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The Effect of Harezmi Education Model on the Computational Thinking Skills of Secondary School Students*

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Abstract
This study aims to investigate the effect of using the Harezmi education model, which has been widely used in Turkey in recent years, in social studies teaching regarding computational thinking skills. Interviews were held with students and teachers seven months after the applications to determine the conceptual knowledge levels of students for computational thinking skills. Teachers' opinions regarding students' feedback and the changes they observed in the students involved in the application process during the seven months were taken. Besides using one of the mixed-method research designs in this study, that is the triangulation (parallel-convergent) design, quantitative and qualitative data collection tools were used simultaneously. Through the joint use of different methods and data collection tools, obtaining rich and various types of data sets was aimed. As for the quantitative dimension of the study, 54 students, which were divided into experimental and control groups, formed the study group. In the qualitative aspect of the study, there are 20 students and three teachers. The computational thinking self-efficacy perception scale was used as a quantitative data collection tool, and the interview forms were used as qualitative data collection tools. While the analysis of quantitative data was made with Wilcoxon signed rank and Mann-Whitney U tests, the analysis of qualitative data was made with content analysis and descriptive analysis methods. As a result, a significant difference was found in the experimental group students' algorithm sub-dimension scores. According to the interviews held seven months after the applications, students' conceptual knowledge was at a good level. Furthermore, teachers included in the application stated that they observed positive changes in the students after the application. In line with the results obtained, suggestions were made to make arrangements for other sub-dimensions of computational thinking skills and to examine the effects of the Harezmi education model as of different variables.

Keywords: Social Studies Teaching, Harezmi Education Model, Computational Thinking, Alternative Education

1. Introduction

* This study is derived from a part of the study named "The Application of the Harezmi Education Model in Social Studies Lesson" prepared at Marmara University Institute of Educational Sciences, Department of Social Studies Education. The study was carried out by Ahmet Tokmak. Advisors: Prof. Dr. Ali Yilmaz, Assoc. Dr. Mustafa Seker

Hence the changing needs of humanity, innovations and developments happen in different areas of our lives. One of the most affected areas of this change is education. Across the world, country policies regarding education are renovated in terms of needs. This change brings along the need to develop and use new educational models, methods and techniques in favour of education and teaching processes. STEM education, which emerged with the integration of computer science and technology into teaching, can be given as an example (Basham and Marino, 2013, p.8; Bryan, Tamara, Johnson, Roehring, 2016, p.23; Corlu, Capraro, 2014). This awareness realized with STEM education has contributed to the emergence of the Harezmi education model as a new education model in Turkey.

The Harezmi education model aims to develop students' high-order thinking skills such as critical thinking, original thinking and problem solving; Enable students to acquire media literacy and information and communication skills; And equip students with features such as self-management, adaptation to teamwork, acting in cooperation, communicating, and showing leadership as part of basic life skills (MONE, 2021b).

The Harezmi education model aims to gain the ability to solve a problem by using the steps of the scientific method. This problem can be a problem in life or any subject or issue within a subject area. In the solution process of this problem, which students and practitioner teachers decide together, five grounds that form the soul of the Harezmi education model should be considered. The solution process should be planned relatedly with the five main grounds (interdisciplinary approach, computational thinking, programming, robotics and game design, and life skills) and with the participation of at least three different discipline teachers. Teachers from various disciplines, such as science-mathematics, social sciences and information technologies, take part in the process (Altınöz et al., 2018). They have equal roles in this process and act together in the design and evaluation processes. In this model, education is based on a process that is carried out by the action of different disciplines due to the five grounds and the nature of the model. The achievements and skills obtained during the solution process of the problem are evaluated with an output, if possible. This process, which is carried out with the coupling of different disciplines, allows students to think multi-dimensionally and use their knowledge and skills in various fields completely. Here, students are also expected to develop their higher-order thinking skills (Koçoğlu, 2018).

The process consists of the teachers' lesson designs and the intertwined planning of topics and diverse disciplines. Thus, students can develop their mathematics skills in a subject related to social sciences or their technology skills in a topic related to mathematics-science (MONE, 2021a; Çorlu, 2016).

