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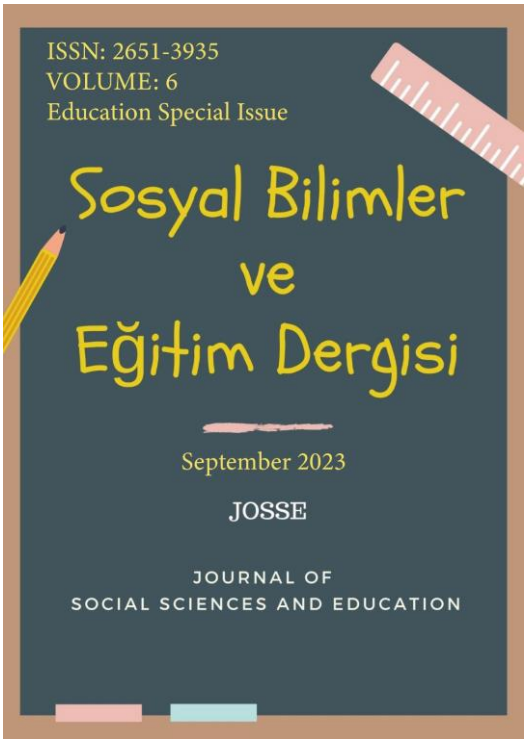

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The Effect of Environment Oriented Science Activities on Secondary School Students' Mental Models Related to Garbage, Waste and Recycling

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ABSTRACT

The research aimed to identify mental models related to garbage, waste and recycling and to determine the development of students' mental models following environment-oriented science activities. One-Group Pretest–Posttest experimental design, which is one of the quantitative research methods, was used for the purpose of the research. 14 seventh grade students participated in the research and the research data were collected using open-ended questions. Mental models have been identified by determining the visual and verbal reasoning levels of students on garbage, waste and recycling topics using the developed rubrics. It was determined that the environment-oriented science activities contributed to the development of students' mental models as well as their visual and verbal reasoning about garbage, waste and recycling. Based on the results obtained, teaching activities aiming to improve the knowledge levels of students studying at different grades on garbage, waste and recycling have been suggested. It was further suggested, at the end of the research, to include more environment-oriented activities in the curriculum of all courses other than science.

Keywords: Environment, garbage, waste, recycling, mental model

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Introduction

The number of living creatures on earth is kept in equilibrium by the ecosystem in which they live, without external influences. However, owing to the intelligence bestowed upon him, man has succeeded in getting out of this limitation. While the world population was approximately 1,6 billion in the 1900s, this figure reached 2,5 billion in the 1950s and 6 billion in the 2000s (Çamurcu, 2005). The population has increased rapidly in every period however owing to the recent scientific and technological advances, not only the population growth has accelerated but also the average life span of human beings has increased. By 2023, the world population has reached approximately 8 billion. Increasing needs of human beings in parallel with population growth, industrialization and consumption habits differentiated by urbanization have further increased the benefit of humanity from the environment (Palabıyık & Altunbaş, 2004). Although the environment has the power to renew itself up to a certain level, this regeneration cannot take place after a certain point (Kızılboğa & Batal, 2012). The growth in the world population further caused the environmental demands of humanity to increase, however natural resources began to deplete before they were given a chance to be renewed. Earth Overshoot Day, defined as the date when humanity's demand for ecological resources and services in a given year exceeds what Earth can regenerate in that year, falls on 2 August by 2023. Türkiye, on the other hand, has already consumed its natural resources as of June 22 (Anadolu Agency, 2023). From this date on, people meet their needs for the rest of the year by borrowing from the next year. The consumption of the yearly offered resources in a much shorter time and the fact that Earth Overshoot Day is brought forward results in the deprivation of the opportunities of future generations to benefit from natural resources. For this reason, it is extremely crucial to convey to individuals the understanding that they should not take away future generations' opportunities to access natural resources while benefiting from the environment (Bruntland,1987; Sander, Jelemenska & Kattman, 2006; Yüzbaşıoğlu & Kurnaz, 2021).

It is of significant importance for individuals to preserve and save natural resources and to reduce the amount of waste while benefiting from the environment both for themselves and for future generations. One of the most important ways to reduce the amount of waste generated and to use the resources economically is recycling and reuse (Tibben-Lembke, 2004). Recycling of waste has environmental, health and economic benefits. Recycling not only reduces environmental pollution, but also reduces the damage to natural resources

(Spiegelman & Sheehan, 2004). The ability of individuals to distinguish between garbage and waste and to understand the significance of recycling further contribute to their sensitivity towards the environment. Effective teaching environments are needed in order to raise individuals who are aware of the concept of recycling and act by paying attention to the separation of garbage and wastes in their daily lives (O'Connor, 1989; Çimen & Yılmaz, 2012). On the other hand, knowing the benefits of recycling is an important achievement that enables individuals to take steps towards recycling (Schultz, Oskamp & Mainieri, 1995). Having knowledge about recycling is an indication that this knowledge can be transformed into behavior (Wright, 2011).

