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| Research Article / Araştırma Makalesi |

Enhancing Middle School Students' Cognitive Structure of Water Cycle Through the Use of Water Cycle Educational Game

Ortaokul Öğrencilerinin Su Döngüsü ile İlgili Bilişsel Yapılarının Su Döngüsü Eğitsel Oyunu ile Geliştirilmesi[1]

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Keywords

1.Water cycle
2.Water literacy
3.Cognitive structure
4.Educational game
5.Middle school students

Anahtar Kelimeler

1.Su döngüsü
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Abstract

Purpose: The aim of this study is to determine the changes in the cognitive structures of middle school students studying at 5th, 6th and 7th grades after the implementation of water cycle educational game activity.

Design/Methodology/Approach: The study was conducted according to a pre-experimental (single group, pre-test, post-test) method. The study group consists of 51 students at fifth (N: 18), sixth (N: 16) and seventh (N: 17) grades in a middle school in one of the districts located in the rural part of a province in the Eastern Black Sea Region. Word Association Test (WAT) and Water Cycle Drawing Test were used as data collection tools. The activity named as "The Incredible Journey" provided by the ProjectWET Association was used as the educational game. Content analysis method was used in the analysis of the data. In order to evaluate the results of the Word Association Test (WAT), the answers given to the key concept of "water cycle" were examined in detail. The rubric prepared by the researchers was used for scoring the drawings.

Findings: According to the data, it was determined that the fifth-grade students' WAT results showed the most change compared to other grades. According to the results obtained from the drawing test, the insufficient and limited understandings of all students turned into limited, sufficient and excellent.

Highlights: Since the development of students' cognitive structures is closely related to the education they will receive, trainings including educational games can be given especially to teachers. Teachers can use ProjectWET-The Incredible Journey in their lessons.

Öz

Çalışmanın amacı: Bu çalışmanın amacı 5., 6. ve 7. sınıflarda okuyan ortaokul öğrencilerinin gerçekleştirilen su döngüsü eğitsel oyun etkinliği sonucunda bilişsel yapılarında meydana gelen değişimin belirlenmesidir.

*Materyal ve Yöntem*Çalışma basit deneysel (tek grup, ön-test, son-test) yönteme göre yürütülmüştür. Çalışma grubunu Doğu Karadeniz Bölgesi'ndeki bir ilin kırsal kesiminde yer alan ilçelerinden birindeki ortaokulda okuyan beşinci (N:18), altıncı (N:16) ve yedinci (N:17) sınıflarda öğrenim gören 51 öğrenci oluşturmaktadır. Veri toplama aracı olarak Kelime İlişkilendirme Testi (KİT) ve Su Döngüsü Çizim Testi kullanılmıştır. Eğitsel oyun olarak ProjectWET Derneğinden temin edilen "İnanılmaz Yolculuk" isimli etkinlik kullanılmıştır. Verilerin analizinde içerik analizi yöntemi kullanılmıştır. Kelime İlişkilendirme Testi (KİT) sonuçlarını değerlendirmek amacıyla "su döngüsü" anahtar kavramına verilen cevap kelimeler ayrıntılı bir şekilde incelenmiştir. Çizimlerin puanlandırılmasında araştırmacılar tarafından hazırlanan rubrik kullanılmıştır.

Bulgular: Elde edilen sonuçlara göre beşinci sınıf öğrencilerinin KİT sonuçlarının diğer sınıf seviyelerine göre daha fazla değişim gösterdiği, çizim testinden elde edilen sonuçlara göre de tüm öğrencilerin yetersiz ve sınırlı anlamalarının sınırlı, yeterli ve mükemmel şeklinde değişim gösterdiği belirlenmiştir.

Önemli Vurgular: Öğrencilerin su döngüsü ile ilgili bilişsel yapılarının geliştirilmesi alacakları eğitimle yakından ilgili olduğu için bu konuda özellikle öğretmenlere eğitsel oyunları kapsayan eğitimler verilebilir, öğretmenler ProjectWET-İnanılmaz Yolculuk etkinliğini derslerinde kullanabilirler.

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INTRODUCTION

The environment in which we live consists of living and non-living things and their mutual relationship. The biotic environment is constituted by organisms and all other organisms that interact with them. These are called biotic factors. The abiotic environment is formed by physical conditions that affect the development of living things in physiological or morphological aspects, and non-living things themselves (Chauhan, 2008). These are called abiotic factors. Survival of living things healthily depends on abiotic factors. Water, one of these factors, is especially essential for living things.

The amount of water in use today is the same amount of water on earth as there was when the earth was formed. Its proportion and amount have changed very little Water can move from one place to another, undergo a change of state, can be used by living things, but it never disappears (Para & Reis, 2009). The water cycle is the phenomenon what makes the continuous movement of water possible. Usable water, salty water as well as wastewater is constantly added to the cycle (Klötzli, 1980). In this way, while water is transferred from one place to another, the polluted water gets cleaned. However, excessively polluted water due to growing population, global warming, increasing demand for water or industrialization in recent years has surpassed water sources' self-refreshing capacity and caused these sources' being polluted rapidly and losing their sustainability (Menteşe, 2017). Water is capable of refreshing itself if the water cycle functions properly without interruption.

For sustainable use of natural sources, several measures can be taken. Raising aware individuals is the starting point of the solution. Steps of raising awareness among individuals was taken firstly with the United Nations Conference on the Human Environment in 1972, when June 5 was declared as World Environment Day, and then, with the United Nations Conference on Environment and Development in 1992. That same year, the United Nations General Assembly adopted a resolution by which 22 March of each year was declared World Day for Water. In our country, which acknowledges and celebrates both of the observance days above, these works were enhanced. What's more, a cooperation protocol was signed between the Ministry of Environment and the Ministry of National Education in 1999 to introduce compulsory environmental lessons to the curricula for developing environmental awareness through formal education. Also, a circular issued in the first week of the 2008-2009 academic year, it was ordered to prioritize training works to teach conscious and efficient use of water in a class chosen by the teacher within the scope of life sciences, social studies and science and technology lessons for all grades of public and private elementary schools and in chemistry, biology and geography lessons for all grades of secondary education institutions (MEB, 2008). With the curriculum renewal, the main objectives of science education today include raising awareness for sustainable development of natural sources and developing curiosity, attitude and interest in natural phenomenon MEB, 2018). The way to achieve these goals goes through restructuring of the education curricula where ecological information has the central piece (Orr, 1992). It was found that the current science curriculum contains enough learning outcomes for knowledge but not adequate attitudes and behaviors (Ursavaş, Aytar & Alpay, 2020). Raising aware individuals can be possible by bringing up water-literate individuals with related knowledge, attitudes and behaviors (Covitt, Günckel & Anderson, 2009).