In the Harezmi education model, one of the practising principles determined by referring to the five main grounds, which are the substructure of the model, is the use of computational thinking skills in the problem solving process (Ceylan et al., 2019). Computational thinking skill, which appears in the literature as the concept of "computational thinking", is also referred to as computerese, informatical, calculative or computer thinking (Yıldırım, 2020, p.8). Computational thinking can be described as solving the problems encountered with a systematic planning or design by clearly handling the information processing processes. It refers to a process. In other words, it is a range of thinking and formulation in solutions to be determined for the problems encountered. (Wing, 2011; Kert, 2016, p.24). Also, it can be expressed as creating strategies through the use of different technological tools to solve problems (Allsop, 2016, p.15; CSTA, 2017). Moreover, it can be enhanced with coding activities (Üzümcü and Bay, 2018).

When the literature is reviewed, it is possible to come across studies examining the effects of different methods and techniques on the development of computational thinking skills. According to the study of Alsancak Sırakaya (2019) on the effect of programming teaching on computational thinking skills, a significant increase was determined in students' computational thinking skills at the end of the teaching process carried out with the programming fundamentals course. In the study conducted by Atman Uslu (2018), the effects of visual programming activities on the computational thinking skills of secondary school students were positive; Hence students' awareness of computer science increased. As per another study by Korkmaz and Oluk (2018), in which the effects of the Scratch application on students regarding algorithm and computational thinking were investigated, a significant positive contribution was made to the computational thinking skills of the student group included in the application. Kaya, Korkmaz, and Çakır (2020), in their study examining the effects of gamified robot activities on secondary school students' problem solving and computational thinking skills, concluded that educational robot activities had a positive impact on students' computational thinking skills. In another study, Tutulmaz (2019), with his data visualization, design, application, and evaluation study for the development of computational thinking skills, stated that the practices contributed positively to the development of computational thinking skills.

In terms of developing computational thinking skills, different methods and technical applications carried out within various disciplines usually contribute positively to CTS. When the grounds that form the basis of the Harezmi education model are examined, it is clear that the model includes interdisciplinary studies, programming, algorithm studies, and data visualization studies used in the literature for the development of CTS. In this respect, the effect of the in-class activities carried out in the social studies course, which is present currently at the topic named "Science, Technology and Society", designed following the principles of the Harezmi education model was a matter of curiosity, and formed the primary motivation of the study. The six problems determined for the aim of the study are as follows:

1. How does the Harezmi education model affect students' computational thinking skills?
2. What is the conceptual knowledge level of the students regarding their computational thinking skills seven months after the application?
3. What are the views of the science, information technologies and visual arts teacher involved in the process seven months after the application?

2. Methods

This study was conducted according to mixed-method principles. This method consists of the collection of data with qualitative and quantitative data collection tools, the analysis process of the collected data, and the integration of the obtained information and results (Cresswell and Plano Clark, 2007). With this method, there is a potential to deal with the quantitative and qualitative aspects of the problems encountered separately. Thus, it is possible to understand the solution to the problem and the process of finding the truth in a rich and holistic framework (Yıldırım and Şimşek, 2016, p.323). Besides using one of the mixed-method research designs in this study, that is the triangulation (parallel-convergent) design, quantitative and qualitative data collection tools were used simultaneously. In the quantitative dimension of the study, a quasi-experimental design including pretest-posttest control groups was used. On the other hand, the case study design was used in the qualitative dimension of the study. With the joint use of different methods and data collection tools, obtaining rich and various types of data sets is aimed. Based on the predictions, the weaknesses of the qualitative or quantitative methods used in the study will be compensated by the strengths of another method.

2.1 Study Group

The implementation process of the study was carried out with 54 secondary school 7th-grade students in a public school in Izmir, Turkey, in the 2021-2022 academic year. Three teachers, including science, information technologies and visual arts teachers from other disciplines, were included in the implementation process of the study. The convenience sampling method was used to determine the students and teachers who participated in the study. Two study groups, experimental and control groups, were generated among the classes in which the researcher was working as a teacher, and the science, visual arts and information technology teachers of these classes were included in the study.

