LOOK ACADEMIC PUBLISHERS
OPEN ACCESS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION
2017, VOL. 12, NO. 3, 349-367
DOI: 10.12973/ijese.2017.01232a

The Effect of Talking Drawings on Five-Year-Old Turkish Children's Mental Models of the Water Cycle

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ABSTRACT

The purpose of the current study is to determine the effect of talking drawings on Turkish preschool children's mental models of the water cycle. The study was conducted in the city of Kastamonu, located in the north-west of Turkey. A total of 40 five-year-old preschool children participated in the study in the spring term of the 2015-2016 school year. Within the context of the study, prior to the initiation of the experimental process, the children were asked to illustrate their opinions about the water cycle through drawings. At the end of the experimental process, they were asked once more to draw pictures to depict the water cycle, after which the code differences between the drawings were determined. At the end of the study it was found that, before the initiation of the experimental process, the codes used by the children most frequently within the framework of the water cycle could be presented in rank order as follows: rain (f = 42, 95.4%), cloud (f = 36, 81.8%) and human (f = 24, 54.5%); after the completion of the experimental process, the same rank order was found: rain (f = 39, 88.6%), cloud (f = 39, 88.6%) and human (f = 28, 63.6%). On the basis of the post-test results, the Mann-Whitney U Test was conducted and revealed a significant difference in the children's drawings in favor of the experimental group (U = 28, z = -5.531, p = 0.000, r = 0.8). Thus, it was concluded that the technique of talking drawings had a positive effect on the children's mental models of the water cycle. In light of this finding, it can be stressed that the technique of talking drawings built on both student-student and teacher-student dialogues, and we recommend that a great emphasis be placed on group work in early childhood science education.

KEYWORDS
talking drawings, water cycle, mental model, drawing, science and environmental education in the preschool period

ARTICLE HISTORY
Received 20 January 2017
Revised 28 March 2017
Accepted 9 April 2017

Introduction

The interaction of human beings and nature has been conducted on the basis of anthropocentrism for a very long time. Particularly after World War II, this interaction has become much more brutal and, as a result of the rapid depletion of natural resources by humans, the natural balance has begun to

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quickly deteriorate. Today, all nations are working hard to restore this balance before this deterioration leads to irreversible destruction. In a report issued by the United Nations Environmental Programme [UNEP] for 2015, a special emphasis was placed on the fact that substances such as water, oxygen and nitrogen are of vital importance for all living organisms (UNEP, 2016). The World Resource Institute (WRI) points out that the basic substance cycle is severely interrupted or highly accelerated by human-induced activities (WRI, 2015). The same institute also states that all living organisms are adversely affected by these changes. Water, especially, is one of nature's most important components as it constitutes the basis of life. The WRI (2016) maintains that, if the situation progresses as it is, nearly 3.5 billion people will be affected by water shortage by 2020. Kaga (2008) argues that the most fundamental and effective solution to human-induced environmental problems is educating people so that they can have adequate scientific knowledge about the issues. Therefore, it seems necessary that people be provided with scientifically correct information about water and its cycle, given that it is one of the most fundamental elements of nature.

Mental Model Theory

Today's educational models are changing under the influence of neurocognitive developments. Following any study focusing on the functioning of the brain – regardless of the discipline in which it is conducted – new developments and concepts emerge related to how information is acquired and retained. Mental models are a concept that has been studied in the fields of social sciences and educational sciences over the last 30 years. In recent years, work conducted in the field of cognitive psychology has aimed at gaining an understanding of how individuals construct and retain knowledge in their minds (Greca & Moreira, 2000). Johnson-Laird (1983) stated that, for mental processes of the construction and retention of knowledge, individuals create internal structures related to the concepts. Johnson-Laird called these structures mental models. Mental models are widely used in science education, given that they make it possible to understand how individuals carry out the process of making sense of a phenomenon, to evaluate mental processes and to determine the extent to which scientific knowledge has been acquired (Vo, Forbes, Zangori & Schwarz, 2015). Mental models have a dynamic structure – they are continuously developing cognitive structures, reinforced and augmented by the experiences of daily life and newly learned information (Jones, at all, 2011). Vosniadou and Brewer (1994) argue that individuals create new knowledge by first disintegrating the concept to which the new information belongs and then integrating each part of the concept in an unsystematic way; for the construction of mental models, new knowledge is needed. Judson (2010) maintains that mental models are affected by different disciplines and cultural lifestyles; thus, educational models include different instructional techniques to generate in individuals the desired mental models and should allow individuals to freely reveal their sociocultural structures. In this regard, the talking drawings technique is enjoyable, particularly for children in the early childhood period, because it promotes interaction between learners, is based on small-to-large group discussions and makes use of drawings.