The water cycle is one of the prominent issues that water-literate individuals should know (Bar, 1989; Chin & Mageswary, 2013; Çardak, 2009; He, 2018; Otaki, Sakura & Otaki, 2015; Wheeler, 2012; Wood, 2014). Although there are not many studies on the water cycle (Bar, 1989; Ben-zvi-Assarf & Orion, 2005; Bechard, Pascoe & Zahor, 2007; Shepadarson et al., 2009; Çardak, 2009; Çelikler & Topal, 2011; Chin & Mageswary, 2013; Çeken, 2010; Derman & Yaran, 2017; Ahi, 2017; Vo, Forbes, Zangori & Schwarz, 2015), previous studies have revealed that students know inadequate and wrong concepts about water cycle (Bechard et al., 2007; Ben-zvi-Assarf & Orion, 2005; Derman & Yaran, 2017; Taiwo, Ray, Motswiri & Masene, 1999). It has been determined that students have limited, insufficient and low level of knowledge about physical processes related to water cycle, the physical processes are not understood properly, and the events in the water cycle cannot be linked with weather events in daily life such as rain and snow (Alkış, 2006; Bar, 1989; Henriques, 2000; Osborne & Cosgrove, 1983; Shepardson, Bryan, Michelle, Schellenberger & Harbor, 2009).

The ambiguity of some biological concepts may have caused the misunderstandings regarding water and its importance in life processes (Brody, 1993; Taiwo et al., 1999). Students' lack of knowledge can be overcome by determining their preliminary knowledge about the concepts and by using appropriate teaching methods and techniques. The number of sense organs addressed is important for the correct understanding and internalization of the concepts. It is shown that water education given in schools increases students' knowledge about water saving and their conscious water consumption behaviors (Middlestadt, 2001). Applied studies have reported positive changes in students' knowledge and attitudes about water and the water cycle (Bechard et al., 2007; Chin & Mageswary, 2013; Ursavaş & Aytar, 2018). Derman and Yaran (2017) stated that instruction can be done in outdoors under suitable conditions while teaching the topic of water cycle, dynamic visuals prepared with multimedia can be benefited besides one-dimensional, static and visual materials such as figures, pictures and diagrams obtained from textbooks or other resources so that students can learn actively and interpret the events they encounter in everyday life.

Studies have shown that as the grade level increases, positive attitudes towards the science lesson turn negative and the reason seems to be the use of deficient methods and techniques (Kozcu-Çakır, Şenler & Taşkın, 2007). Educational games are one of the methods in which students can actively participate, employ more than one sense organ, learn by doing and living, and ensure permanence of their knowledge while having fun (Demirel, 2009; Ülküdür, 2016; Budak, Kanlı, Köseoğlu ve Yağbasan, 2006; Çavuş, Kulak, Berk ve Öztuna-Kaplan, 2011). Educational games are activities that enable students to reinforce the information they have learned in the school environment by repeating them, and enable them to have fun and learn through play while using their cognitive abilities (Demirel, 2009). Educational games are seen as a method that can develop a positive attitude towards the Science course and ensure permanence and continuity of the knowledge learned (Çavuş et al., 2011). However, when the Science Lesson Curriculum and the Science Lesson textbook were examined, it was seen that educational games were not included at an adequate extent (Kaya & Elgün, 2015). Therefore, the current study aimed at improving the knowledge level of students about the water cycle by using educational games. The educational game employed here was obtained from the ProjectWET Association in the United States. The ProjectWET Association is known for developing water education resources around the world, organizing water activities, managing a worldwide local implementation network, and advocating the role of water education in solving the world's most pressing water issues.

Elimination of students' lack of knowledge can be achieved with appropriate teaching methods and techniques. However, early ages are of great importance in raising awareness (Ergin, 2008). In the curriculum, topics related to the water cycle are offered at the 8th grade, but this age level is not supported by the literature on raising awareness. Since the water cycle concerns intangible processes as well as concrete events, the most appropriate age or grade level should be determined. Therefore, figuring out the cognitive structures and development of different grade levels related to the water cycle may be effective in solving this problem. The purpose of this study is to determine the change in the cognitive structures of middle school students in the 5th, 6th and 7th grades as a result of the water cycle educational game activity. In the light of all this information, answer was sought for the following research question:

What changes have taken place in the cognitive structures of the 5th, 6th and 7th grade students as a result of the water cycle educational game activity?

METHOD

This study was conducted with simple experimental (single group, pre-test, post-test) method as it aimed to reveal the change in the cognitive structures of students at different grade levels after the applications. Simple experimental method allows exposing participants to a practical activity during a certain period of time and observing the participants before and after the activity by various means (Creswell, 2012; Çepni, 2010). Observations include data collection tools to be used as pre-test and post-test. Simple experimental studies are usually used to measure various curriculum innovations or a new teaching method put forward by different researchers, based on a dependent variable (Cohen, Manion & Morrison, 2007). In this study, single group pre-posttest simple experimental method was preferred since the study intended to depict the cognitive structures of the students related to the water cycle and how they changed through the educational game.

Universe and Sample

The universe includes 5th, 6th and 7th grade students at middle school level, and the study sample consists of 51 students studying in the 5th grade (N: 18), 6th grade (N: 16) and 7th grade (N: 17), enrolled in a middle school located in a rural district of a province in the Black Sea Region. Purposeful sampling was used in selecting the classes and the participants because the Science Course Curriculum for the 5th, 6th and 7th grades do not cover learning outcomes regarding the water cycle. The 8th graders were not included in the sample since the curriculum for this grade contains outcomes as "F.8.6.3.1. To be able to explain the matter cycles by showing them on the diagram", "F.8.6.3.2. To be able to question the importance of the matter cycles in terms of their importance for life". Thus, it could have manipulated the pre-test scores showing the participants' preliminary knowledge and post-test scores.

