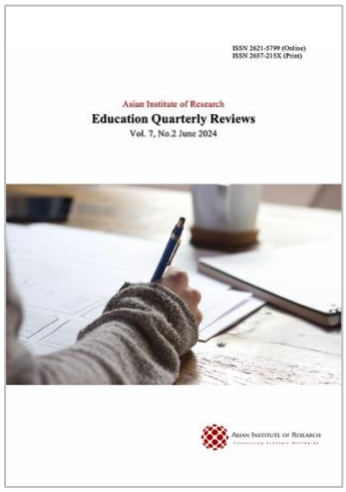

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The Effect of the Harezmi Education Model on Secondary School Students' Science Academic Achievement*

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Abstract

Today, as technology develops, needs also diversify. These emerging needs are tried to be met with changing curriculum, teaching materials and different education models. The Harezmi Education Model (HEM), which has become widespread in Türkiye in recent years, can also be considered because of this process. This study aims to investigate the effectiveness of the HEM on students' academic achievement. The research was conducted in the first semester of the 2022-2023 academic year with 19 students studying in the 5th and 6th grades of a public secondary school in Türkiye. The research was conducted using a pre-test post-test quasi-experimental design without a control group. Because of the data analysis, it was seen that the courses supported by HEM significantly increased the students' achievement. Since participants were selected based on volunteering and a 10-week application period was required, the study did not include a control group. Based on this, science teachers are recommended to use HEM more frequently in their lessons in addition to existing teaching.

Keywords: Harezmi Education Model, Academic Achievement, Science Education, Secondary School Students

1. Introduction

Technology is developing rapidly daily, affecting related fields (Fer, 2011; Göçen, 2022) and individuals' qualifications. For the current century, individuals are expected to have 21st-century skills (Kang et al., 2010). Many countries are developing teaching methods to acquire these skills and include different methods and techniques in their programs. Many OECD countries have made curriculum changes or regulations. Some countries focused on all skills in their curricula, while Austria, Finland, Norway, and the Netherlands included some skills in their systems (Hamarat, 2019). With scientific and technological developments, new innovative

* This study was produced from the master's thesis of the first author, and a part of the study was presented as an oral presentation at the Xth International Eurasian Educational Research Congress (EJER-2023) on June 08-11, 2023, TED University, Ankara, Türkiye

societies can produce solutions to economic and social problems by considering the human benefit. In line with all these developments, countries are updating their curriculum so that their citizens are equipped to meet the needs of the new age (Çelikkaya & Kürümlüoğlu, 2018; Haridza & Irving, 2017) and designing many education models in this direction (Akgündüz et al., 2015). One of these models is the Harezmi Education Model (HEM).

The HEM studies, which started with the "Mind to Machine Computer Science and Interdisciplinary Education" workshop in Türkiye and spread all over the country, involving thousands of teachers and students, were first carried out as a pilot in the 2016-2017 academic year, and throughout Istanbul in the 2017-2018 academic year. It started to be implemented throughout the country in the 2018-2019 academic year, and the patent of the model was received on July 11, 2018, on behalf of the Istanbul Provincial Directorate of National Education (MoNE [Ministry of National Education], 2018*a*; MoNE, 2022; URL-1, 2023).

The HEM, is the process of designing an algorithm to identify and solve students' daily real-life problems, determining how to solve this problem step by step, and generating innovative ideas by taking advantage of the power of programming. In addition, it is a system that integrates computer science with the branch of social science, adapts computational thinking skills to life, uses programming and teaching tools effectively, reinterprets the interdisciplinary approach and adopts cooperation in which different disciplines are equally involved, produces by having fun with robotics and game design, and constantly updates itself (URL-1, 2023). HEM is built on five grounds (Figure 1).

Figure 1: Five grounds of the HEM

During this process, students are expected to define real-life problems, design an algorithm to solve this problem, evaluate how to solve the problem step by step and produce innovative solutions by taking advantage of the power of programming. It is a process of raising a generation that exists in the industrial field and is solution and production-focused, not consumption-focused. Experience-sharing meetings with practice teachers and administrators are held at the district level to ensure motivation and coordination (Ceylan et al., 2020).