Science course in Turkey plays a significant role in raising individuals who have knowledge about recycling at secondary school level. The science courses' curriculum aims to make students understand the significance of recycling and reuse (MoNE, 2018). Although the students develop positive attitudes towards the environment after the science courses they are provided, they may still experience deficiencies in practices such as purchasing environmentally friendly products, sorting wastes on the basis of recycling activities and donating to environment-friendly organizations (Demir & Atasoy, 2021). Direct interaction of societies with the environment has been decreasing due to the fact that they mostly live in cities. The theoretical knowledge provided to the students within the scope of environmental education will not be sufficient alone, accordingly it is necessary to give more space to activities that include opportunities for direct interaction with the environment (Özdemir, 2010). Activities carried out within the scope of environmental education, in which students take an active role, have been found to increase students' knowledge of the environment and to improve their environmental attitudes positively (Efe, Yücel & Efe, 2020; Stern, Powell & Ardoin, 2008). As a matter of fact, this result is also observed in practical studies. For the purpose of their research Onur, Çağlar and Salman (2016) determined that the knowledge and practical activities provided to the students about the evaluation of wastes resulted in a positive development in the students. Therefore, it is thought that teaching students about the concept of recycling and taking practical steps will contribute to making them more sensitive towards environmental issues and ensure them to be voluntary participants for protecting the environment.

Raising awareness on the events taking place in their environment, discovering the interactions between people, the environment and nature are among the desired acquisitions that students have after the education presented to the students in the teaching environments

(MoNE, 2018). Certain education is presented to students in teaching environments; however, it is important for the learners to structure this education appropriately in their minds. In order for the presented knowledge to be internalized, existing knowledge and concepts should be compatible with newly acquired knowledge and it is necessary for the individuals to mentally process them instead of memorizing (Önen, 2005). Knowing what individuals think about a subject, how they already perceive it and how they mentally structure a certain knowledge is very important in designing an effective teaching environment (Horton, 2007). The cognitive structures that individuals develop by mentally associating the knowledge they have acquired with each other are defined as mental models (Gilbert, 2011). Mental models are directly related to how we understand certain knowledge (Hanke, 2008). Mental model construction takes place in all successful or unsuccessful integration processes of the acquired knowledge (Tversky, 1993). The mental model that an individual has is personal and incomplete. Therefore, mental model development continues as new knowledge is acquired. Considering that mental models are the reflections of knowledge in the minds of individuals, identifying and revealing these reflections will give clues about the quality of learning (Bozdemir Yüzbaşıoğlu & Sarıkaya, 2019; Kurnaz, 2011; Moseley, Desjean-Perrotta & Utley, 2010). Based on these points, this research aimed to identify mental models related to garbage, waste and recycling and to determine the development of secondary school students' mental models following environment-oriented science activities.

Method

One-Group Pretest–Posttest experimental design, which is one of the quantitative research methods, was used for the purpose of the research. Research conducted using the experimental design aims to test the relationship between variables (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2018). One-Group Pretest–Posttest Design, on the other hand, measures the effect of independent variable applied to a group before and after the experiment (Fraenkel & Wallen, 2006). Within the scope of the current study objectives, pre-test and post-test mental models were identified via a teaching practice using environment-oriented activities and the effect of the procedure has been tested.

Study Group

This study, in which the one-group pretest–posttest experimental design was used, was conducted with 14 7th grade students from a secondary school located in the Western Black Sea Region. The inclusion of household garbage and recycling in this grade curriculum caused the conduct of the research with 7th graders.

Convenience sampling, one of the non-random sampling methods, which includes groups of people who are suitable, accessible and ready for the study (Fraenkel & Wallen, 2006) were used in the study.

Teaching Practices

For the purpose of the current research, the mental models of the students were determined before the teaching practices. As the teaching practice would to be implemented within the scope of the science course, the curriculum was examined in advance (MoNE, 2018). Then activities aiming the development of students' mental models on garbage, waste and recycling concepts were designed. In this context, a total of 24 environment-oriented activities that students can actively participate in were determined. The activities implemented are presented in Table 1.

Table 1

Activities carried out with the participation of students in line with research purposes