Data Collection Tool

In this study, Word Association Test (WAT) and Water Cycle Drawing Test were used as data collection tools. The students were briefed about the Word Association Test before the WCDT was applied. Students attending different grade levels were asked to note down the associated words about the key concept "water cycle". In the WAT, gaps were left opposite the key concept so that the respondents could write the associated words. Bahar and Özatlı (2003) pointed out that knowledge in the semantic memory is directly proportional to learning, so learned information will be revealed quickly. Based on this scientific view and the age of the participants addressed, they were given one minute to complete the association test. This technique allows the respondents to write various concepts they find associated with the given key concept. In this way, a researcher can have an idea about the respondents' cognitive structures related to the key concept.

Drawing enables students to express their existing knowledge and beliefs in visual terms without being dependent on words (Ayas, 2006). In this study, it was attempted to find out how students depict the processes of water cycle and what elements and processes they include in the water cycle by having them draw the water cycle. The purpose of this procedure was to examine in detail the nature of the knowledge structures of students on the topic of "water cycle" and the relationships between concepts in their knowledge structures. To this end, the participants were asked to express their views freely with no limitation by drawing the "water cycle" in nature with all its aspects and providing written explanations on the connections between the natural phenomena. Both of the data collection tools were first piloted with 24 middle school students within the scope of the project titled "Do not Waste Your Water, Do not Fade Your Future: Water Awareness Training of Elementary Students Research (WATER) funded by TUBİTAK 4004 Nature Education and Science Schools. The pilot studies showed that the word association and drawing tests were understandable and students did not have difficulty in responding

The Educational Game: The Incredible Journey

In this study, the activity named "The Incredible Journey" provided by the ProjectWET Association was used as the educational game. For implementing this activity, the multi-purpose hall in the state school was used. The implementation of the game was represented in narration and visuals below.

Nine separate stations (cloud, sea/ocean, lake, animal, plant, soil, river, glacier, underground water) were placed onto the floor to symbolize the elements of the water cycle (Figure 1). One dice was placed next to each station. The dice have 6 sides each with an image relevant to that station. For example, there are cloud images on three sides of the dice next to the station of cloud and sea/ocean, river and lake images on the remaining sides.

Figure 1. Stations for the cycle elements

Color beads were placed in a box at each station (Figure 2). A different color was used for each station. Each student was given a 25-cm-long fishing line to pick one bead from the stations they visit each time and to put them on the line.

Figure 2. Boxes and beads for the stations

The students were dispersed to nine stations as they wished (Figure 3). The student who was in the forefront of each station threw the dice to whether stay at their own station or move to another station, depending on the cycle element on the upward-looking side. For example, if a student found a cloud on the dice while they were at the sea/ocean station, they went to the cloud station and took a bead before moving to the back of the row.

Figure 3. Start of “The Incredible Journey” educational game

The activity was started by the researcher by blowing the whistle, and after each whistle, the students in the front row threw the dice belonging to the station where they were standing.

From time to time, the researcher asked the students questions about the water cycle. In this 40-minute activity, the students figured out how the water cycle is formed, where in the world and in what conditions water is found, by playing the game.

In the second phase of the activity, the students got seated as arranged by the researcher (Figure 4). The researcher distributed the forms she prepared beforehand to the students and asked them to write the stations they visited throughout the "The Incredible Journey” educational game by looking at the colored beads on the fishing lines. After the ordering, they were asked to write a story that includes the water cycle processes according to this order. The students were asked to start their story with the sentence “I am a drop of water on the earth" and make up a story accordingly.

After allowing them enough time, each student stood up and read out their story after introducing themselves. A total of 6 hours of practice was carried out at each grade level at an interval of one week. Pre-tests were given in the first week, the educational game was practised in the second week, and post-tests were applied in the third week. Data collection was completed in this way.

Figure 4. Making up a story

Validity and Reliability

The data in this study were collected with two different tools. There is a direct proportion between the percentage of inter-coder agreement and reliability (Miles & Huberman, 1994). According to the coding check on internal consistency, the consensus between coders must be at least 80% (Miles & Huberman, 1994; Patton, 2002; Baltacı, 2017). In this study, consistency of the data was checked from the inter-coder agreement of the two researchers who are experts in the field of science education. According to the formula proposed by Miles and Huberman (1994), the consistency of the tools was calculated as 89.98% for the 5th class WAT, 89.47% for the 6th class WAT, and 93.47% for the 7th class WAT. Given that all these results are over 80%, the data are considered reliable. While preparing the Water Cycle Drawing Test, the relevant literature was used and the opinions of Science experts were also taken.

Pilot Study

The pilot study of this research was carried out with 24 students who had just finished the 5th grade of middle school and started the 6th grade in the city of Rize in the spring term of 2017. The project “Do not Waste Your Water, Do not Fade Your Future: Water Awareness Training of Elementary Students Research (WATER) funded by TUBİTAK 4004 Nature Education and Science Schools targeted to reveal the development of middle school students' knowledge level, awareness and perspectives on water. Within the scope of the project, besides many different activities, the educational game named "The Incredible Journey" was also included as the focal point of the current study. It was found from the implementation of the project that no problems were faced in terms of the implementation or appeal of the game to students. Yet, the implementation and data collection were adjusted thanks to this experience as following:

A whistle was used to give commands to the students before the implementation.

The researcher planned to pause the game and ask reinforcing questions at some point during the game so that the students could better understand and question the density in the cloud.

The activity was prepared in advance in the field of application in order to avoid time management problems.

After the game, forms were made ready to give out to the students for writing the start and end points of their journey in order to internalize the information they learned.

The students were informed about the tests to be applied in advance and ready-made forms were used especially for the WAT.

The students were allowed to keep the beads they put on a fishing line as a memento so that the learned knowledge can be more permanent due to the association with a tangible object.