The HEM aims to develop "computational thinking (CT)" skills in all age groups without using computers. The troubleshooting process is wholly structured with CT. In this way, students can experience the stages of the logical

thinking cycle. Additionally, learning computer science concepts and principles will better prepare students for the ever-changing world of technology and business. With a mindset similar to computational computing, students are intended to learn throughout their lives without being influenced by the development of tools and applications. The tasks and goals of CT are also problem-related and can be developed and maintained through coding, programming, and robotic game design. Another of the most striking features of HEM is that students and teachers work on the "problem from life (PfL)" that they have determined together, and make decisions and take initiatives appropriate to their environment by making risk analysis thanks to the CT skill. At this point, Koçoğlu (2018) stated in his research that the responsibilities of teachers are to provide students with the opportunity to explore and design, prepare technological learning environments, listen to the student patiently, and learn together with the student.

As a result of the review of the literature, it was seen that the number of studies on the application of HEM is limited. Examining the opinions of 3rd-grade primary school students and their parents regarding HEM (Çimşir et al., 2022); the effect of HEM on the creativity skills of gifted students (Yavuz et al., 2019*b*); determining students' metaphorical perceptions towards HEM (Ceylan et al., 2020); determining the opinions of teachers who apply HEM about the model (Seçer, 2021); application of HEM in social studies course (Tokmak, 2022); analysis of HEM, which is in the pilot implementation process in Türkiye, in line with the opinions of field experts (Koçoğlu, 2018); studies have been found in the literature, such as the effect of HEM on the cognitive thinking skills of secondary school students (Tokmak et al., 2022); the effect of HEM on the development of problem solving skills of secondary school students (Tokmak, 2023).

When studies in the literature that may be directly or indirectly related to HEM are examined, Ceylan et al. (2020) research conducted to reveal students' metaphorical perceptions of HEM, it was concluded that the most produced metaphors for the model were "life" and "HEM being a source of information." Yavuz et al. (2019*a*) revealed that students participating in HEM activities improved their original thinking. As a result of Yıldız (2019) research, the HEM application, which was carried out to give students self-confidence, develop their thinking skills, and increase their ability to act in cooperation, showed positive results. Uçan (2019) tried to evaluate the contributions of the model from the parent perspective in his interviews with the parents of students participating in HEM activities and revealed that the students' parents had an opinion on the implementation of HEM activities. In their research, Akın et al. (2019) investigated the effect of changing physical conditions during HEM application in learning. They stated that improving physical conditions with HEM or different activity environments would positively affect education. Özyıldırım et al. (2019) in their research, they planned solutions for people who have forgetfulness problems with HEM applications and designed a robot with a timer. Doğan et al. (2019) concluded in their research that the five foundations that form the basis of HEM positively contribute to preschool students' awareness level and teachers' development.

1.1 The Purpose of the Study

This study aims to investigate the effectiveness of the HEM on students' academic achievement. For this purpose, the research question was determined as follows:
"What impact does implementing the HEM model have on enhancing the secondary school students' academic achievement in understanding key concepts in science education?"

2. Method

In this section, the research model, study group, data collection tool, data collection, teaching intervention, and data analysis titles are given.

2.1 Research Model

In the study, quantitative data collection tool were used. The research was conducted using a pre-test post-test quasi-experimental design without a control group. Since participants were selected based on volunteering and a 10-week application period was required, the study did not include a control group. Since participants were

selected based on volunteering and a 10-week application period was required, the study did not include a control group. Although the lack of a control group in this design is considered a limitation, these designs are still used in studies where it is impossible to create a control group for technical and situational reasons (Knapp, 2016).

2.2 Study Group

The research was conducted in the first semester of the 2022-2023 academic year with 19 students studying in the 5th and 6th grades of a secondary school in the center of a province in Türkiye. Easily accessible case sampling, one of the purposeful sampling methods, was used to determine the study group from the classrooms where the researcher worked and taught. The purpose of choosing the easily accessible sampling method is to include voluntary and appropriate participants in the study (Creswell, 2005). The demographic characteristics of the students in the study group are shown in Table 1.