Talking Drawings Technique

The talking drawings technique has been widely employed in preschool and elementary school education for nearly 30 years. This technique was developed by McConnel (1993). The main objective of this technique is to elicit the pictures in children's minds related to a phenomenon and then to develop these pictures (McConnel, 1993). Fello, Paquette and Jalongo (2006) stress that the talking drawings technique helps to determine the child's existing knowledge and for the child to learn scientific knowledge in a realistic way. According to these authors, this technique can create a visually based connection between the individual's prior knowledge and new knowledge. Drawings are quite effective tools for eliciting the schemes already existing in individuals' minds and understanding what the individual knows and has learned. They are thus widely used in science education (Chang, 2012). Moreover, research (e.g., Hayes, Symington and Martin, 1994) has shown that children enjoy drawing during science activities. As a tool for discovering information, drawing is quite effective for allowing children to reflect on their knowledge together with their emotions (White & Gunstone, 1992). At the root of the talking drawings technique lies the child's drawings. The child is asked to share both his/her prior knowledge and newly acquired information with his/her peers through his/her drawings. In this way, while the teacher can rapidly evaluate the prior knowledge possessed by the child, the child can also discuss his/her opinions with his/her peers. Thus, various skills (e.g., speaking, listening) can be developed. In addition to these advantages, this technique is quite suitable for use with young children as it relies on drawing and speaking skills (Paquette, Fello & Jalongo, 2007). The technique comprises six stages. These stages are presented in Table 1.

Table 1. The stages of the talking drawings technique

The stages of the talking drawings technique	
Stage	Work to be done during each step of the process
1	The topic to which the technique will be applied is selected and a simple discussion is held with the children about the topic.
2	The children create their drawings related to the topic. The children illustrate all their opinions about the topic on a piece of paper.
3	The students are organized into pairs. Each child discusses his/her drawing with his/her partner.
4	The students are read selected source book(s). If available, photos and visuals are shared with the class.
5	The children revisit their drawings in light of these resources and compare their newly learned information with their drawings. They then each create a new drawing.
6	The children discuss their first and second drawings with one another, creating a child-centered discussion environment.

The talking drawings technique has been found to improve children's language skills (McConnel, 1993; Paquette, Fello & Jalongo, 2007) as well as to contribute to their learning of scientific subjects (Fello, Paquette & Jalongo, 2006). McConnel (1993) states that, among a wide range of disciplines, this technique can be used in the teaching of environmental issues (e.g., the greenhouse effect). Dove, Everett and Preece (1999) reported that exploration through drawings of specific subjects, such as cloud types, the water cycle and leaf forms, is quite effective. Assaraf and Orion (2005) emphasize that the concept of "*water*" is of great importance within the context of the environment. The water cycle is a complex system connected with the geosphere, atmosphere and biosphere (Kali, Orion & Eylon, 2003). Thus, in the current study, we attempted to evaluate the effectiveness of this technique in teaching the complex topic of the water cycle. In Turkey, though science education is an important element of the instructional-educational process during the preschool period, "*the water cycle"* is taught in a very superficial way.

Science Education in Preschool Education in Turkey

The basis of the preschool education conducted in Turkey was established in 1994. The program that has been in effect since 2016 is the fourth revised program, which resulted from pilot applications conducted in 2013. The program has been designed since 1994 using an eclectic, spiral approach, integrated on the basis of the constructive philosophy. Within the program, there are a number of learning outcomes and indicators of these outcomes. These learning outcomes and their indicators are classified according to the fields of social and emotional, motor, cognitive, language development and self-care skills (NoE, 2013).

There are no standards specific to any one discipline within the program. Instead, science education is conducted within the framework of general science activities. Just as science activities can be conducted in an integrated way with other activities, they can also be conducted on their own. The preschool education program proposes that science activities should be conducted within a science center in the classroom. The science center is a special area within the classroom including science materials, posters, test equipment, 3D materials, etc. The present preschool education program also suggests that some science activities should be conducted outdoors and through one-to-one experiments (NoE, 2013).