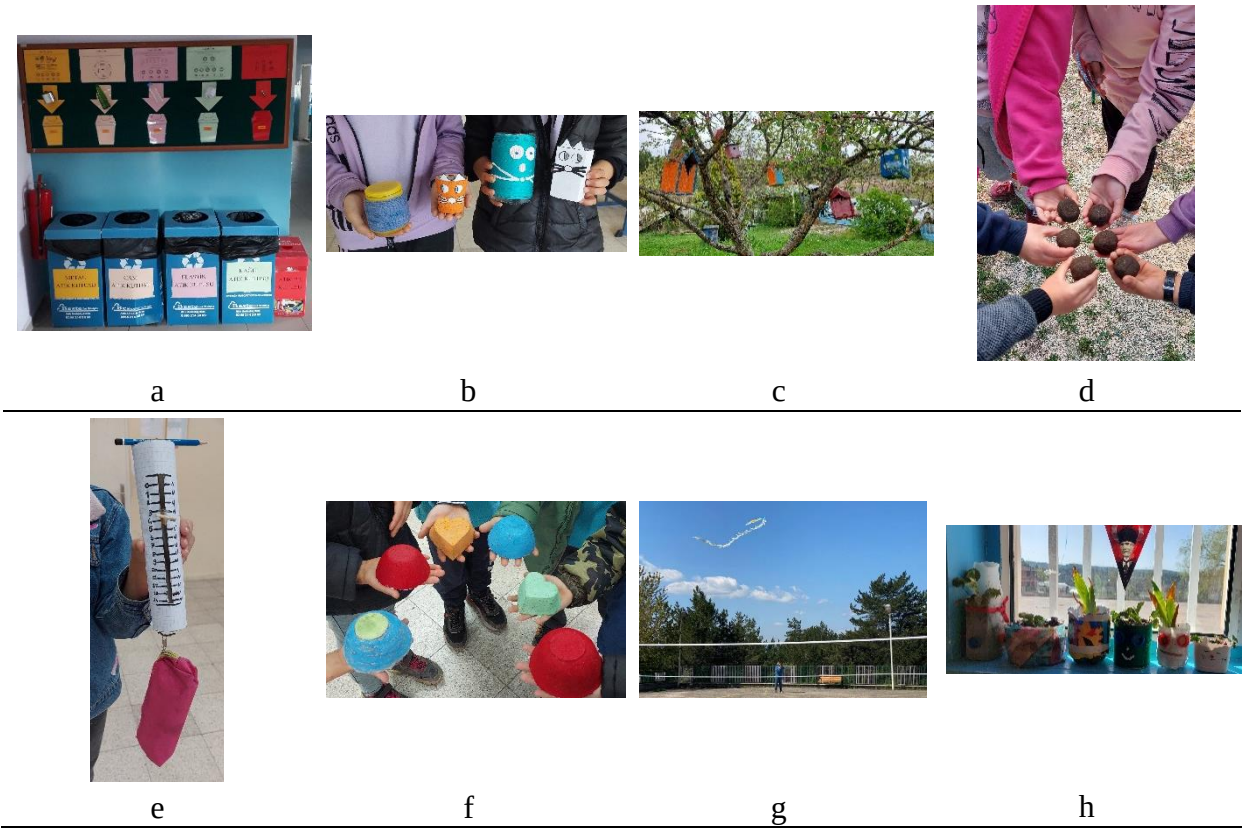
Week	Activity
1	A board on the concepts of garbage, waste and recycling has been created at the school.
2	Waste collection boxes were prepared and placed in appropriate areas in the school.
3	A presentation was made about waste oils and their effects on the environment, and a waste oil collection campaign was started.
4	Faculty members were invited to the school and asked to hold seminars on recycling and its types.
5	Informative presentations were presented about the zero waste project.
6	Planetary models were created from waste materials.
7	Artistic works were designed using waste materials.
8	A model cell was designed from waste materials.
9	A dynamometer was designed using waste materials.
10	A word game on the theme of garbage, waste and recycling was designed and played with the students.
11	A pen holder and piggy bank were designed using waste materials.
12	Kraft pulp was prepared from waste paper and cardboard materials and then pots and pen holders were designed using this pulp.
13	Various school logos were designed from waste materials.
14	Atom models were designed from waste materials.
15	Garbage, waste and recycling themed cartoons were drawn.
16	Recycling themed computer game was developed.

17	Original recycling logos were designed using waste materials.
18	Seed balls were prepared from waste papers and released to nature.
19	Flower pots were designed using waste materials and a flower bed was created in the classroom using these pots.
20	A virtual tour was organized to the compost and recycling facility.
21	Compost was prepared and used for planted plants.
22	Birdhouses were designed from waste materials and placed in appropriate places in the school garden.
23	Children's games were designed using waste materials.
24	Kites were prepared from waste materials and flown in the school yard.

The activities presented in Table 1 were applied within the scope of the science course together with the students for a total of 24 weeks, each of which was 1 week on average. Exemplary images of the activities carried out with the participation of students are presented in Figure 1.

Figure 1

Exemplary images of the activities carried out with the participation of students



a: Waste collection boxes, b: Pen holder and piggy bank designs, c: Birdhouses, d: Seed balls, e: Model dynamometer, f: Materials designed using pulp, g: Kite, h: The flower bed in the classroom

Active participation of students were ensured in the activities, examples of which are given in Figure 1, and all other activities. The materials required in the activities were provided by the students from the wastes generated in their classrooms, schools and homes

Data Collection and Analysis

A data collection tool consisting of six open-ended questions, developed within the scope of the current research, was used in order to determine the mental models that students have about garbage, waste and recycling. The acquisitions of the related subject in the science course curriculum were examined in detail before the development of the data collection tool. Developed questions were submitted to expert opinion to be evaluated in terms of language, clarity and suitability for the study. The measurement tool, consisting of a total of six questions (three verbal and three visual), was finalized after the expert's opinion.