Data Analysis

Content analysis method was performed on the data obtained in this study. The main purpose in content analysis is to reach the concepts and relationships that can explain the collected data. The data summarized and interpreted in descriptive analysis are subjected to a deeper processing in content analysis and concepts and themes that cannot be recognized with a descriptive approach can be discovered as a result of this analysis (Yıldırım & Şimşek, 2006). In order to evaluate the results of WAT, the answers given to the key concept "water cycle" were examined in detail. The suggestions for this concept were written one by one for the pre and post-test and their frequencies were found. A frequency table was created showing the frequency of each associated word. Then, words that are semantically similar and can appear in the same context were brought together and themes were created. Tables containing data on the words and the frequencies of the words under each theme were created. In order to clearly show the relationships between the concepts in the cognitive structure, the cut-off point (CoP) technique of Bahar, Joohnstone, and Sutcliffe (1999) was used. With this technique, the change in the relationship between the words associated with "water cycle" as the key concept was tried to be shown by looking at the pre and post-test. In the cut-off point technique, a certain level below the most repeated response for any key concept in the frequency table is determined as the cut-off point. Concepts above this value make up the first part of the concept web. Then, the cut-off point is pulled down at certain intervals and the process continues until all key concepts appear in the concept network (Eren, 2012). Yılmaz (2019) argued that the number of repetitions in each cut-off point range gives the number of respondents within that interval. The strong and weak relationships between the themes related to the water cycle were demonstrated separately for both pre and post-tests, and concept networks were created for both tests. During the analysis of the data, concept networks were created according to the cut-off points 31 and above, 25-30, 19-24, 13-18, 7-12 and 0 -6: As a result, the change in the relationship between water cycle and themes in the pre and post-test could be shown clearly.

Drawings obtained from the Water Cycle Drawing Test were assessed by using a rubric developed in cooperation with a faculty member in the field of Science Education. An activity sheet was distributed to the students for the Water Cycle Drawing Test. It was given as both pre and post-test in order to monitor the students' cognitive and visual change. The students were allowed sufficient time for the activity. They were instructed to make a drawing about the water cycle flow on a blank side of the paper after narrating the topic. They also colored their drawings with dry paint. Afterwards, they were asked to write the name of each of the two-dimensional objects in the drawings (water cycle elements) and to establish a connection between them and the other figures. These links were in the form of the water cycle events, connections between the cycle elements, and the states of water. The drawings related to the Water Cycle Drawing Test were evaluated based on the categories used in the analysis of the data obtained through the Water Cycle Drawing Test, which was prepared with the Science Education, shown in Table 1.

Table 1. Scoring scale used in the analysis of data obtained by the water cycle drawing test

Category	Score Interval
Insufficient	0-25
Limited	26-50
Sufficient	51-75
Excellent	76-100

According to the assessment criteria above, respondents getting between 0 and 25 points in the pre- and post-application of the Water Cycle Drawing Test were regarded insufficient, scoring 26 to 50 were regarded at a limited level, those who score between 51 and 75 were regarded sufficient, and 76 to 100 points were accepted to be excellent. Apart from that, a rubric was developed for assessing the data obtained through the Water Cycle Drawing Test in cooperation with a specialist of Science Education for the purpose of appraising the students' drawings.

Table 2. Rubric for assessing the water cycle drawing test data

	Water cycle elements (animals, plants, soil, seas-oceans, lakes, rivers, glaciers, clouds, underground water)	Water cycle events (condensation, precipitation, surface run-off, percolation, evaporation, transpiration, sublimation, frostiness, stream flow, source)	Connection between the cycle elements	The states of water (solid, liquid, gaseous)	Level
Insufficient performance	0-2 elements are drawn and named	0-2 events are named	0-9 connections are shown with an arrow.	0 is shown	0-25 points
Limited performance	3-4 elements are drawn and named.	3-5 events are named.	10-18 connections are shown with an arrow.	1 is shown	26-50 points
Sufficient performance	5-7 elements are drawn and named.	6-8 events are named.	19-27 connections are shown with an arrow.	2 are shown	51-75 points
Excellent performance	8-9 elements are drawn and named	9-10 events are named	28-35 connections are shown with an arrow	3 are shown.	76-100 points

In Table 2, themes in the Rubric for Assessing the Water Cycle Drawing Test Data are grouped under 4 headings. These themes are; *water cycle elements, water cycle events, connection between cycle elements* and *the states of water*. The water cycle elements are elements directly related to the water cycle. These consist of animals, plants, soil, seas-oceans, lakes, rivers, glaciers, clouds and groundwater. The water cycle events refer to the processes that water goes through above and below the ground and within the atmosphere. These include condensation, precipitation, surface run-off, percolation, evaporation, transpiration, sublimation, frostiness, stream flow, and source. Water can exist in three different states, either as solid ice, liquid water, or vapor gas.

Connections between the cycle elements refer to various connections formed by elements of the water cycle with each other. There are 35 connections in total. Some of the connections are used more than once. They are shown in Table 3.

Table 3. Connections between water cycle elements

Water cycle elements	Connections					
Animals	Clouds	Soil	Oceans	Plants		
Plants	Clouds	Animals	Soil			
Clouds	Glaciers	Soil	Oceans	Lakes	Rivers	
Oceans	Clouds	Animals				
Soil	Rivers	Plants	Clouds	Underground water		
Glaciers	Clouds	Rivers	Underground water	Oceans		
Underground water	Rivers	Lakes				
Lakes	Animals	Underground water	Clouds	Rivers	Plants	
Rivers	Animals	Lakes	Oceans	Underground water	Clouds	Plants

Based on the rubric for assessing the Water Cycle Drawing Test Data, scores between 0 and 25 points (insufficient) mean that the student can draw and name 0-2 elements, name 0-2 events, show 0-9 connections with an arrow, and cannot mention the states of the water. Students scoring between 26 and 50 points (limited) can draw and name 3-4 elements, name 3-5 events, show 10-18 connections with an arrow, and mention one of the three states of water. Students who get 51 to 75 points (sufficient) can draw and name 5-7 elements, name 6-8 events, show 19-27 connections with an arrow, and mention two of the three states of water. Lastly, students scoring 76 to 100 points (excellent) can draw and name 8-9 elements, name 9-10 events, show 28-35 connections with an arrow, and mention all three states of water.

FINDINGS

Findings Obtained from Word Association Test

Study themes were elicited by analyzing the associated words written by the students in response to the key concept water cycle in the pre-test and post-test through content analysis. The themes are shown in Table 4. The table also displays the associated words under the themes in both pre-test and post-test.