Table 1: Study Group

Groups	Class / Field	Male	Female	Total
Students Control Group	Class K	13	14	27
Students Experimental Group	Class I	15	12	27
Teachers Group	Social Studies Teacher (Researcher)	1	0	4
	Science Teacher	0	1	
	Information Technologies Teacher (ICT)	1	0	
	Visual Arts Teacher	1	1	

2.2 Data Collection Tools and Data Analysis

Two types of data collection tools were used for the quantitative and qualitative dimensions of the study. The "Self-efficacy perception scale for computational thinking skills" by Gülbahar, Kert, and Kalelioğlu (2019) was used to determine the computational thinking skills of the students. The scale, which was applied as a pre-test and post-test, was designed in a five-factor structure with 39 items. During the validation of the model, three items were excluded from the scale with the confirmatory factor analysis; Hence the final form was given with 36 items. The item-total correlation values of the scale were measured between 0.632 and 0.386. Cronbach's alpha coefficients were found to vary between 0.762 and 0.930 points. Accordingly, the differences between the items were significant based on the measurement results made by the t-test and the lower-upper group method.

In the qualitative dimension of the study, teachers' opinions on the application process were taken both at the end of the process and nine months after the application. A semi-structured interview form was used to collect teachers' opinions. As part of the purpose of the form, teachers were asked about their views on student observations regarding the effect of the process. In the interviews with the students nine months after the application, the interview form developed by the researcher was used. Regarding the student interview form, it was aimed to determine what students remember about the concepts related to computational thinking skills and questions were asked about what they remember about the application process.

The analysis of the quantitative data was conducted with the SPSS statistics software. The Wilcoxon signed-rank and Mann-Whitney U tests were used in the analysis of the data obtained to determine the change experienced by students in their computational thinking skills. The analysis of the data obtained from the students and teachers through the interview forms was carried out with content analysis and descriptive analysis methods.

2.3 Implementation Process

During the study process, seven activities were carried out in the experimental group. Science, information technologies and visual arts teachers were involved in the implementation process together with the researcher teacher in the activities determined in line with the target acquisitions of science, technology and society learning area. Regarding the experimental group, seven-week activities were carried out, including puzzle design with a puzzle maker, scientists visualization, infographic preparation, ink-making experiment, water clock experiment, steam turbine experiment, and thought jars. As for the control group, education was carried out in the field of science, technology and society learning in line with the annual plan determined by the decision of the group teachers' board.

3. Results

In this part, the results related to the sub-problems determined as per the aim of the study are given.

3.1 Results Related to the Effect of Harezmi Education Model on Students' Computational Thinking Skills

The data and analysis results of the scale, which was applied to the experimental group and the control group twice (before and after the application), were handled under three independent headings that are the results of the experimental group, the results of the control group, and the statistics regarding the comparison of the experimental group and the control group.

3.1.2. Results Regarding the Experimental Group

The descriptive data of the scale were handled separately including five sections that make up the scale. Also given gregariously under the title of Computational Thinking Skill. In addition, statistical information of the sections and the total scale statistics are shown in Table 2 as a whole.

Table 2: Descriptive Statistics of the Experimental Group

Scale/Test	**Test Period**	**n**	**Min.**	**Max.**	$\bar{X}$	**SD**	**S.**	**K.**

Algorithm Design Competence	Pre-test	27	1	27	13,52	4,73	0,65	-0,47
	Post-test	27	1	27	23,11	3,08	-0,83	-0,21
Problem Solving Competence	Pre-test	27	1	30	24,70	3,27	-0,56	-0,39
	Post-test	27	1	30	25,93	3,05	-0,67	-0,20
Data Processing Competence	Pre-test	27	1	21	15,00	3,65	-0,51	0,27
	Post-test	27	1	21	17,89	2,65	-1,10	1,68
Basic Programming Competence	Pre-test	27	1	15	9,26	2,35	0,20	-0,47
	Post-test	27	1	15	11,19	3,16	-0,41	-0,80
Self Confidence Competence	Pre-test	27	1	15	11,78	2,31	-0,66	0,32
	Post-test	27	1	15	12,89	1,95	-0,37	-1,15
COMPUTATIONAL THINKING SKILL	Pre-test	27	1	108	74,26	10,15	0,14	0,22
	Post-test	27	1	108	91,00	11,93	-0,70	-0,21

The computational thinking skills total score of the experimental group in the pre-test was determined as 74.26±10.15 and in the post-test as 91.00±11.93.