Research on the Water Cycle

The literature addressing the topic of the water cycle highlights the difficulties experienced in the teaching of this complex subject. Piaget (1930), in a study focusing on the structures and shapes of clouds, found that children can explain clouds according to a staged system. In one of the studies addressing the topic of the water cycle, Bar (1989) worked with Israeli children between the ages of five and 15. This study showed that the children experienced particular difficulties in understanding the concepts of water vapor, condensation and evaporation, and that they only begin to fully understand these concepts when they are 11 years old. A study by Fetherstonhaugh and Brezzi (1992) found that the participants experienced difficulties in defining the concept of underground water. In a similar manner, in the study conducted by Agelidou, Balafoutas and Gialamas (2001), the students were able to define underground water as standing water occurring among rocks. Assarf and Orion (2005) found that students are missing information and have misconceptions particularly regarding underground water and the parts of the water cycle occurring in the atmosphere. Similarly, Çardak (2009) reported that university students have some misconceptions about the events taking place in the atmosphere. In a study by Strang and Aberg-Bengtsson (2010), over the course of conversations taking place between teachers and students about "*water*", it was determined that the students, especially, are missing information regarding the water cycle. Vo et al. (2015) attempted to teach the water cycle through modeling to children between the ages of eight and nine, and found that the children experienced difficulties in understanding some points related to the aspects of the phenomenon that occur in the atmosphere and changes between states of matter. In addition to these studies, some others focused on the incidence of "rain" (Christidou & Hatzinikita, 2006; Savva, 2014; Saçkes, Flevares & Trundle, 2010) and reported that, while children have some general opinions about rain, they experience some difficulties in understanding the formation of rain, the mechanics of the system and concepts related to the water cycle, such as evaporation and condensation. When the results of these studies are considered in general, it can be maintained that problems are experienced in understanding the mechanisms of the water cycle taking place in the atmosphere.

Children are taught science subjects mainly at school as a part of their formal education, but they do not start school as "*tabula rasa"* in relation to science subjects (Driver, Guesne & Tiberghien, 1989). Driver and Oldham (1986) stress that, according to the constructivist approach, meaningful learning can occur on the basis of interpretation of new information in light of existing knowledge and beliefs. Therefore, by making use of different learning methods, new doors can be opened for learning concepts related to science and the environment. Thus, it would seem to be important to elicit and understand children's existing knowledge about the water cycle for science and environmental education. Furthermore, for children to more effectively understand scientific phenomena, it is necessary to use new curricula and methods (Saçkes, Flevares & Trundle, 2010). As such, the current study seeks an answer to the question "what is the effect of the talking drawings technique on children's models of the water cycle?" In this pursuit, answers to the following questions were sought:

1. What are the codes used by the participating children regarding the water cycle in the pretest and post-test?
2. Is there a statistically significant difference between the experimental group children and control group children's mental models of the water cycle within the framework of the pretest?
3. Is there a statistically significant difference between the experimental group children and control group children's mental models of the water cycle within the framework of the post-test?

Method

The current study, aiming to determine the effect of the talking drawings technique on the mental models of preschool children aged five years old, was built on a pretest/post-test semi-experimental model with a control group.

According to Erkuş (2011), in cases in which random appointment is not performed, semi-experimental design should be used instead of experimental design. As typical case sampling was used in the current study, semi-experimental design was preferred. Fraenkel and Wallen (2009) state that there are different varieties of semi-experimental designs. The current study adopted a matched pretest/post-test control group design. This design is built on the matching of the groups according to certain criteria as a result of the pretest administered to the study group in cases in which random assignment is not performed. Within the context of the current study, matching operations were carried out on the basis of developmental characteristics and the level of the children's drawings of the water cycle in light of the information given by their teachers. Though this method is not as powerful as random sampling, it can be effective in terms of reducing limitation (Fraenkel & Wallen, 2009; Wiersma & Jurs, 2005).

Study Group

The study group of the current research was constructed by means of the typical case sampling method. The typical case sampling method is constructed to determine the most general situation related to a phenomenon and is generally used in studies aiming to reflect children's academic performance (Wiersma & Jurs, 2005). As the current study intended to determine the effect of the talking drawings technique on the development of five-year-old children's mental models regarding the water cycle, the children should have average (typical) developmental characteristics and academic achievement. Therefore, the typical case sampling method was used in the study.

The study group consists of five-year-old children attending preschool institutions in the city of Kastamonu in the spring term of the 2015-2016 school year. In order to determine the study group, one of the most average (typical) preschools in the city of Kastamonu was first selected. The pretest was administered to the five-year-olds attending this preschool and then, by performing matching on the basis of pretest levels, the control and the experimental groups were formed. There are 44 children in the study group. Of these, 22 were assigned to the experimental group and the other 22 were assigned to the control group. Information about the study group is shown in Table 2.