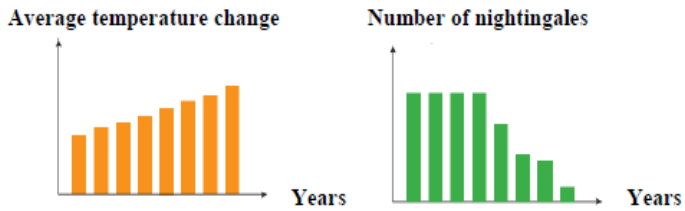
Table 1: Demographic characteristics of students

	N	Percent (%)
Gender		
Female	9	47.4
Male	10	52.6
Total	**19**	**100**
Grade Level		
5	7	36.8
6	12	63.2
Total	**19**	**100**

2.3 Data Collection Tool

The Academic Achievement Test (AAT) was used to collect quantitative data. The AAT, which consists of 18 multiple-choice questions on topics such as environmental pollution, water pollution, air pollution, global warming, energy consumption, fossil fuels, solar energy, and water use, was prepared by researchers. Two sample questions from the composed achievement test are shown in below:

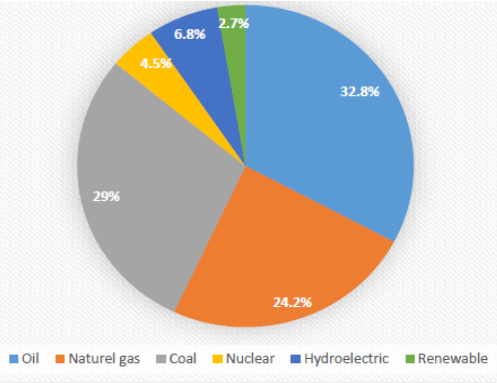
1. Global warming increases the average temperature on the earth's surface every year. The increase in temperature also causes some changes in living things. Below are graphs showing the changes in average temperature and number of nightingales in a region over the years.



Accordingly, which of the following can be reached when the graphs are examined?

A) If the temperature value decreases over time, the number of nightingales decreases.
B) Nightingales may have migrated to regions with suitable temperatures.
C) The number of caterpillars, which are the food of nightingales, may decrease over time.
D) Not only nightingales but also other bird species are affected by the increase in temperature.

2. The chart below shows the source-based distribution of worldwide energy consumption rates in 2015.



According to this chart,

I. The share of renewable energy obtained from natural resources in total energy consumption is approximately 9.5%.
II. Thanks to the investments made, the consumption rates of renewable energy are gradually increasing.
III. Fossil fuels constitute the majority of consumed energy types.
Which of the statements are correct?
A) Only I B) I and III C) II and III D) I, II, and III

While preparing the achievement test, questions and various test books previously prepared by the MoNE were used. Initially, an item pool consisting of 25 questions was designed, and these questions were presented to three science teachers and two faculty members, and expert opinions were received about the questions. Five items were removed from the achievement test, and an achievement test with 20 questions was obtained in line with expert views. This test was pre-applied to 150 seventh-grade students who were not included in the study group, and the obtained data was analyzed with the SPSS program. Each question's item difficulty index (*p*) and item discrimination index (*r*) values were calculated. The data obtained are shown in Table 2.

Table 2: Item difficulty index (*p*) and item discrimination index (*r*) values of the AAT

Question number	***p***	***r***	**Question number**	***p***	***r***
1	0.70	0.46	11	0.57	0.39
2	0.88	0.24	12	0.70	0.52
3	0.77	0.58	13	0.53	0.52
4	0.56	0.40	14	0.69	0.60
5	0.73	0.28	15	0.31	0.16
6	0.37	0.30	16	0.58	0.58
7	0.49	0.45	17	0.55	0.48
8	0.63	0.33	18	0.49	0.52
9	0.45	0.45	19	0.43	0.48
10	0.62	0.49	20	0.49	0.50

According to Table 2, as a result of the analysis, the 2nd and 15th questions with low *p* and *r* values were removed from the test, and the achievement test was reduced to 18 questions. The reliability of the final version of AAT was calculated with Kuder-Richardson (KR-20), and the obtained data are presented in Table 3.