After the 7-week Harezmi education model-based activities carried out with the experimental group, the self-efficacy perception scale regarding computational thinking skills was reapplied. The Wilcoxon signed-rank test was used to determine which tests differed between pre-test and post-test measurements. Table 3 shows the analysis of the comparison of test scores.

Table 3: The Comparison of Experimental Group's Pre-Test and Post-Test Scores

Scale/Test		**n**	**Rank Avg.**	**Rank Sum**	**Z**	**p**
Algorithm Design Competence Post-Test-Pre-Test	Negative Ranks	0	0,00	0,00	-4,54	**0,000**
	Positive Ranks	27	14,00	378,00		
	Equality	0				
	Total	27				
Problem Solving Competence Post-Test-Pre-Test	Negative Ranks	6	11,67	70,00	-2,08	**0,037**
	Positive Ranks	17	12,12	206,00		
	Equality	4				
	Total	27				
Data Processing Competence Post-Test-Pre-Test	Negative Ranks	5	7,20	36,00	-3,11	**0,002**
	Positive Ranks	18	13,33	240,00		
	Equality	4				
	Total	27				
Basic Programming Competence Post-Test-Pre-Test	Negative Ranks	7	12,57	88,00	-2,01	**0,044**
	Positive Ranks	18	13,17	237,00		
	Equality	2				
	Total	27				

Self Confidence Competence Post-Test-Pre-Test	Negative Ranks	6	9,08	54,50	-2,14	**0,032**
	Positive Ranks	15	11,77	176,50		
	Equality	6				
	Total	27				
COMPUTATIONAL THINKING SKILL Post-Test-Pre-Test	Negative Ranks	2	8,00	16,00	-4,16	**0,000**
	Positive Ranks	25	14,48	362,00		
	Equality	0				
	Total	27				

Accordingly, there is a significant difference between the post-test and pre-test scores of the experimental group regarding algorithm design competence ($Z=-4.54$; $p<0.05$), problem solving competence ($Z=-2.08$; $p<0.05$), data processing competence ($Z=-3.11$; $p<0.05$), basic programming competence ($Z=-2.01$; $p<0.05$), self confidence competence ($Z=-2.32$; $p<0.05$), and computational thinking skills ($Z=-4,16$; $p<0.05$). As to the Wilcoxon signed-rank test results;

- After the application of the Harezmi education model, the algorithm design competence score of all the students increased, which means the model has a positive and significant effect on students' ability to design algorithms.
- After the application of the Harezmi education model, the problem solving competence scores of 17 students increased, six students decreased, and the scores of four students did not change. To conclude, the model has a positive and significant effect on student's problem solving competence.
- Since the application of the Harezmi education model, the data processing competence scores of 18 students increased, five students decreased, and the scores of four students did not change. As a result, the Harezmi education model has a positive and significant effect on the data processing competence of the students.
- After the application of the Harezmi education model, the data processing competence scores of 18 students increased, five students decreased, and the scores of four students did not change. As a result, the Harezmi education model has a positive and significant effect on the data processing competence of the students.
- With the application of the Harezmi education model, the self-confidence competence scores of 15 students increased, six students decreased, and the scores of six students did not change. As a consequence, the Harezmi education model has a positive and significant effect on students' self-confidence competence.
- After the application of the Harezmi education model, the computational thinking skill score of 25 students increased and two students decreased. So, it is clear that the Harezmi education model has a positive and significant effect on students' computational thinking skills.

3.1.3. Results Regarding the Control Group

The Self-Efficacy Perception Scale for Computational Thinking Skills was applied to the control group twice, before and at the end of the education process, which was carried out within the framework of textbooks and reference books as per the annual acquisition plans of the Ministry of National Education. In addition, it was not planned based on the Harezmi education model or any alternative education model. Descriptive statistics for the control group are shown in Table 4.