Table 2. Distribution of the children in the study group

Distribution of the children in the study group						
Gender	Experimental group		Control group		Total	
	f	%	f	%	f	%
Boy	13	40.9	12	54.5	25	56.8
Girl	9	59.1	10	45.5	19	43.2
Total	22	100.0	22	100.0	44	100.0

The city of Kastamonu, where the current study was conducted, is located in the north-west of Turkey. The Black Sea climate prevails in Kastamonu, meaning that there is rain all year round. The most rain falls in autumn. Nearly 74.6% of the city is covered with mountains and forests (General Directorate of Forest [GDoF], 2013). According to data reported by the General Directorate of Meteorology (2016), the mean number of rainy days in the period between 1950-2015 was 126.4 annually and the annual average rainfall is 485.2 kg/m^2. Thus, it can be concluded that rain is an important phenomenon in the daily lives of the children in the study group. Moreover, it can be maintained that the children frequently experience the water cycle in their daily lives.

Experimental Process

Within the framework of the study, a program was developed for the execution of the experimental process. This program was prepared in a manner suitable for the talking drawings technique and conducted in line with the stages of the technique. The experimental process was completed over three sessions. In the first session of the process, a large group discussion about the water cycle, the selected topic of the study, was performed with the participation of the children. This process lasted for nearly 40 minutes and culminated in reaching a decision on the basis of the children's opinions and the researcher's contributions. Immediately following the large group discussion, the children were asked to illustrate their opinions through drawings. After the completion of the drawings, the students were seated in groups and were asked to explain their drawings to one another. This completed the first session.

In the second session, the researcher brought a book (Pons, 2013; Slade, 2013) and various visual materials. A book reading activity was performed and, using the materials, the water cycle was explained to the children. At the end of this instructional process, a discussion was conducted with the children about the topic and all the children's questions were answered.

In the third session of the experimental process, the children were asked to again draw the water cycle to express their opinions. Following the completion of the drawings, the children were organized into pairs to discuss their drawings. Next, all the children were given their first drawings from the beginning of the process and were asked to detect the differences between their first and second drawings. As the final stage, in the form of a large group activity, all the children talked about their drawings and explained, one by one to the whole class, the differences between their first and second drawings. The researcher then summarized the new information and thus the experimental process was ended. This entire process was completed within three sessions over a seven-hour period.

Data Collection

The required permissions for the study were first granted by the teachers and principal of the school in which the experiment would be carried out. Then, together with the teachers, planning of the activities within the science curriculum was performed in such a way as not to interrupt their own program. The study data consist of the children's drawings of the water cycle. The drawings were collected once at the beginning of the experimental process and for a second time at the end of the process. The first drawings were considered to be a pretest and the last drawings were considered to be a post-test. The children made their drawings on A4 paper using dry paint or crayon. The children were asked the question *"could you draw the route followed by water in nature?"* The drawing process lasted almost 30 minutes. After the completion of the drawings by the children, the researcher and four third-year pre-service classroom teachers (who were taking part in the study as research assistants) wrote what the children meant in their drawings on the back of the drawing papers. In this way, the codes obtained from the drawings were constructed and limitations resulting from the developmental characteristics of the children were eliminated as far as possible.

Data Analysis

The drawings obtained within the context of the current study were classified according to Çardak (2009). In this regard, the drawings of the water cycle can be classified as follows:

1st Level – no drawing: This indicates a level at which the children do not have any understanding of the topic. Codes detected in such drawings are either inadequate or irrelevant to the water cycle.

2nd Level – non-conceptual drawing: The drawings at this level include written depictions of the elements or processes related to the water cycle rather than drawings of the water cycle.

3rd Level – drawings with misconceptions: In the drawings at this level, though some information about the water cycle is conveyed, many misconceptions are encountered.

4th Level – partial drawing: In the drawings at this level, elements related to the water cycle (e.g., clouds, evaporation) are presented, and there are few misconceptions. This is a level at which the water cycle is partially understood.

5th Level – drawings with sophisticated illustrations: The drawings at this level are quite realistic and sophisticated. There are at least seven elements related to the water cycle presented in these drawings and some specific processes are also depicted.

The drawings produced in the current study were classified as 1st, 3rd and 4th level drawings. No drawing of the 2nd or 5th levels was encountered. Sample drawings from these levels are presented below.