Questions Asked in the Data Collection Tool

1. What is garbage? Please explain.
2. Please draw the image formed in your mind with regard to the concept of garbage.
3. What is waste? Please explain.
4. Please draw the image formed in your mind with regard to the concept of waste.
5. What is recycling? Please explain.
6. Please draw the image formed in your mind with regard to the concept of recycling.

For the purpose of the data collection phase, data collection tool was applied to the students by giving one class hour before the teaching practices. Then, a total of 24 activities within the scope of the science course were implemented with the participation of the students. The data collection tool was re-applied to the students after the activities were implemented.

A literature review was conducted before analyzing the answers given by the students to the data collection tool. Rubrics were created to determine students' reasoning levels and mental models about garbage, waste and recycling, in line with the purpose of the current research, based on the rubrics used by Yüzbaşıoğlu and Kurnaz (2020) to analyze the open-ended verbal and visual questions. The answers given by the students to the questions in the

data collection tool were analyzed in two separate groups, verbal and visual, by using the rubrics created. The reasoning levels derived from the answers given by the students to the related questions were classified according to the criteria presented in Table 2.

Table 2

The rubric used to determine students' reasoning levels

Level	Code	Score	Criteria related to Verbal Reasoning Levels	Criteria related to Visual Reasoning Levels
No Reasoning	[NR]	0	Questions left blank, vague or incomprehensible answers.	Questions left blank, vague or incomprehensible drawing(s)
Complex Reasoning	[CR]	1	Answers containing non-scientific information.	Drawing(s) reflecting non-scientific information.
Incomplete Reasoning	[IR]	2	Knowing some basic issues besides answers containing partially wrong/alternative ideas.	Drawings that reflect correct knowledge besides drawings that contain partially incorrect/alternative ideas.
Partially Scientific Reasoning	[PSR]	3	Answers that do not contain partially incorrect/alternative ideas, but basic knowledge.	Drawing(s) that do not contain partially incorrect/alternative ideas, but reflecting basic knowledge.
Scientific Reasoning	[SR]	4	Scientific answers (The level expected by the curriculum).	Drawings including scientific answers (The level expected by the curriculum).

The answers provided by the students to the questions, posed within the scope of the study, were evaluated and classified separately on the basis of garbage, waste and recycling issues in line with the criteria presented in Table 2. Next stage aimed to reveal the mental models of the students based on their visual and verbal reasoning levels. The rubric used for identifying mental models is presented in Table 3.

Table 3

Rubric for Identifying Mental Models

Models	Reasoning Levels	Characteristics
Incompatible Model [IM]	$\begin{bmatrix} 0 & 0 \\ 1 & 1 \\ 2 & 2 \end{bmatrix}$	Insufficient visual and verbal reasoning
Verbally Dominant Model [VDM]	$\begin{bmatrix} 0 & 4 \\ 1 & \\ 2 & 3 \end{bmatrix}$	Their visual reasoning is non-scientific, however their verbal reasoning is scientific.
Visually Dominant Model [ViDM]	$\begin{bmatrix} 4 & 0 \\ & 1 \\ 3 & 2 \end{bmatrix}$	Their visual reasoning is scientific, however their verbal reasoning is non-scientific.
Scientific Model [SM]	$\begin{bmatrix} 4 & 3 \\ 3 & 4 \end{bmatrix}$	Both visual and verbal reasoning levels are scientific in nature.

As presented in Table 3, the student's mental model for the relevant subject was classified as "Scientific Model" in case the students' visual and verbal reasoning levels on garbage, waste and recycling were of a scientific nature (if the student's visual and verbal reasoning level score is 4 or 3, mental model was classified as a SM). The student's mental model for the relevant subject was classified as "Visually Dominant Model" in case the students' visual reasoning levels were scientific however their verbal reasoning levels were of non-scientific nature (if the student's visual reasoning score was 4 or 3 and verbal reasoning score was 0, 1 or 2, their mental model was classified as a ViDM). The student's mental model for the relevant subject was classified as "Verbally Dominant Model" in case the students' visual reasoning levels were non-scientific however their verbal reasoning levels were of scientific nature (if the student's visual reasoning score was 0, 1 or 2 and verbal reasoning score was 4 or 3, their mental model was classified as a VDM). The student's mental model for the relevant subject was classified as "Incompatible Model" in case the students' visual and verbal reasoning levels were both evaluated as insufficient (if the student's both visual and verbal reasoning scores were 0, 1 or 2, their mental model was classified as an IM). These processes were repeated independently for the data collected before and after the implementation of environment-oriented activities. An independent researcher was asked to evaluate the answers provided by 5 randomly selected students in the data collection tool for calculating the reliability of the study. Then the codes of the independent researcher were compared with the codes determined within the scope of the current research by using the formula suggested by Miles and Huberman (1994) [Reliability = (Consensus) / (Consensus+Disagreement)]. At the end of the calculations, the percentage of agreement was calculated as 0,94. Studies with a percentage of agreement over 70% are considered reliable (Miles & Huberman, 1994). In order to ensure validity within the scope of the study, direct quotations were included and detailed explanations were made.

