activity. However, obtaining such a finding in the pre-test could simply be explained by the fact that it was the result of an observation that could be obtained by anyone who had seen a world globe. The teachers thought that groundwaters were the most potable water in the pre-test, while glaciers, in the post-test. Most of the tap water for domestic usage was supplied from groundwaters, which was one of the fresh water sources (Çelik & Muhammetoğlu, 2018). Although groundwaters were accessible freshwater resources, they came after glaciers in terms of reserving water. This information that individuals were exposed to in their daily lives might have caused them to think groundwaters as the most freshwater reserves. However, this situation changed in the desired direction in the post-test, and it was thought to be due to one of the activities "A Drop in the Bucket".

The teachers evaluated rivers as the most easily accessible and potable water resource in both tests. Currently, this result did not coincide with the knowledge that groundwater was the largest and most easily accessible potable water reserves in the world after glaciers (Yılmaz, 2021). Although the teachers' opinions did not seem to have changed in the pre-test and post-test, there was an increase in the variety of answers given in the post-test. It may be derived from the teachers' dominant beliefs or the question might not be fully understood. The teachers stated that Turkey was a water stressed country in both tests. This result was in congruence with Gezer and Erdem's (2018) study that reported Turkey was a water stressed country according to most of the participants. The teachers were right in their views because Turkey was known to be a "water stressed" country according to the Falkenmark indicator (Falkenmark, Lundqvist & Widstrand, 1989; Hakyemez, 2019). It is satisfactory that about half of the teachers (f:12) answered this question correctly in the pre-test. In addition, the fact that this number increased from 12 to 20 in the post-test shows that the training is effective. Along with these, the words from the WAT revealed that the number and the total frequency of new entries increased under this principle. New words such as "life source", "pollution agents", "point source pollution", and "nonpoint source pollution" were noted. Besides, there was an increase in the number of the teachers' views on water-related issues in the post-test.

When the teachers' views on water users under the principle "Water resources are managed" were examined, it was determined that soil, plants and animals were in the first three places in both the pre-test and post-test. Normally, these were the first things that came to mind as people generally thought that they were as direct users (ProjectWet, 2011). However, in the post-test, there were some users were noted such as industry, transportation, recreation, tourism, agriculture that were also called indirect water users (Reutter, Lant & Lane, 2018). This could be interpreted as a result of the activity called "8-4-1 One for all" that focused on water management challenges with eight water users. This result was so important because being aware of these indirect water users probably made it easier to understand the complexity of water resource management and to find solutions for water issues. Hence, people will behave more consciously when consuming anything to protect the water. In comparison to the results of the Seelen et al.'s (2019) study, where many participants had been seen to be unfamiliar with indirect water users, teachers mentioned indirect water users as factors encouraging to demonstrate their awareness of water resource management. They also mentioned the same water users in connection with the importance of water. These results were supported by the WAT test and the answers to the question about water-related topics. According to the results of the WAT, this principle recorded a rise in different words like "energy", "industry", and "recreation" with the number of new entries.

When the teachers' views on tips to save water in daily lives under the principle "Water resources exist within social constructs" were analyzed, many ideas were seen to emerge. All of these showed that the teachers had a certain level of water awareness about water saving and they could be interpreted as being sensitive while consuming water, which was similar to the Gezer and Erdem's (2018) finding that most of the participants considered water-saving so important (Bargayo & Go, 2021). Although the number of ideas that teachers put forward to save water in their daily lives did not change much (f:16, f:18), the change in the total number of

frequencies (f: 26; f: 63) showed that their ideas focus on certain examples and a teacher offered more than one idea. In addition, instead of abstract ideas such as "do not waste water", the teachers stated more concrete ideas such as "using transportation", "running full dishwasher and washing machine", "closing the taps tightly", and "using drip irrigation system" in the post-test. The change of teachers' ideas about water saving was pleasing and showed that the activities reached their goals. There was a significant change in the pre-test and post-test frequencies of the teachers in raising people's consciousness of water saving. As a part of social constructs, the teachers thought that one of the important ways to develop water awareness in individuals was education. Considering the data obtained, the belief of the teachers who received this training that water education should be given with formal education in schools increased considerably in the post-test. It was obvious that water education especially given at an earlier age plays a vital role in increasing awareness through family involvement (Bryx & Bromberg 2009; Endry, 2010; Gezer & Erdem, 2018; McCarroll & Hamann, 2020; Yan, 2010; Zuchowicki & Kuczynski, 2008). Some of the teachers offered to develop water policy, which is similar to Tortajada and Josh's (2013) study that reported water policies' main goal should be raising people's consciousness of consuming water use (Katz, 2013). Furthermore, according to WAT results, this was the first principle. Besides these, the results obtained from definition, basic characteristics and importance of water addressed the same outcomes. These results imply that the teachers' water literacy level and awareness has improved with these activities.

Consequently, separate activities focusing on the water literacy principles of ProjectWet and different questions have been asked to teachers to determine the reflection of these activities on teachers' knowledge and views in this study. From this point of view, teachers may be considered water literate in the context of six principles, which are as following: *"Water has unique physical and chemical characteristics", "Water is essential for all life to exist", "Water connects all Earth systems"*, *"Water is a natural source", "Water resources are managed"* and "*Water resources exist within social constructs"*. However, little data could be obtained to for discussion in the cultural context. This situation can be evaluated as a result of the teachers' inability to think about water in a cultural context. It may be due to the fact that drama activities are not sufficient to teach the cultural construct of water. This situation may be also seen as a result of fewer activities done in this context. Currently, ProjectWet has fewer activities under this principle than the other principles (ProjectWet, 2011).

Studies emphasize that not only early age groups but also parents, adults and teachers, as in this study, should be educated or trained about water (Fisk, 2016). Considering the increasingly complex issues of water problems and the water knowledge gaps, it is thought that any action, practice or training that can raise water awareness (McCarroll & Hamann, 2020). For this reason, such studies on water literacy should be increasingly continued.

RECOMMENDATIONS

The teachers have sufficient knowledge about the principle *"Water has unique physical and chemical characteristics", "Water is essential for all life to exist", "Water connects all Earth systems"*, *"Water is a natural*

source", "Water resources are managed" and "*Water resources exist within social constructs"* except "*Water resources exist within cultural constructs"*.

Reviewing all the results, it could be concluded that there is not much data in the cultural context of water. Although some data came from WAT and the question about basic characteristics of water, it is not enough to comment on the teachers' knowledge about the cultural context of water. This may be due to the lack of a specific ProjectWet activity focusing on the cultural context of water. Therefore, the number of activities related to this principle should be increased.

Also, for future research, doing more projects on water literacy at different levels can be recommended. Furthermore, follow-up studies can be carried out for the participants of the project afterwards like longitudinal studies within these areas that can disseminate and develop water literacy.

ETHICAL TEXT

This study is a research project designed to develop teachers' water literacy supported by the Turkish National Scientific and Technological Research Council.

In this article, the journal writing rules, publication principles, research and publication ethics, and journal ethical rules were followed. The research permission was obtained from Turkish National Scientific and Technological Research Council dated 20/12/2018 and numbered 77533774-115.02. The responsibility belongs to the author (s) for any violations that may arise regarding the article.

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