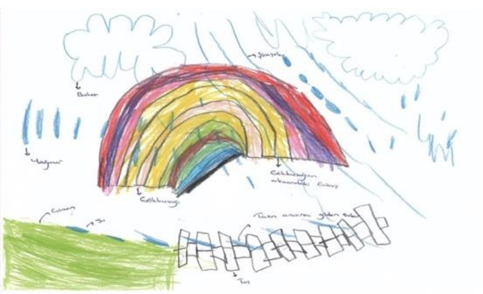
1st Level Drawing: There is no information relevant to the water cycle presented here.

3rd Level Drawing: The incidence of rain is depicted. Additionally, factors that might affect the water cycle are illustrated. Some information is missing and there are some misconceptions.

4th Level Drawing: Various elements belonging to the water cycle are illustrated. Underground water is emphasized. On the left side raindrops represent rain and on the right side long lines represent evaporation.

The drawings made within the context of the pretest and post-test were classified according to the above levels by the researchers. Then, two biology experts performed the same operation of classifying the drawings. On the basis of three different classifications, the Kappa Goodness of Fit Index was calculated and found to be 0.91. Thus, it can be concluded that inter-rater compliance is high (Büyüköztürk, 2011).

In order to determine the statistical tests to be employed, the distribution of scores taken from the pretest and post-test was examined. To do so, the mean values were first compared with 5% trimmed mean values. For the pretest the mean value was found to be 1.13 and the 5% trimmed mean value was found to be 1.04, while for the post-test the mean value was found to be 2.36 and the 5% trimmed mean value was found to be 2.34. As in the current study, analyses were conducted on small values and a small difference was found between these two means. Moreover, skewness and kurtosis values were found to be, respectively, 3.54 and 11.09 for the pretest and 0.13 and -1.94 for the post-test. It is thus found that the values are highly distant from zero. Furthermore, the result of the Kolmogorov-Smirnov test was calculated to be $p < 0.05$. Thus, though the difference between the mean and the 5% trimmed mean is small, it was concluded that the scores taken from the pretest and post-test did not show a normal distribution. Therefore, non-parametric tests were used in the study. In this regard, the Mann-Whitney U Test was used to determine pretest and post-test between-group difference. Effect sizes were also calculated. According to Pallant [39], the effect sizes of both tests should be calculated with the formula $r = Z / \sqrt{N}$. Additionally, the percentages (%) and frequencies (f) of the codes in the drawings are also reported.



Internal and External Validity of the Experimental Process

In research models employing experimental design, there are some factors that pose threats to internal and external validity (Büyüköztürk, 2011). One of these factors threatening internal validity, participation selection, was controlled for by conducting the matching after the pretest, though random assignment was not performed. In the current study, the maturity of the participants was also taken into consideration; though children's maturity develops rapidly in the preschool period, it was assumed that no problem would arise from participants' increasing maturity over the course of the experiment, given that the experimental process lasted for only three days. The choice of data collection instrument is also a factor affecting internal validity. Within the context of the current study, the data collection instrument is a sheet of blank paper and the data are the children's drawings. Therefore, the children did not feel any effect of the data collection instrument; the data were collected within an art activity.

In terms of the factors affecting external validity, efforts were made to control for the sampling effect. Though the study was conducted with a small sample, the sampling effect was controlled for using the typical case sampling technique. So as not to increase the effect of reactivity (expectations), the children were not exposed to lessons different from normal educational processes. In this way, children's perception of the experimental process was minimized. The activities were performed within daily routines in line with the preschool curriculum. In terms of pretest experimental variable interaction, the children made their drawings during the art activities class. The researcher asked the children to draw the route followed by water in nature. Thus, the children's feeling that they were exposed to any evaluation or test was reduced to a minimum level.

Findings

The findings of the study are reported according to the three questions outlined above.

Findings Related to the First Question

The codes involved in the pretest drawings of the children regarding the water cycle, along with their distributions, are shown in Table 3.

When Table 3 is examined, it is seen that a total of 11 codes were derived from the pretest drawings of the children. The most striking among these codes is rain (f = 42, 95.4%). Almost all of the students in the experimental and control groups (95.4%) included rain in their drawings. Thus, it can be argued that the children have some information about the fall of water vapor from the air to the ground. However, it can be seen that the children do not understand processes such as evaporation and condensation that make it possible for water on earth's surface to be transferred to the atmosphere. Very few children indicated evaporation (f = 3, 6.8%) or condensation (f = 1, 0.02%) in their drawings. A student from the control group, Ç11, mentioned evaporation by stating that *"The sun warms seas and thus some water goes to the air. When this water accumulates in the air, then it falls as rain."* In addition to these, the children also included important elements of the water cycle such as the sun (f = 20, 45.4%) and the atmosphere (f = 9, 20.4%) in their drawings. Some of the children (f = 11, 25.0%) illustrated the relevant elements of the artificial environment, such as cars, houses and roads, in their drawings. Within the context of the pretest, codes included in the drawings of the control group students and the experimental group students are very similar to one another and used in similar frequencies. Thus, it can be maintained that, prior to the experimental process, the structures (codes) belonging to the children's mental models of the water cycle were similar across the two groups.