Table 3: The AAT's KR-20 reliability analysis results

N	**Minimum**	**Maximum**	**$\bar{X}$**	**Sd**	**Reliability (KR-20)**
18	3	18	10.3	4.06	0.78

According to Table 3, the reliability value of the test was calculated as 0.78. According to Büyüköztürk (2011), it is stated that a value above 0.70 is sufficient to talk about the reliability of a test. While calculating, each correct answer was considered 1 point, and incorrect answer or not answer was considered 0 points. Each question in the AAT and its related concept are shown in Table 4.

Table 4: Question and concept relationship in the achievement test

Question	Related topic	Question	Related topic
1	Global warming	10	Water pollution
2	Solar energy	11	Water pollution
3	Environmental pollution	12	Air pollution
4	Environmental pollution	13	Water pollution
5	Water pollution	14	Water pollution
6	Energy consumption	15	Air pollution
7	Global warming	16	Solar energy
8	Water scarcity	17	Fossil fuels
9	Water pollution	18	Energy consumption

2.4 Teaching Intervention

Before starting the application, a Harezmi classroom was formed, in which 19 students in the 5th and 6th grades of secondary school participated voluntarily. The research process took ten weeks in total. The research process was carried out by the researcher, who also worked as a science teacher at the school where the research was conducted. However, due to the subject and principles of HEM, teachers from five different disciplines working in the same school were included in the study. In the Harezmi classroom, mathematics, Turkish, English, and information technology teachers worked in the same school, and the science teacher participated. The topics to be taught in the Harezmi classroom were determined. Care was taken to ensure that these subjects were not included in the 5th and 6th-grade science course curriculum as much as possible, and the aim was for the participants to learn these determined topics in the Harezmi classroom. Because a design without a control group was used in the research, it was tried to minimize the situations that could affect academic achievement scores. When the 2018 Science Course Curriculum (MoNE, 2018*b*) is examined, environmental pollution, one of the subjects taught in the Harezmi classroom, is mentioned in the 5th-grade subject of human and environment, and another issue, fossil fuels, is mentioned in the 6th-grade energies subject. Therefore, students learned these subjects in the Harezmi classroom, and their academic achievement was evaluated accordingly.

Teachers from five different disciplines carried out the lessons taught in the Harezmi classroom. One hour of the four-hour-a-week practice was planned as the planning process with the teachers before the implementation, two hours were designed as the HEM implementation, and the other hour was scheduled as the teachers' lesson evaluation meeting after the performance. The research period was determined as ten weeks (40 lesson hours), with four hours per week. Regarding the activities prepared in this direction, opinions were received from science field experts regarding the achievements of the activities and their consistency with the relevant concepts. Necessary arrangements were made in the events in line with the opinions received. After all the required arrangements were made, the planning was finalized. After organizing the process into a flow, teachers and researchers from other disciplines involved in the process prepared weekly implementation plans for ten weeks (Table 5).

Table 5: Implementation process in the Harezmi classroom

Week (Four lesson hours)	Activity performed
Week 1	Implementation of the achievement test as a pre-test, introduction activities, presentation of the Harezmi education model, wolf, lamb, and grass activity
Week 2	Coding activity without a computer

Week 3	Problem statement, sub-problems, problem scenario, problem from life (PfL) Sentence
Week 4	Intelligence games, activities with the determined PfL sentence
Week 5	Research on the problem determined by the PfL sentence
Week 6	Infographic preparation (Canva), poster design
Week 7	Sensor faucet design with Arduino sets
Week 8	Water treatment plant tour activity, preparing a survey for parents in Google Forms
Week 9	Protect your water seminar, poetry, and painting competition about water waste
Week 10	Evaluating the survey results sent to the parents of students at the relevant school via Google Forms, designing infographics and brochures in Canva, applying the achievement test as a post-test, implementing SSIF

A few application examples are given below. Other activities carried out weekly are given in the Appendix A.

Week 2

At the beginning of the course, the "minefield activity" (Figure 2), a computer-free coding activity, was held as a warm-up game.