Compliance with Ethical Standard

This study received ethics approval from the Kastamonu University Social and Human Sciences Research and Publication Ethics Board (Dated 17.05.2022 and numbered 2022/2/5)

Findings

The answers provided by the students for each question about garbage, waste and recycling before and after the implementation of the environment-oriented activities were analyzed independently of each other. First, the reasoning levels of students were determined in line with the criteria given in Table 2 based on the answers provided by each student. Pre-test visual and verbal reasoning levels of students on garbage, waste and recycling (before the implementation of activities) were presented in Table 4.

Table 4

Pre-test Visual and Verbal Reasoning Levels of Students

Subject	Reasoning	Level	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
Garbage	Visual	[NR]														√
		[CR]			√	√	√			√			√			
		[IR]	√	√							√	√		√	√	
		[PSR]						√	√							
		[SR]														
	Verbal	[NR]							√							√
		[CR]				√	√			√	√	√				
		[IR]	√	√	√								√	√	√	
		[PSR]						√								
		[SR]														
Waste	Visual	[NR]		√												
		[CR]												√		
		[IR]										√	√			√
		[PSR]			√		√	√		√	√				√	
		[SR]	√			√			√							
	Verbal	[NR]		√		√	√			√		√		√		
		[CR]														√
		[IR]	√										√			
		[PSR]			√						√				√	
		[SR]						√	√							
Recycling	Visual	[NR]														
		[CR]				√		√			√	√				
		[IR]														
		[PSR]	√	√	√		√			√				√	√	√
		[SR]							√				√			
	Verbal	[NR]														√
		[CR]				√					√	√				
		[IR]					√									
		[PSR]	√		√			√		√					√	
		[SR]		√					√				√	√		

Table 4 reveals that both visual and verbal reasoning levels of the majority of students about garbage were grouped under IR (f=6) and CR (f=5) codes. None of the students provided answers grouped under SR category at both reasoning levels. In both visual and

verbal questions, majority of the students were not clear about garbage. It was further determined that the students generally consider all the materials they do not commonly use as garbage. Visual reasoning levels of the students in the waste concept were mostly classified under PSR code (f=6) whereas their verbal reasoning levels were classified under NR code (f=6). It was determined that students have significant deficiencies in distinguishing between the concepts of waste and garbage. It was found that students more likely classify most of the waste materials they encounter at school and at home as garbage. Visual reasoning levels of the students in the recycling concept were mostly classified under PSR code (f=8) whereas their verbal reasoning levels were classified under PSR code (f=5) and SR code (f=4). Students were determined to be more successful in recycling concept compared to other subjects. It was concluded that students had deficiencies in visual reasoning of the concept of recycling although their verbal reasoning of the concept of recycling was at acceptable levels. It was observed that the deficiencies related to the concepts of garbage and waste further caused problems in reasoning concept of recycling and although the students were able to express recycling verbally to a certain extent, they had deficiencies with regard to visualization. Examples of the answers provided by the students to the data collection tool before the implementation of environment-oriented activities were presented in Figure 2.

Figure 2

Examples of the pre-test answers provided by the students to questions about garbage, waste and recycling

Garbage	Waste	Recycling
		
İnsanların herhangi bir ürünü kullandıktan sonra atılan artık maddelere çöp denir	atık geri dönüştürülebilir o yüzden onlara uygun kutulara atınız	İnsanların herhangi bir ürünü kullandıktan sonra atılan artık maddelere çöp denir

The activities presented in Table 1 were developed considering the visual and verbal reasoning performances of the students presented in Table 4. In the next step, developed

activities were carried out with the participation of the students and the data collection tool was applied again. Reasoning levels of students were evaluated in line with the criteria given in Table 2 based on the answers provided by each student. Post-test visual and verbal reasoning levels of students on garbage, waste and recycling (after the implementation of activities) were presented in Table 5.

Table 5

Post-test Verbal and Visual Reasoning Levels of Students

Subject	Reasoning	Level	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
Garbage	Visual	[NR]														
		[CR]														
		[IR]	√		√	√				√					√	
		[PSR]		√				√	√		√	√	√			√
		[SR]					√							√		
	Verbal	[NR]														
		[CR]														
		[IR]			√	√			√							
		[PSR]		√			√						√	√	√	
		[SR]	√					√		√	√	√				√
Waste	Visual	[NR]														
		[CR]														
		[IR]														
		[PSR]					√	√				√		√		√
		[SR]	√	√	√	√			√	√	√		√		√	
	Verbal	[NR]														
		[CR]														
		[IR]				√										√
		[PSR]			√									√		
		[SR]	√	√			√	√	√	√	√	√	√		√	
Recycling	Visual	[NR]														
		[CR]														
		[IR]														
		[PSR]		√		√		√		√		√	√	√	√	√
		[SR]	√		√		√		√		√					
	Verbal	[NR]														
		[CR]														
		[IR]														
		[PSR]				√	√	√								
		[SR]	√	√	√				√	√	√	√	√	√	√	√