Table 3. The codes involved in the children's pretest drawings of the water cycle

Codes of the water cycle	Control group		Experimental group		Total	
	f	*%*	*f*	*%*	*f*	*%*
Atmosphere	6	27.2	3	13.6	9	20.4
Biotic element	10	45.4	10	45.4	20	45.4
Evaporation	1	4.5	2	9.0	3	6.8
Cloud	17	77.2	19	86.3	36	81.8
Rainbow	7	31.8	17	77.2	24	54.5
Sun	5	22.7	15	68.1	20	45.4
Human	14	63.6	10	45.4	24	54.5
Rain	21	95.4	21	95.4	42	95.4
Artificial environment	6	27.2	5	22.7	11	25.0
Condensation	1	4.5	0	0	1	2.1
Surface water	4	18.1	5	22.7	9	20.4

The codes involved in the post-test drawings of the control and experimental group children are given in Table 4.

When Table 4 is examined, it is seen that a total of 13 different codes were derived from the children's post-test drawings of the water cycle. Within the context of the post-test, the most frequently drawn codes are cloud (f = 39, 88.6%) and rain (f = 39, 88.6%). There are two codes absent in the pretest that are present in the post-test: soil (f = 3, 6.8%) and underground water (f = 5, 11.3%). One of the more remarkable findings in the post-test is that the experimental group students included two of the important elements of the water cycle – evaporation (f = 6, 27.2%) and condensation (f = 3, 6.8%) – in their drawings. One of the experimental group children, Ç36, mentioned these processes within the water cycle by stating *"The water on earth becomes water through the sun. Then when it rises, it becomes colder [he/she means condensation] and forms cloud."* The experimental group children, especially, illustrated biotic elements (f = 9, 40.9%), humans (f = 12, 54.5%) and the sun (f = 9, 40.9%) in their drawings.

Table 4. The codes involved in the children's post-test drawings of the water cycle

The codes involved in the children's post-test drawings of the water cycle

Codes of the water cycle	Control group		Experimental group		Total	
	f	*%*	*f*	*%*	*f*	*%*
Atmosphere	2	9.09	1	4.5	3	6.8
Biotic element	8	36.3	9	40.9	17	38.6
Evaporation	1	4.5	6	27.2	7	15.9
Cloud	21	95.4	18	81.8	39	88.6
Rainbow	6	27.2	12	54.5	18	40.9
Sun	6	27.2	9	40.9	15	34.0
Human	16	72.7	12	54.5	28	63.6
Soil	1	4.5	2	9.09	3	6.8
Rain	20	90.9	19	86.3	39	88.6
Artificial environment	5	22.7	10	45.4	15	34.0
Underground water	0	0.0	5	22.7	5	11.3
Condensation	0	0.0	3	13.6	3	6.8
Surface water	3	13.6	5	22.7	8	18.1

Findings Related to the Second Question

The drawings of the children were classified according to the levels proposed by Çardak (2009). As a result of this classification, the each child's level was determined. Within the context of the pretest, the drawing levels of the experimental and control group children are given in Table 5.

As can be seen in Table 5, a great majority of the children (93.2%) were found to be unsuccessful in reflecting the water cycle in their drawings, and few of them (6.8%) created drawings depicting the water cycle including misconceptions and missing information. None of the children were determined to have information in general terms about the water cycle.

Table 5. Distribution of the children's pretest drawings across levels

Distribution of the children's pretest drawings across levels						
Level	Experimental group		Control group		Total	
	f	%	f	%	f	%
1st level	20	90.9	21	95.4	41	93.2
2nd level	0	0.0	0	0.0	0	0.0
3rd level	2	9.1	1	4.6	3	6.8
4th level	0	0.0	0	0.0	0	0.0
5th level	0	0.0	0	0.0	0	0.0

The Mann-Whitney U Test results relating to the statistical significance of the difference between the pretest scores of the experimental group and the control group are presented in Table 6.