Table 4. Themes related to the water cycle and associated words

	5th grade		6th grade		7th grade	
Theme	**Pre-test (f)**	**Post-test (f)**	**Pre-test (f)**	**Post-test (f)**	**Pre-test (f)**	**Post-test (f)**
Natural and human problems	Drought (1)	-	Pollution (2) Drought (1)	-	-	-
Overall processes	Cycle (3) Life (2) Living (1)	-	Life (2)	-	-	-
Precipitation pattern	Rain (11)	Rain (11) Snow (2) Hail (1)	Rain (15) Snow (3) Hail (1)	Rain (11) Snow (8) Hail (2)	Rain (15) Snow (3)	Rain (8) Snow (8) Hail (5)
State of matter	Solid (1)	Liquid (14) Solid (12) Gaseous (2)	Liquid (1) Gaseous (1)	Liquid (7) Solid (4) Gaseous (1)	-	Gaseous (3) Liquid (2)
Abiotic Factors	Water (16) Sun (6) Air (3) Oxygen (1)	Water (13) Sun (8)	Water (10) Sun (3) Air (2) Mud (1)	Water (13) Air (5) Sun (3)	Water (12) Sun (9) Air (3)	Water (13) Sun (8)
Water cycle elements	Clouds (13) Lakes (3) Rivers (3) Seas/Oceans (3)	Lakes (14) Seas/Oceans (13) Clouds (12) Rivers (11)	Rivers (12) Seas/Oceans (11) Lakes (7) Clouds (7)	Soil (13) Plants (12) Lakes (12) Rivers (12)	Clouds (12) Rivers (9) Seas/Oceans (7)	Clouds (16) Seas/Oceans (13) Rivers (12)

	5th grade		6th grade		7th grade	
	Sky (2)	Glaciers (10) Animals (7) Underground water (7) Soil (7) Plants (6) Mountains (1)	Mountains (2) Sky (1) Trees (1)	Seas/Oceans (11) Clouds (10) Underground water (9) Animals (5) Glaciers (5)	Lakes (4) Glaciers (4) Forests (1) Soil (1)	Glaciers (10) Lakes (10) Soil (7) Plants (6) Underground water (6) Animals (6)
Change of state	Evaporation (13)	Evaporation (14) Melting (8) Freezing (7)	Evaporation (7) Condensation (1)	Evaporation (10) Condensation (4) Melting (3) Sublimation (3) Freezing (1)	Evaporation (15)	Evaporation (8) Condensation (3) Melting (2) Freezing (2)
Quality of water	Hot water (2) Cold water (1) Drinking water (1) Polluted water (1) Warm water (1)	-	-	-	Hot water (9) Cold water (8) Warm water (5) Muddy water (1)	-
Discipline	Science (1)	-	-	-	-	-
Unrelated concepts	Glasses (3) Impact (1) Direction (1) Universe (1)	Pot (4)	School (1) Tap (1) Shower (1) Beach (1) Glasses (1) Fountain (1) Pit (1)	-	Kettle (4) Pot (4) Umbrella (4) Road (1) Neighborhood (1) Isolation (1)	Kettle (3)
Total Average	**25/94 3,76**	**22/184 8,36**	**28/98 3,5**	**23/164 7,13**	**23/133 5,78**	**21/151 7,19**

Study themes were elicited through content analysis of the associated words written by the students. A total of 10 themes were obtained: Natural and Human Problems, Overall Processes, Precipitation pattern, State of Matter, Abiotic Factors, Water Cycle Elements, Change of State, Quality of Water, Discipline, Unrelated Concepts. The associated words related to the themes are as shown in Table 4. According to the table, a total of 25 and 22 words were produced by the 5th graders in the pre and post-test, respectively. Their frequency was 94 in the pre-test and 184 in the post-test. In the 6th grade, the number of entries was 28 and 23 in the pre-test and post-test, respectively, and the respective frequencies were 98 and 164 in the post-test. Finally, in the 7th grade, a total of 23 words were produced in the pre-test and 21 in the post-test, and the frequency of the related words were 133 and 151, respectively. Looking at the number of frequencies per word (f/n), the average of the words in the 5th grade was seen to be 3.76 in the pre-test and 8.36 in the post-test; it was 3.5 in the pre-test and 7.13 in the post-test in the 6th grade; lastly, the value was 5.78 in the pre-test and 7.19 in post-test in the 7th grade.

The associated words written by the students regarding the water cycle were re-evaluated based on the themes. In Table 5, the number of words under each theme and relevant frequencies are shown in a simple form for comparison.

Table 5. Themes obtained from the word association test

	5th grade		6th grade		7th grade	
Theme	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
Water cycle elements	5/24	10/88	7/41	9/89	7/38	9/86
Change of State	1/13	3/29	2/8	5/21	1/15	4/15
State of Matter	1/1	3/28	2/2	3/12	-	2/5
Precipitation pattern	1/12	3/14	3/19	3/21	2/18	3/21
Unrelated Concepts	4/6	1/4	7/7		6/17	1/3
Abiotic Factors	4/26	2/21	4/16	3/21	3/24	2/21
Discipline	1/1	-	-	-	-	-
Quality of Water	5/6	-	-	-	4/23	-

	5th grade		6th grade		7th grade	
Natural and Human Problems	1/1	-	2/3	-	-	-
Overall Processes	3/6	-	1/2	-	-	-
Total Average	**25/94** **2,5/9,4**	**22/184** **3,67/30,67**	**28/98** **3,50/12,25**	**23/164** **4,6/32,8**	**23/133** **3,67/22,17**	**21/151** **3,5/25,17**

According to Table 5, a total of 10 themes emerged for the concept of water cycle at all grade levels. Of these themes, the most common themes at all grade levels were “water cycle elements", “change of state”, “state of matter”, “precipitation pattern” and “abiotic factors”. On the other hand, “quality of water”, “overall processes”, “natural and human problems”, “unrelated concepts” and “discipline” were fewer common themes.

The fifth-grade students represented the water cycle with 10 themes in the pre-test and 6 themes in the post-test. At the fifth grade, the number of words per theme in the pre-test was 2.5 and the frequency per theme was 9.4, while the number of words per theme in the post-test increased to 3.67 and the frequency to 30.67.

The sixth-grade students represented the water cycle with 8 themes in the pre-test and 5 themes in the post-test. At the sixth grade, the number of words per theme in the pre-test was 3.50 and the frequency was 12.25, while the number of words per theme in the post-test increased to 4.6 and the frequency to 32.8.