Table 5 revealed that the students' visual reasoning levels about the concept of garbage were mostly classified under PSR (f=7) code and their verbal reasoning levels were mostly classified under SR (f=6) and PSR (f=5) codes. Considering both reasoning levels, it was determined that none of the students' reasoning levels were classified under the code CR, which includes non-scientific knowledge, and under the code NR, which represents vague and incomprehensible answers. After the activities implemented, it was determined that majority

of the students were able to characterize the items that cannot be reintroduced into the system and that cannot be reused as garbage. It was determined that both visual (f=9) and verbal (f=10) reasoning levels of the students about the concept of waste were mostly classified under the category of SR, which represents answers at the scientific level. After the activities implemented, it was determined that the students were able to characterize the items that could be re-evaluated, converted into raw materials through various processes and reintroduced into the production process as wastes. It was further determined that students preferred drawing about materials such as used paper, plastic bottles and tin cans that they have commonly used in school activities and frequently encountered in their daily lives. Visual reasoning levels of the students in the recycling concept were mostly classified under PSR code (f=9) whereas their verbal reasoning levels were classified under SR code (f=11). It was concluded that the education provided and the practices implemented, together with the environment-oriented activities, positively contributed to the students' reasoning of the recycling concept. Examples of the answers provided by the students to the data collection tool following the implementation of environment-oriented activities were presented in Figure 3.

Figure 3

Examples of the post-test answers provided by the students to questions about garbage, waste and recycling

Garbage	Waste	Recycling
		
Çöp geri dönüştürülemeyen atıklar	atık geri dönüştürülerek tekrar kullanılır. örneğin; atık pil, atık kağıt birde cüsel atıklar var.	Atıkların çeşitli fiziksel veya kimyasal işlemlerden geçerek tekrar kullanılabilir hale getirilmesidir.

Students' mental models were identified, using the rubric presented in Table 3, based on the students' levels of visual and verbal reasoning about the concepts of garbage, waste and recycling. The pre-test mental models of the students related to garbage, waste and recycling (before the implementation of activities) were presented in Table 6.

Table 6

Pre-test Mental Models of the Students

Subject	Mental Model	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
Garbage	[IM]	√	√	√	√	√			√	√	√	√	√	√	√
	[VDM]														
	[ViDM]							√							
	[SM]						√								
Waste	[IM]		√								√	√	√		√
	[VDM]														
	[ViDM]	√			√	√			√						
	[SM]			√			√	√		√				√	
Recycling	[IM]				√					√	√				
	[VDM]						√								
	[ViDM]					√									√
	[SM]	√	√	√				√	√			√	√	√	

Table 6 revealed that almost all of the students had mental models categorized under IM (f=12) code with regard to garbage concept before the implementation of activities and very few students had mental models categorized under ViDM (f=1) and SM (f=1) codes. Considering the subject of waste, on the other hand, it was determined that the students' mental models were distributed under IM (f=5), ViDM (f=4) and SM (f=5) codes. It was further determined that more than half of the students had a mental model about the concept of recycling categorized under SM (f=8) code. The rest of the students had IM (f=3), VDM (f=1) and ViDM (f=2) mental models. The post-test mental models of the students related to garbage, waste and recycling (following the implementation of activities) were presented in Table 7.

Table 7

Post-test Mental Models of the Students

Subject	Mental Model	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
Garbage	[IM]			√	√										
	[VDM]	√							√					√	
	[ViDM]							√							
	[SM]		√			√	√			√	√	√	√		√
Waste	[IM]														
	[VDM]														
	[ViDM]				√										√
	[SM]	√	√	√		√	√	√	√	√	√	√	√	√	
Recycling	[IM]														
	[VDM]										√				
	[ViDM]														
	[SM]	√	√	√	√	√	√	√	√	√		√	√	√	√

Table 7 revealed that more than half of the students had a mental model categorized under IM (f=8) about the concept of garbage and a small number of students had mental models grouped under the categories of IM (f=2), VDM (f=3) and ViDM (f=1). It was further determined that almost all of the students had a mental model categorized under SM (f=12) code with regard to waste concept and other students had a mental model categorized under ViDM (f=2) code. Considering the concept of recycling, it was further determined that the number of students with the mental model categorized under SM (f=13) code was quite high and only one student had the mental model categorized under VDM code.

It was concluded that the activities implemented contributed positively to the mental models of the students. Post-test changes in the mental models of the students were presented in Table 8.

Table 8

Changes in the Mental Models

			Mental Model			
			Incompatible Model	Verbally Dominant Model	Visually Dominant Model	Scientific Model
Garbage	Pre-test	f	12	-	1	1
	Post-test	f	2	3	1	8
Waste	Pre-test	f	5	-	4	5
	Post-test	f	-	-	2	12
Recycling	Pre-test	f	3	1	2	8
	Post-test	f	-	1	-	13

As can be deduced from Table 8, the mental models of the students on garbage, waste and recycling have improved after the implementation of the activities. While the visual and verbal reasoning of 12 students about garbage was insufficient, majority of them switched to scientific reasoning after the implementation of the activities. It was concluded that the students who previously had IM mental models about the concept of waste had mental models categorized under ViDM and SM codes together with the implementation of the activities. Considering the concept of recycling, it was further determined that almost all of the students had the mental model categorized under SM following the implementation of the activities. Significant positive developments were identified in the visual and verbal reasoning levels of the students on garbage, waste and recycling together with the implementation of the

activities. It was determined that the knowledge of all students on the relevant subjects, except for the two students participating in the study, achieved the level of scientific quality expected by the curriculum. Detailed analysis of the answers provided by S3 and S4, which were classified under the "Incompatible Model" category because their visual and verbal reasoning on the concept of garbage concept was insufficient, revealed that students still cannot clearly distinguish between garbage and wastes.