Table 6. Experimental and control groups pretest Mann-Whitney U Test results

Experimental and control groups pretest Mann-Whitney U Test results						
Total score	Group	n	Mean rank	Rank sum	U	*p*
	Control	22	22.00	484.00	231	.554
	Experimental	22	23.00	506.00		

The Mann-Whitney U Test results revealed that there is no significant difference between the control group (Md = 1, n = 22) and the experimental group (Md = 1, n = 22) in terms of the level of the drawings. For both groups, U = 231, z = -0.531, p = 0.554, and the effect size was found to be r = 0.08. Thus, it can be claimed that, prior to the experimental process, there was no significant difference between the experimental group students and the control group students' mental model levels concerning the water cycle.

Findings Related to the Third Question

The distribution related to the children's post-test drawing levels is given in Table 7.

The children's post-test drawings showed that the drawing levels of a high majority of the experimental group children (63.6%) were ahead of the average level for their age group (see 4th level). On the other hand, the control group children's post-test level distribution is similar to their pretest level distribution.

Table 7. The distribution of the children's post-test drawings across levels

The distribution of the children's post-test drawings across levels						
Level	Experimental group		Control group		Total	
	f	%	f	%	f	%
1st level	3	13.6	20	90.9	23	52.2
2nd level	0	0.0	0	0.0	0	0.0
3rd level	5	22.7	2	9.1	7	15.9
4th level	14	63.6	0	0.0	14	31.8
5th level	0	0.0	0	0.0	0	0.0

The Mann-Whitney U Test results related to the statistical difference between the post-test scores of the experimental group and the control group are given in Table 8.

Table 8. Experimental and control group post-test Mann-Whitney U Test results

Experimental and control group post-test Mann-Whitney U Test results						
Total Score	Group	n	Mean rank	Rank sum	U	*p*
	Control	22	12.77	281.00	28	.000
	Experimental	22	32.23	709.00		

The Mann-Whitney U Test results revealed that there is a significant difference between the control group ($Md = 1.18$, $n = 22$) and experimental group ($Md = 3.54$, $n = 22$) in terms of the levels of their post-test drawings, in favor of the experimental group, where $U = 28$, $z = -5.531$, $p = 0.000$, and the effect size was found to be $r = 0.8$. In this regard, it can be argued that the mental models of the experimental group students and the control group students regarding the water cycle differed significantly at the end of the experimental process in favor of the experimental group. The effect size found is large according to Cohen (1988).

Results, Discussion and Suggestions

The purpose of the current study was to determine the effect of the talking drawings technique on children's mental models of the water cycle. In light of the data obtained in the study, it seems that the most frequently used codes in the children's pretest drawings of the water cycle are as follows: rain ($f = 42$, 95.4%), cloud ($f = 36$, 81.8%) and human ($f = 24$, 54.5%). In the post-test however, the most frequently used codes can be presented as follows; rain ($f = 39$, 88.6%), cloud ($f = 39$, 88.6%) and human ($f = 28$, 63.6%). Thus, it seems to be clear that the awareness of "rain" in the water cycle is high among the children.

The second most important element seems to be "cloud". The children's awareness of the role of clouds in both rain and the water cycle is high. In some studies, such as that conducted by Piaget (1930), it has been reported that some children explain the fact that clouds bring rain using animistic and artificialist thinking. Savva (2014) also found that preschool children stated that rain is carried by clouds. Similarly, in a study by Bar (1989), children frequently emphasized the role of clouds in the water cycle as carriers of rain.

Water reservoirs were depicted as playing an important role in the water cycle in both the pretest and post-test children's drawings. In the pretest drawings, the sea or river elements defined as surface water were depicted by nine children (20.4%). In the post-test drawings in the experimental group, eight children (18.1%) drew surface water and five children (11.3%) drew underground water. Savva (2014) stressed that children between the ages of three and five experience particular difficulty in understanding and explaining underground reservoirs. Dove, Everett and Preece (1999) stated that children experience difficulty in understanding the mechanisms by which water goes underground, remains there and then returns to the surface. A similar finding was reported by Assarf and Orion (2005). Piaget (1930) argues that, especially during the preoperational period covered by the preschool period, children experience difficulties in understanding events, states and phenomena without sensing and experiencing them directly with their own sense organs, as the role of concrete thinking and sense organs is significant in learning at this age. In the current study, the reason for the children's lack of emphasis placed on underground water might be related to Piaget's explanation. On the other hand, in the post-test drawings, underground water was only depicted by children from the experimental group, which might be proof of the efficacy of the experimental process and the talking drawings technique.