The seventh-grade students represented the water cycle with 6 themes in the pre-test and post-test. At the sixth grade, the number of words per theme in the pre-test was 3.50 and the frequency was 12.25, while the number of words per theme in the post-test increased to 4.6 and the frequency to 32.8.

The cut-off point technique was used to show the change that occurred in the word association test. The cut-off point was applied to the themes formed by grouping the associated words, not to the associated words written in response to the water cycle key concept. This logic is shown in Table 6.

Table 6. Cognitive structure of themes related to water cycle

Column 1	Cut-off point	5th grade		6th grade		7th grade	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
	CoP:31 and above **(6)**		**SD**→Water cycle elements	**SD**→Water cycle elements	**SD**→Water cycle elements	**SD**→Water cycle elements	**SD**→Water cycle elements
Strong	CoP:25-30 **(5)**	**SD**→ Abiotic factors	**SD**→ Change of state State of matter				
	CoP:19-24 **(4)**	**SD**→ Water cycle elements	**SD**→ Abiotic factors	**SD**→ Precipitation pattern	**SD**→ Change of state Precipitation pattern Abiotic factors	**SD**→ Abiotic factors Quality of water	**SD**→ Precipitation pattern Abiotic factors
Association Strenght.	CoP:13-18 **(3)**	**SD**→Change of state	**SD**→Precipitation pattern	**SD**→ Abiotic factors		**SD**→ Precipitation pattern Unrelated concepts Change of state	**SD**→Change of state
Week	CoP:7-12 **(2)**	**SD**→ Precipitation pattern		**SD**→Change of state Unrelated concepts	**SD**→ State of matter		

Column 1	Cut-off point	5th grade		6th grade		7th grade	
	CoP:0-6 **(1)**	**SD**→Overall processes Quality of water Unrelated concepts State of Matter Discipline Natural and Human Problems	**SD**→ Unrelated concepts	**SD**→ Natural and Human Problems State of Matter Overall processes			**SD**→ State of matter

Table 6 shows the concept networks of the themes obtained from the water cycle, and associated words are given according to the Cut-off Point (CoP) technique. It also shows the weak and strong changes in the relationship of the themes with water cycle. In the table, "SD" stands for Water Cycle. The arrow mark (→) indicates the relation and the themes corresponding to the cut-off point in those themes. Multiple themes located at a cut-off point are ranked from high to low in frequency. The pre-test and post-test findings of all grade levels are presented in this way, and thus it is also possible to make comparisons between different grade levels. As a result, one can have an idea about the cut-off point of the themes in the pre-test and post-test and the strength of their relationship with the concept of the water cycle.

In the pre-test, at level 1 (CuP: 0-6), the most themes were found at the fifth grade. There were six themes as “overall processes”, “state of matter”, “discipline”, “natural and human problems”, “quality of water” and “unrelated concepts”. It was followed by the sixth grade with three themes. At the seventh grade, there was no theme at level 1. As for the post-tests, one theme was seen at the fifth grade and two themes at the seventh grade at level 1, whereas no theme was found at at the sixth grade at this level.

Some themes disappeared after the implementation process. Also, some themes became weaker by going closer to the lower cut-off points, while some others became stronger by going up to higher cut-off points. This change in the themes demonstrates the following:

The theme of "state of matter" went from level 1 (CoP: 0-6) to level 5 (CoP: 25-30) at the fifth grade, from level 1 to level 2 (CoP: 7-12) at the sixth grade, it never emerged in the pre-test but it was listed at level 1 (CoP:0-6) in the post-test at the seventh grade.

“Unrelated concepts” theme appeared placed at level 1 (CoP: 0-6) in the pre and post-test at the fifth grade. While it appeared at level 2 at the sixth grade (CoP: 7-12), it disappeared completely in the post-test. At the seventh grade, it dropped from level 3 (CoP: 13-18) to level 1 (CoP: 0-6).

The theme of “precipitation pattern” increased from level 2 (CoP:7-12) to level 3 (CoP:13-18) at the fifth grade, from level 3 (CoP:13-18) to level 4 (CoP:19-24) at the seventh grade, and it remained stable at level 4 in the sixth grade.

“change of state” increased from level 3 to 5 at the fifth grade, from level 3 (CoP:13-18) to level 4 at the sixth grade (CoP:19-24), and it remained unchanged at level 3 (CoP:13-18) at the seventh grade.

The theme “elements of change” went from level 4 (CoP:19-24) up to level 6 (CoP:31 and above) at the fifth grade, whereas it remained stable at level 6 (CoP: 31 and higher) in the sixth and seventh grades.

Finally, “abiotic factors” dropped from level 5 (CoP: 25-30) to level 4 (CoP: 19-24) at the fifth grade, but it increased from level 3 (CoP: 13-18) to level 4 at the sixth grade. But it did not increase or decrease at the seventh grade, staying unchanged at level 4 (CoP:19-24).