Figure 2: Minefield activity

Students were given information about Canva, one of the Web 2.0 tools. All the problems identified by the students assigned in the previous week were written on the board, the problems that interested them the most were determined, and groups were formed to prepare presentations to answer the questions stated below and suggested on the HEM training page.

- Who has been affected by this problem, and for how long?
- If we don't do anything about this problem, who will be affected and how?
- What other problems could not solving this problem cause?
- What will solving this problem change in our lives?
- If we solve this problem, what other problems will we solve?
- What is currently being done to solve this problem? In what ways are these efforts ineffective? (URL-2, 2023).

Week 7

The information technologies teacher explained Basic Arduino coding for the sensor faucet design determined the previous week. To purchase five Arduino sets, the Harezmi classroom organized a bazaar at school (Figure 3) and

provided the necessary financial income for the sets. The students divided into groups and designed sensor taps with the Arduino sets they offered (Figure 4).

Figure 3: Harezmi classroom bazaar activity

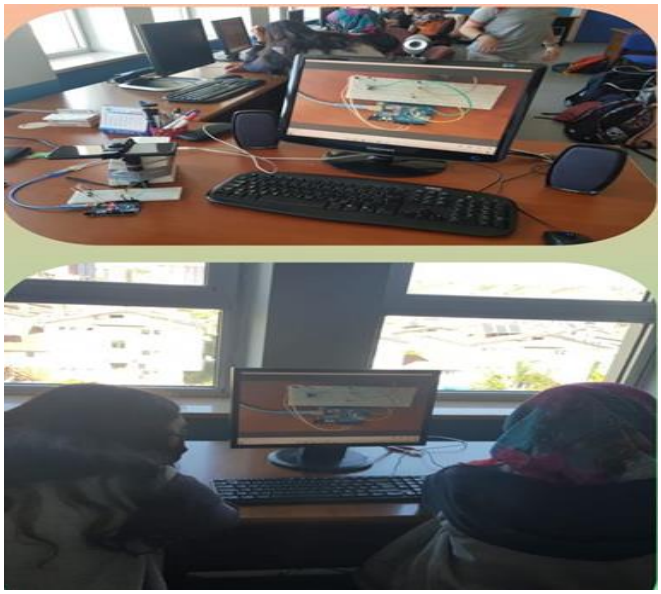


Figure 4: Arduino coding activity

2.5 Data Analysis

The quantitative data of the research were obtained from the data collected through the academic achievement test. Tests and normality assumptions were made with the SPSS program. First, to determine which tests to use, whether the data conformed to normal distribution was checked. Since the sample size was less than 50 in the study, Shapiro and Wilk (1965) test results were used.

3. Findings

The findings of the study are presented in this part of the study based on the research question. Before examining the students' academic achievement, normality test was applied. Test results regarding the AAT difference scores of the study group are given in Table 6.

Table 6: The AAT normality test results

AAT	N	Min.	Max.	$\bar{X}$	Sd	*p*
Difference scores (Pre-test/post-test)	19	1	10	6.211	2.573	.110

p> .05

According to Table 6, it is seen that the distribution of AAT difference scores follows the normal distribution. Therefore, it was deemed appropriate to use the paired sample t-test (PSTT), one of the parametric tests, to analyze the data obtained from AAT.

The ABT prepared by the researchers was applied to 19 students in the study group as a pre-test in the first week of the 10-week HEM application and as a post-test after the application was completed. The difference scores of the pre-test results before the application to the study group and the post-test results after the application were analyzed with PSTT after checking the normality distributions. The analysis results are presented in Table 7.

Table 7: Results obtained from AAT

Test	N	$\bar{X}$	Sd	df	t	*p*	Cohen *d*
Pre-test	19	5.947	1.747	18	-10.552	.000	2.421
Post-test	19	12.158	2.986				

$p < .05$

According to Table 7, the analysis results show that there is a statistically significant difference between the students' academic achievement pre-test scores and post-test scores ($t(18) = -10.552$, $p < .05$). This result shows that students increased their academic achievement compared to the pre-test. Effect size value for dependent samples;

$Cohen\ d = \frac{t}{\sqrt{n}}$ (t: t value for conditional models; n: number of students),

it was calculated using the formula. According to Cohen (1988), it changes as d=0.20 is a low level, d=0.50 is moderate, and d=0.80 is a significant level. Accordingly, d was calculated as 2.421. Since $d > .80$, the pre-test and post-test differed significantly in favor of the post-test.