Discussion and Resutls

In order to prevent garbage and waste from becoming an environmental problem, disposal of garbage and wastes in irregular dumping sites should be prevented; their recycling and proper disposal should be ensured. Therefore, individuals in the society should primarily be ensured to reduce wastes at their source, and should be directed to recycling and finally to appropriate disposal methods (Ministry of Environment and Urbanization, 2020). This aim can undoubtedly be realized with the education of the society. In the current study, certain steps were taken to train students about the concepts of garbage, waste and recycling and the effectiveness of the implemented training activities was examined. In this context, students' mental models were determined by identifying their visual and verbal reasoning levels on garbage, waste and recycling concepts before and after the implementation of the activities. It was determined that the environment-oriented science activities contributed to the development of students' mental models as well as their visual and verbal reasoning about garbage, waste and recycling.

It was found that students could not provide scientific answers to visual and verbal questions about garbage before the activities. Vast majority of students did not clearly know the difference between the concepts of garbage and waste and gave waste-related answers to garbage-related questions. Students in the lower age group are known to have insufficient knowledge about the environment, recycling and environmental protection (Onur, Çağlar & Salman, 2016). The inability of the students to clearly distinguish the concepts of garbage and waste further prevents them from performing the separation of wastes and causes inability to carry out recycling activities. In order to raise individuals who care for, understand and protect the environment, it is necessary for the students to experience educational processes in which they can interact with the environment (Ewert, Place & Sibthorp, 2005; Taff et al., 2010). In line with the current research purposes, various trainings were provided to the

students by both their science course teacher and different faculty members (see Table 1). Students were further given the opportunity to perform certain activities in which they are directly involved in order to transform the knowledge they have acquired during the courses into practice. Schools are one of the places where packaging waste is most commonly generated due to the food items consumed by students who spend a large portion of their daily lives at school (Çelik, 2011). For the purpose of the activities, students were required to provide the materials they needed from the waste released in their classrooms and at home. Thus, students had the opportunity to directly observe the garbage and waste found in their living areas. The activities implemented were found to be positively improving the students' reasoning levels about the concept of garbage and it was concluded that the majority of the students had a scientific mental model about garbage.

Pursuant to the assessment report on environmental problems and their priorities, waste is one of the top three priority environmental problems in Turkey. Main source of the waste problem is observed to be the wild (irregular) storage of household waste and the lack of storage facilities in some provinces (Ministry of Environment and Urbanization, 2020). It is of significant importance to cease the wastes from being an environmental problem, to be separated, stored and recycled in order to economically contribute to society. For this purpose, individuals should be properly trained. The findings in the current research revealed that the students' reasoning levels related to wastes in all categories of visual and verbal reasoning were distributed under low score categories before the implementation of the activities. However, after the implementation of the activities, it was determined that almost all of the students had achieved a scientific mental model. Two students were classified in the ViDM category. It was found that these students considered broken pieces of glass materials as garbage and categorized used syringes, pet cups and wet wipes as recyclable wastes. It was determined that all the students gave place to samples based on materials such as photocopy papers, plastic bottles, glass jars and bottles, metal cans and tools, used batteries that they encountered directly in the school environment and at home and often used for the purpose of activities in their answers to the questions. Supporting the results of the current research, literature review revealed that the students who separate their wastes for recycling purposes mostly preferred to recycle paper, plastics, glass and aluminum cans (Demir & Atasoy, 2021) and that paper wastes are most often disposed into waste collection bins (Çimen & Yılmaz, 2012). Similarly, Kıvrak and Uyanık (2020) determined that students studying in the village and students studying in the district included examples about environmental pollution related

to the regions they lived in when they were asked about their mental models. Therefore, it may be possible to conclude that the mental models of individuals are in direct interaction with the environment in which they live. Another point that attracted attention in the current study was the students' interest in the concept of organic waste. While students previously perceived organic wastes as garbage before the implementation of the activities, they have further become aware that these are wastes. After the implementation of the activities, the students gave place to organic wastes and composts in the responses they provided to the questions in the data collection tool. It is known that individuals more easily deal with environmental problems that they can observe directly in their immediate surroundings (Bozdemir Yüzbaşıoğlu, 2020). The findings regarding organic wastes and composts, obtained within the scope of the current research, suggested that students had previously paid attention to the organic wastes released in their immediate surroundings, such as their homes and the school cafeteria, but had considered them as garbage before the implementation of the activities.