Findings Obtained from the Water Cycle Drawing Test

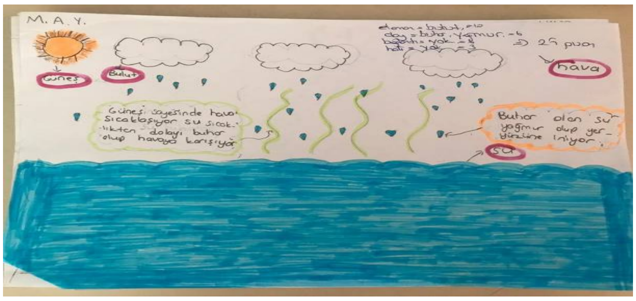
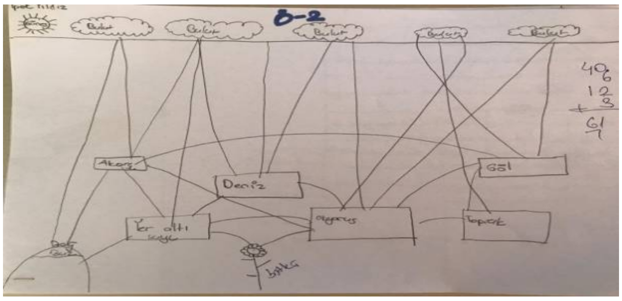
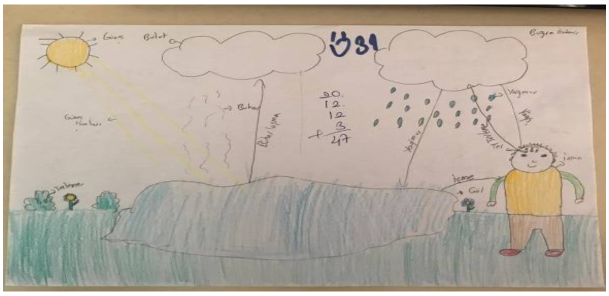
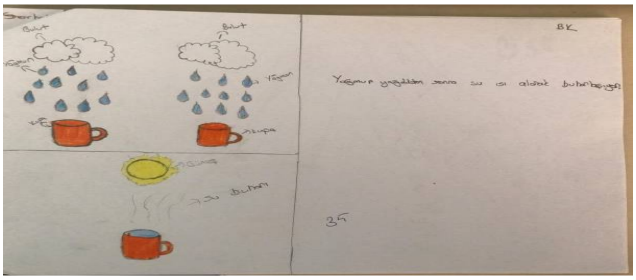
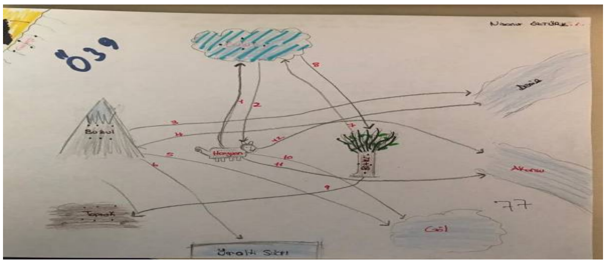
The findings obtained from the analysis of the Water Cycle Drawing Test as pre-test and post-test are presented in Table 7.

Table 7. Pre and post-test results of the water cycle drawing test

Grade level	**5th grade**		**6th grade**		**7th grade**	
Category	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
Insufficient	16	-	10	-	16	-
Limited	-	9	-	10	-	9
Excellent	-	4	-	2	-	5
Average	25,98	61,25	28,75	57,43	25,58	66,28

According to the pre-test scores in Table 7, drawings of 16 fifth-graders were found insufficient and 2 were found limited, 10 sixth-graders were insufficient and 6 were limited, and drawings of 16 seventh-graders were rated insufficient and 1 was limited. When it came to the post-test, the “insufficient” fifth-grade drawings were distributed across the categories like limited (n: 3), sufficient (n: 9) and excellent (n: 4). A similar change was observed among the students at the sixth grade. More specifically, there were no “insufficient” drawings, 4 “limited” drawings, 10 “sufficient”, and 2 “excellent” in the post-test. At the seventh grade, the students were in the categories sufficient (n: 9) and excellent (n: 5). When the grade averages were examined on the basis of the categories, the averages for all of the three grades were found to be insufficient. However, the post-test averages of the three grades were sufficient. Below are examples of drawings for each grade level and category.

Table 8. Examples of drawings by grade level and category

Category and Paintings (Pre-test)	Category and Paintings (Post-test)
Insufficient	**Sufficient**
 S1 pre-test	 S2 post-test
Limited	**Limited**
 S22 pre-test	 S31 post-test
Limited	**Excellent**
 S38 pre-test	 S39 post-test

DISCUSSION AND CONCLUSION

In this study, 5th, 6th and 7th grade middle school students' responses to the key concept water cycle are discussed under 10 different themes. Of these, the themes with the highest frequency at all grade levels were *cycle elements* (Çardak, 2009; Chin & Mageswary, 2013; Topal & Çelikler, 2013; Derman & Yaran, 2017; Ahi, 2017), *change of state, state of matter* (Wheeler, 2012; Ahi, 2017), *precipitation pattern* and *abiotic factors* (Topal & Çelikler, 2011; Ursavaş & Aytar, 2019). On the other hand, *quality of water* (Ursavaş & Aytar, 2019), *overall processes, natural and human problems* (Ursavaş & Aytar, 2019), *unrelated concepts* and *discipline themes* exhibited a smaller number of common themes (Table 4). According to the findings obtained, WAT results of the fifth-grade students changed more than the other grade levels. While the fifth-graders wrote 25 different words about the key concept water cycle in the pre-test, the sixth-graders wrote 28 and seventh-graders wrote 23 words. Considering the frequencies of the pre-test results and the average frequency per word, it was seen that the best results were demonstrated by the seventh-graders. The average scores of the grades were *3.76, 3.5,* and *5.78*, respectively. However, the fifth-grade students wrote 22 different words related to the key concept water cycle, the sixth-grade students wrote 23 and the seventh-grade students wrote 21 words in the post-test. With the decrease in the number of words, the increase in the number of frequencies per word was biggest at the fifth-grade level. The grade averages were *8.36, 7.13,* and *7.19,* respectively. This result is consistent with the previous studies in the literature (Ayvacı & Çoruhlu, 2009; Seçer, 2015; Özbek, 2015; Ayvacı & Bakırcı, 2018).

Looking at the frequency of the related words in the pre-test, the fifth-grade students predominantly associated the water cycle with concepts such as water (f: 16), cloud (f: 13), evaporation (n:13), and rain (f: 11). Among the sixth-graders, the most popular concepts were "rain" (f: 15), "river" (f: 12) and "sea/ocean" (f: 11). Lastly, the seventh-grade students mentioned "evaporation" (f: 15), "rain" (f: 15), "cloud" (f: 12), "water" (f: 12), "sun" (f: 9), and "river" (f: 9). This result can be said to be compatible with the learning outcomes related to water in the curriculum given for each of the grade levels. In other words, the students used words related to the educational content they learn at school (Çeken, 2010). The post-tests results showed that the numbers of words used in each grade level decreased. However, the frequency of the words increased strikingly. The decrease in the number of words can be explained with the decrease in the number of words under the theme "unrelated concepts" and the students' preference of terms closely related to the water cycle. As one looks closer at the theme "unrelated concepts", it is seen that the number of the associated words at the fifth grade decreased from 4 to 1, seven words at the sixth grade disappeared completely, and the number of the associated words suggested by the seventh-graders decreased from 6 to 1. This result implies that the students' minds were cleared off from the concepts unrelated with the water cycle in the post-test at a certain extent.