4. Conclusion, Discussion and Recommendations

Looking at the research findings, it was seen that the academic achievement scores of the students increased as a result of the interdisciplinary activities given in the mathematics, science, Turkish, English, and information technology courses within the scope of the HEM, by establishing a 5-ground relationship. There is no other study in the literature examining the effect of HEM on students' academic achievement in science teaching. However, for this study, further studies examining different problem-based and project-based education approaches enriched and differentiated with other methods similar to HEM and STEM education were reviewed, and it was concluded that the results were consistent.

In line with HEM's practices, the achievement test prepared to determine the change in the academic achievements of secondary school 5th and 6th-grade students in teaching subjects such as environmental pollution, water pollution, air pollution, global warming, energy consumption, fossil fuels, solar energy and water use in science course. It was applied as a pre-test. After the 10-week application, the same achievement test was involved again as a post-test, and the score difference was determined. According to these results, it was determined that there was a significant difference in favor of the post-test between the pre-test and post-test scores of the students in the study group. In other words, it was concluded that HEM used in teaching relevant science course subjects effectively increased student achievement.

Although there are no studies on science lesson in the literature, studies indicate that they improve student achievement in social studies courses (Tokmak, 2022). Tokmak et al. (2022) found a significant difference in their students' algorithm subdimension scores because of their study titled "the effect of the HEM on the cognitive thinking skills of secondary school students." In the study Arslan-Namli and Aybek (2022) conducted with 5th-grade students in the context of the effect of block-based programming, the achievement of computational thinking skills, self-efficacy, and computer science teaching activities without computers in academic subjects is similar to this study in which HEM designed science teaching was carried out. Tokmak et al. (2023), in their research titled using an alternative model in the social studies course: Harezmi Education Model, found that the HEM used in

teaching the social studies course had a significant and positive effect on the academic achievement of 7th-grade students. In their research, Yavuz et al. (2019*b*) found that students' creativity scores increased within the scope of the HEM.

In the HEM, the process carried out in collaboration with different disciplines around a problem situation or problem scenario offers students an activity or activity and a design-based learning environment where they can learn by doing and experiencing. The most crucial point distinguishing the model from other methods and techniques is that more than one teacher from different disciplines acts together throughout the application. It is thought that working with more than one teacher from other fields to evaluate different ideas and discuss the subject in depth is effective in students' positive evaluation of the process.

The results of similar studies conducted in the literature also support these research results. Çimşir et al. (2022) stated in their study that HEM improved students' problem-solving, using Web 2.0 tools and collaborative working skills. Ceylan et al. (2020), in their research titled determining students' metaphorical perceptions towards HEM, the most used metaphor by students regarding HEM is that HEM is a source of information. However, HEM has often been associated with life and evaluated as a model in which problem-solving solutions can be produced and learned by doing and experiencing.

4.1 Recommendations

Based on the results of the present study, suggestions for further studies can be listed as follows:

- Similar to this study, a quantitative or mixed method patterned study can be conducted to investigate the effect of a different application process on students' problem-solving skills.
- The research can be done by including a control group.
- Teachers can develop and implement current lesson activities according to HEM.
- Studies can be conducted investigating the effects of HEM application processes on different skills.

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Informed Consent Statement/Ethics approval: All of the participants volunteered to participate in the study. The ethical principles and rules were followed in the research's planning, data collection, analysis, and reporting stages. All rules included in the "Directive for Scientific Research and Publication Ethics in Higher Education Institutions" have been adhered to, and none of the "Actions Contrary to Scientific Research and Publication Ethics" included in the second section of the Directive have been implemented. The research design, data collection and research instruments were approved by the Kastamonu University Social and Human Sciences Research and Publication Ethics Committee with the decision dated April 12, 2022, and numbered 4/20.