The students were able to verbally explain the recycling concept to a certain level in their pre-test responses to the data collection tool before the implementation of the activities, it was found that they had serious deficiencies with regard to drawing visual illustrations. Individuals cannot be expected to exhibit appropriate attitudes and behaviors about recycling without being duly informed about recycling and its significance (Nikolaeva, 2008). Knowing the benefits of recycling is an important achievement that enables individuals to take steps towards recycling (Schultz et al., 1995). In the activities implemented in accordance with the current research purposes, students were informed about the significance of recycling and had the opportunity to implement appropriate activities. The reflections of this conclusion were observed in the answers provided by the students to the data collection tool following the implementation of environment-oriented activities. Both visual and verbal reasoning levels of the students improved and this situation was reflected in their mental models. All but one of the students participating in the study have reached the level of scientific mental model. It was further concluded that the only student who could not achieve a scientific mental model was classified under the verbally dominant model. Detailed analysis with regard to the responses of this student helped to determine that the student's inability to visually express the concept of recycling prevailed. Another remarkable result reached within the scope of the research was that the students mentioned the types of recycling while answering the questions in the data collection tool after the implementation of activities. Whereas the types of recycling are

not included in the 7. grade and lower level curriculum. Moreover none of the students mentioned these concepts while answering the questions in the data collection tool before the implementation of activities. It is known that students mostly acquire their knowledge about recycling from the teaching environment (Çimen & Yılmaz, 2012). It is therefore argued that students got aware of these concepts during the seminars given by the faculty members invited to the school within the scope of the current research and getting to know artists performing recycling art activities further affected students. Students will also be able to carry the information about recycling duly provided in the school environment to their friends and family (Harman & Çelikler, 2016). Considering the grades of the students, the capability of the students to mention the concepts of advanced conversion and downstream processing in addition to the concept of recycling both in the activities they participated in as well as their responses to the measurement tool was concluded to be very valuable output derived in the research.

The materials required in the activities performed during the research were provided by the students from the wastes generated in their classrooms, schools and homes. For this reason, not only they resorted to separating the wastes but they also disposed the released waste into waste collection bins. Thus, students have been given the opportunity to transfer their waste and recycling awareness directly to their daily lives. It is extremely important for students to relate the information they have acquired to their daily lives and use it to figure out problems they may encounter in daily life for ensuring the permanence of knowledge. As a matter of fact, students are required to assume responsibility and use their knowledge and skills in figuring out daily life problems for the purpose of achieving the objectives of the curriculum (MoNE, 2018). The education/trainings provided over a longer period of time contribute positively on the knowledge, awareness (Aksan, 2016) and sensitivity towards the concepts of waste and recycling (Uyanık, 2022). The activities covered within the scope of the current research were implemented throughout approximately one academic year. Pre-test and post-test changes in the mental models of the students supported the results obtained by Aksan (2016) and Uyanık (2022) in their research.

Individuals are expected to plan effective solutions for waste disposal and recycling in the cities where they live collectively (Gil Garcia, Pardo & Nam, 2015). Environment-oriented call of acts and international conventions also emphasize the necessity of waste conversion (Çelikyay, 2021). That is why it is extremely important to educate the younger generations who make up both today and the future of our world. As a matter of fact, students

in the younger age group have been included in the focus of the current research. In order for students to take part in recycling activities, they first need to know the concepts of garbage and waste as well as the differences in between them. In order to carry out recycling practices, waste and garbage should be separated beforehand. If this experience is popularized within the society, the implementation of recycling activities may increase. The activities implemented within the scope of the current research aimed to enable students to have knowledge about garbage and waste, to separate their wastes and to engage in recycling activities. It was concluded at the end of the research that the activities implemented enabled the students to improve their mental models concerning garbage, waste and recycling. In order to maximize the rates of recycling activities in the whole society, garbage and wastes should be separated as much as possible. Therefore, waste collection and garbage bins should be placed in easily accessible places. Failure to place these bins and containers in suitable and easily accessible places will cause the release of garbage and wastes in the nature and environmental pollution. One of the biggest causes of environmental pollution is mentioned by students as leaving garbages to nature (Uyanık, 2017). It was concluded that students in the younger age group are aware of the need to protect the environment and they think that waste collection bins should be placed in different locations (Yaşaroğlu & Akdağ, 2013). Students have a certain level of awareness about not leaving garbages in the nature. Placement of waste collection containers in common and easily accessible locations affects the recycling behavior of individuals (Hansmann et al., 2006). Waste collection bins which will be placed at many different locations such as schools, parks, train stations, bus stops and shopping centers, where individuals are frequently involved in their daily lives, will positively affect the recycling rates in the society (Doğan, 2020). Therefore, it is thought that the widespread use of garbage and waste collection bins will enable students to dispose of their wastes and garbage in appropriate containers in order to reduce environmental pollution. Based on the results obtained, teaching activities aiming to improve the knowledge levels of students studying at different grades on garbage, waste and recycling have been suggested. It was further suggested to include more environment-oriented activities in the curriculum of all courses other than science.

Compliance with Ethical Standard

This study received ethics approval from the Kastamonu University Social and Human Sciences Research and Publication Ethics Board (Dated 17.05.2022 and numbered 2022/2/5)

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