Another important topic that can be addressed within the water cycle is the aspects of the cycle occurring in the atmosphere. Evaporation and condensation processes, particularly, are the most important mechanisms of the water cycle. Bar (1989) and Saçkes, Flevares and Trundle (2010) stated that children encounter difficulties in understanding these two phenomena. Bar (1989) contends that condensation and evaporation can be understood only after the age of nine because children can understand these phenomena only after they have understood the state changes of the matter and that, even if water condenses or evaporates, it is still water. Piaget (1970) states that understanding the conservation of mass enables children to explain many scientific occurrences. Adbo and Taber (2009) also argue that, in the early childhood period, chemical processes such as the change of state of matter can be conceived by children only by means of processes that can be experienced through their sense organs. Thus, difficulties experienced by children in learning the processes of evaporation and condensation, along with their inability to place these phenomena within their existing mental models, can be seen as normal during the preschool period. In the current study, while only two children (2.1%) highlighted the process of condensation in the pretest, in the post-test three children (6.8%) indicated the process of condensation and seven children (15.9%) indicated the process of evaporation. As mentioned above, the fact that the number of children depicting these processes in their drawings is small may be attributable to the fact that the children have not thoroughly understood the conservation of mass and, thus, they do not yet understand changes of states.

The Mann-Whitney U Test revealed a statistically significant difference between the mental model levels of the experimental group students and the control group students within the context of the post-test. Boschhuizen and Brinkman (1995) emphasize that children experience difficulty in understanding the term "*cycle"* and that they have particular difficulties with regard to the starting and ending points of cycles taking place within ecology. As a result of the studies by Piaget (1930) and Bar (1989) regarding the water cycle, a staged model was proposed. In his study, Piaget pointed out that preschool children remained in a primary stage of understanding, believing that clouds are made by God and failing to draw connections between clouds and rain. In a similar manner, Bar (1989)developed stages and emphasized that children between the ages of five and seven provide explanations on the basis of simple knowledge in their minds and their culture. The constructivist theory maintains that learning occurs as a result of an active process of connecting prior knowledge with new information (Driver & Bell, 1986). Ausubel (2000) defines knowledge as a cognitive construct emerging as a result of psychological processes and Vygotsky (1986) emphasizes the importance of culture and social interaction in terms of the formation of cognitive constructs. Vo et al. (2015) state that, in learning complex structures like the water cycle, it can be useful to conduct small group works to promote social interaction so that children can reflect their own opinions and ideas. Given that the talking drawings technique includes small group sessions, this technique can be used in teaching complex constructs such as the water cycle.

Strang and Aberg-Bengtsson (2010) point to the efficacy of scientific dialogues between teachers and students for learning concepts regarding nature, such as "water" and "the water cycle". A similar point is made by Christidou and Hatzinikita (2006) who note that student-teacher dialogues are very important in science education. The talking drawings technique is one that promotes both types of dialogue. Paquette, Fello and Jalongo (2007) and Fello, Paquette and Jalongo (2006) argue that this technique is effective in developing receptive and expressive language skills, in addition to its benefits for science education. In the current study, depictions of concepts such as evaporation, condensation and underground and surface water reservoirs – which, according to Bar (1989), can be known by children between the ages of seven and nine, can indicate the efficacy of the talking drawings technique.

Lin and Hu (2003) argue that the topic of changes of states is one of the most outstanding subjects of the hierarchic and comprehensive structure of biology and ecology. On the basis of the findings reported in the literature regarding the teaching of complex constructs such as the water cycle within the context of science education, the use of different techniques seems to be necessary. Modeling and interactive dialogues, particularly, are believed to develop reification and inquiry skills that facilitate learning. In addition, creating some specific standards in terms of curricula for science and other disciplines within the framework of preschool education in Turkey is believed to be beneficial for the development of the content of the program so that children can become more academically successful.

Ecological subjects, such as the water cycle, are claimed to be affected by the atmosphere (Saçkes, Flevares & Trundle, 2010) and culture (Bar, 1989) of the research area. Therefore, future research in this field should be carried out in various atmospheres and climates, thereby helping to define external variables that can make important contributions to the field.

In the current study, the collected data are limited to the children's drawings and their preschool educational environment. Utilization of different data collection methods may allow for the collection of more in-depth information. Moreover, the technique used in the current study was employed in a preschool educational institution in Turkey, but there is also a need for such research to be conducted at different levels of schooling.

Acknowledgement

I am really grateful to the third-year students; Emine CAN, Sevgi BOZTOĞAN, Reyhan ÇETİNKAYA and Keziban ÇANKAYA, from the Department of Preschool Teacher Education at Kastamonu University for their contributions to the conduct of the experimental and data collection processes of the current study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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