Data Availability Statement: The data can be obtained from the corresponding author upon request.

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Appendix A

Week 1

In the first week of the application, students were given information about HEM and Harezmi, which is the reference point of the model. Introductory games were organized for students from different branches and classroom to get to know each other. Questions were asked to learn the students' prior knowledge about the concept of "algorithm," which is one of the concepts that make up the logic of HEM, and their ability was determined. Later, to understand the concept, the information technologies teacher used various materials to perform the "Wolf, lamb, and grass" activity

Wolf, lamb, and grass activity

First, the students were asked "What is the problem?" to brainstorm. They were asked to come to classroom by observing their environment or researching the situations they saw as problems in the next week and noting the conditions they saw as problems.

Week 3

In this week of the application, the cup tower game was played as "a warm-up activity".

Warm-up activity

This activity aims to develop students' ability to think analytically and look from different perspectives. Presentations were made on the problems identified the previous week. Then, a selection environment was created to determine the problem to be worked on, and voting was held. The PfL sentence selected due to the vote has been defined as "The effects of water waste on global warming and the dangers awaiting our world." The chosen problem was written on the board, divided into sub-problems using the fishbone technique, and a cause-effect diagram was created. At the end of the lesson, students were allowed to brainstorm about the PfL sentence and its solutions.

PfL Sentence voting and deepening in PfL sentence

Week 4

In this week of the research, brain games and Resfebe were played as a warm-up activity.

Brain games and resfebe were played as a warm-up activity

Groups were formed for the actions, and students could work collaboratively. The school logo was designed to help them reinforce what they learned in the Canva application. Drama activities related to the specified PfL sentence and story creation activities with the PfLsentence were carried out.

Week 5

The slogan related to the PfL sentence was determined. Students researched concepts such as climate change, greenhouse effect, fossil fuel, water crisis, water footprint, water-poor, and water-rich, and prepared presentations to delve deeper into these subjects. The science teacher presented the issues, reinforcing the concepts by playing the Kahoot.

Research activity by students

Week 6

In this week of the research, a logo design was made in Canva regarding the slogan determined the previous week. The information technologies teacher informed the students about reading the water meter to see how vital water waste is in our lives. Data regarding water waste in our homes through various activities has been determined. The mathematics teacher and the students analyzed these data together and showed the results with graphs. Students designed a poster containing these results and suggested solutions to prevent water waste.

Zero waste poster design activity

Students hung warning signs with striking and exciting information on the sinks to minimize water waste at school. Students in Canva designed these signs. It was decided to build a representative sensor tap for the following week.

Week 8

The Harezmi clasroom visited the water treatment facilities and was briefed by the chemical engineer on duty.

Water treatment plant tour activity

Students were informed about the subjects they were curious about by asking about the issues they wanted to learn. In addition, to determine the water consumption habits of our school's parents, a survey created in Google Forms with questions determined by Harezmi classroom students and teachers were shared with our school parent groups.

Week 9

In cooperation with the "Protect Kastamonu Water Platform" organized by Kastamonu Governorship, the Harezmi classroom was invited to their schools. This platform gave a seminar on "water" to the school's students and parents and showed them the "25 liters documentary" they had prepared.

Water seminar and 25 liters documentary

In addition, the Harezmi classroom organized a competition to inform all their friends at school about the problems they identified and to find solutions. In this competition, the subject of which was "waste of water," the students were asked to write poems and draw pictures under the coordination of the Turkish teacher, and the winners were given awards. In this way, all students in the school where the Harezmi classroom is located were aware of "water waste."

Week 10

As mentioned in other weeks, a concept planned to be taught every week was led by science, mathematics, Turkish, English, and information technology teachers with student-centered activities based on HEM. All activities carried out by the Harezmi classroom were exhibited at the The Scientific and Technological Research Council of Türkiye (TUBITAK) science fair of the relevant school. Harezmi classroom students and teachers jointly evaluated the survey results sent to the parents of the students in the appropriate school via "Google Forms," the students were asked to design infographics and brochures in Canva. In the 10th and last weeks of the research, AAT and SSIF were administered to the students as post-tests.