As a result of the analysis of the words associated with the water cycle at all grade levels, different themes emerged revealing the students' comprehension in the pre and post-test. There were 10 themes in the pre-test and 6 themes in the post-test among the fifth-graders; 8 themes in the pre-test 5 in the post-test among the sixth-graders; and there were 6 themes in both pre and post-test among the seventh-graders. "*water cycle elements", "change of state", "precipitation pattern", "abiotic factors"* and "*state of matter"* were common to all grades during both tests. Of these themes, only *state of matter* did not appear in the pre-test results of the seventh graders. Shepardson et al. (2009) found in their study with 1298 students from grades 4 through 12 that students associated the water cycle with evaporation, condensation and precipitation. This finding supports the current study as the themes of *precipitation pattern* and *change of state* were revealed here. In another study, it was seen that preschool students included concepts such as rain, cloud and human in both pre and post-test drawings (Ahi, 2017). In a study based on role playing technique with pre-service teachers, the students associated the water cycle with themes of lake, river, animal, and glacier (Chin & Mageswary, 2013). Similar concepts emerged under the water cycle elements in the current study. Ben-zvi-Assraf and Orion (2005) suggested that evaporation, condensation, sweating, precipitation, dissolution and precipitation of minerals from sea water should be understood. In their study carried out with grades 7 through 9, the participants mostly focused on atmospheric events, ignored underground components, and often associated the water cycle with rain, cloud and evaporation. In this regard, it can be said that the researchers drew attention to water cycle elements and abiotic factors. In this study, unlike in the literature, the students heavily touched upon solid, liquid and gaseous states of matter. In this respect, water cycle can be described and taught around themes such as water cycle elements, change of state, state of matter, abiotic factors and precipitation pattern.

The prominent themes students cited for defining the water cycle were *(water) cycle elements, precipitation pattern, change of state, state of matter,* and *abiotic factors*. The cut-off point technique was used to determine how these themes changed in the pre and post-test. This technique consists of 6 categories and they show how strong the relationship is on a 6-item range. The starting point 1 refers to the weakest degree of relationship, and 6 represents the strongest relationship. From this point of view, it was seen that the students associated the water cycle with *(water) cycle elements* with the strongest degree at all grade levels. After the application, the most noticeable change took place in the theme *state of matter*. According to the cut-point technique, *state of the matter* increased from level 1 to level 5 at the fifth grade, from level 1 to 3 at the sixth grade, and from 0 to level 1 in the sevent grade. As a consequence, the theme that showed a positive shift curve at all grade levels became *state of matter*. Although *water cycle elements* were the most strongly related theme, it remained at the same level in the sixth and seventh grades and it went up from level 4 to 6 only at the fifth grade. Similarly, *precipitation pattern* and *change of state* changed in a positive direction only in two grades, and *water cycle elements* and *abiotic factors* changed positively in one grade each. In view of the positive changes; four themes changed at the fifth grade, three themes changed at the sixth grade, and two themes at the seventh grade. It can thus be suggested that the study proved the most effective with the fifth-grade students. In the post-test, the students did not associate unrelated words with the water cycle, whereas they indicated a stronger relation at a higher frequency with words associated with the water cycle. It could be concluded that awareness concerning water cycle was created and the students' cognitive structure saw improvement regarding the water cycle in this study. This improvement could be partly due to the educational game utilized here.

When findings obtained from the drawing tests were evaluated, the scores of the fifth-grade students differed between the pre-test and post-test. While the average pre-test score was 25.89, it increased by 143.65% and became 61.25 in the post-test. To put differently, the students' understanding became sufficient while it was insufficient in the beginning. Considering the change at the sixth grade, the grade average was insufficient with 28.75 points in the pre-test, but it increased by 103.60% in the post-test and reached a sufficient level with 57.43 points. Lastly, the pre-test scores of the seventh-grade students increased from 25.58 to 66.28 points with an increase of 158.85%, to a sufficient level. As Tokiz (2013) stated in his study, the students could provide more accurate drawings after the educational game. It was understood that they made more rational and logical drawings about the water cycle by adding new knowledge onto their prior knowledge. As a result, they produced more comprehensive drawings. The fifth, sixth and seventh grade students generally included concepts such as cloud, rain, sun, and evaporation in their pre-test drawings. The reason seems to be the fact that such concepts are on their minds as a result of the events they encounter in daily life. Çardak (2009) found out in his study that the students linked the water cycle with inanimate things and events in the pre-test. Nuutinen, Kärkkäinen and Keinonen (2011) reached supportive conclusions. The concepts such as mountain, glacier, human, plant, animal, river, and groundwater were included in their drawings. Ben-Zvi Assaraf and Orion (2005) stated that the students' drawings regarding the water cycle were not complete in the pre-test but concepts related to the water cycle increased in their post-drawings significantly. According to the drawing test scores, the most visible improvement was seen at the fifth grade, followed by the seventh and sixth grade, respectively. This finding does not support the view that students' drawings improve as their age increases (Ben-Zvi Assaraf & Orion, 2005; Yörek, 2007; Kara et al., 2008; Uzunkavak, 2009; Çelikler & Topal, 2011). In a similar study conducted with undergraduate and primary school students, it was found that primary school students were more interested in educational games and achieved better results (Aycan, Türkoğuz, Arı, & Kaynar, 2002). This difference can be accounted for with the characteristics of the developmental period in which games are more effective in concretizing the concepts in transition from the concrete operations period to the abstract operations period (Açıkgöz, 2014).

RECOMMENDATIONS

Students' knowledge on water cycle can be enriched starting from an early age.

Interest and attitude towards the Science course can be increased by including educational games in the curriculum at an early age.

Teachers can benefit from the activity titled ProjectWET-The Incredible Journey in their lessons.

Teachers can include more educational games in their lessons.

Drawings can be used both as a tool to determine students' prior knowledge and to reinforce their learning about the water cycle.

Ethics Committee Approval Information

In this study, all rules under the "Directive on Higher Education Institutions' Scientific Research and Publication Ethics" were followed. The study data collected during the 2019 Fall Term within the scope of the master's thesis registered in number XXXXXX at the Higher Education Council's National Center.

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