Table 4: Descriptive Statistics of the Control Group

Scale/Test	**Test Period**	**n**	**Min.**	**Max.**	$\bar{X}$	**SD**	**S.**	**K.**
Algorithm Design Competence	Pre-test	27	1	27	15,44	5,00	0,47	-0,50
	Post-test	27	1	27	19,26	5,52	-0,24	-1,16
Problem Solving Competence	Pre-test	27	1	30	24,74	3,15	-1,51	2,78
	Post-test	27	1	30	26,48	2,83	-1,64	3,63

Data Processing Competence	Pre-test	27	1	21	16,04	3,37	-0,68	-0,64
	Post-test	27	1	21	17,22	3,60	-1,05	0,16
Basic Programming Competence	Pre-test	27	1	15	10,22	2,75	0,11	-1,17
	Post-test	27	1	15	11,11	3,34	-0,61	-1,11
Self Confidence Competence	Pre-test	27	1	15	12,26	2,41	-0,99	-0,02
	Post-test	27	1	15	13,04	1,87	-0,86	-0,52
COMPUTATIONAL THINKING SKILL	Pre-test	27	1	108	78,70	11,3	0,05	0,38
	Post-test	27	1	108	87,11	13,8	-0,78	-0,08

The computational thinking skills total score of the control group in the pre-test was determined as 78.70±11.93 and in the post-test score as 87.11±13.78. The average of the algorithm design competence was determined as 15.44 in the pre-test and 19.26 in the post-test, regarding problem-solving competence, it was 24.74 in the pre-test and 26.48 in the post-test, for data processing competence it was 16.04 in the pre-test and 17,22 in the post-test, as for the basic programming competence it as 10.22 in the pre-test and 11.11 in the post-test, and finally, for the self confidence competence, it was 12.26 in the pre-test and 13.04 in the post-test.

As per the tests applied according to the Friedman test results, significant differences were found in the sum of algorithm design, problem solving, data processing competencies and computational thinking skills. The Wilcoxon signed-rank test was used to determine which tests differed between pre-test and post-test measurements. The test results are given in Table 5.

Table 5: The Comparison of Control Group's Pre-Test and Post-Test Scores

Scale/Test		**n**	**Rank Avg.**	**Rank Sum**	**Z**	**p**
Algorithm Design Competence Post-Test-Pre-Test	Negative Ranks	7	10,93	76,50	-2,52	**0,012**
	Positive Ranks	19	14,45	274,50		
	Equality	1				
	Total	27				
Problem Solving Competence Post-Test-Pre-Test	Negative Ranks	5	11,70	58,50	-2,22	**0,026**
	Positive Ranks	17	11,44	194,50		
	Equality	5				
	Total	27				
Data Processing Competence Post-Test-Pre-Test	Negative Ranks	6	10,17	61,00	-2,18	**0,029**
	Positive Ranks	16	12,00	192,00		
	Equality	5				
	Total	27				
Basic Programming Competence Post-Test-Pre-Test	Negative Ranks	8	10,06	80,50	-1,22	0,222
	Positive Ranks	13	11,58	150,50		
	Equality	6				
	Total	27				
Self Confidence Competence Post-Test-Pre-Test	Negative Ranks	10	7,90	79,00	-1,27	0,203
	Positive Ranks	11	13,82	152,00		
	Equality	6				

	Total	27				
COMPUTATIONAL THINKING SKILL Post-Test-Pre-Test	Negative Ranks	4	17,00	68,00	-2,73	**0,006**
	Positive Ranks	22	12,86	283,00		
	Equality	1				
	Total	27				

Accordingly, there was no significant difference between the post-test-pre-test scores of the control group's basic programming competence and self-confidence competence (p>0.05); Yet, there were significant differences between the post-test and pre-test scores of the control group's algorithm design competence (Z=-2.52; p<0.05), problem solving competence (Z=-2.22; p<0.05), data processing competence (Z=-2.18; p<0,05) and computational thinking skills (Z=-2.73; p<0.05).

According to the Wilcoxon signed-rank test results;

- At the end of the teaching process in the control group, while the algorithm design competence score of 19 students increased, the score of seven students decreased, and in one student, the score did not change. As a result, the education given in line with the current Ministry of Education textbooks and plans has a positive and significant effect on the student's ability to design algorithms.
- At the end of the teaching process in the control group, the problem solving competence score of 16 students increased, the score of six students decreased, and the score of five students did not change. As a result, the education given in line with the current Ministry of Education textbooks and plans has a positive and significant effect on the problem solving competence of the students.
- While the data processing competence scores of 16 students increased, the scores of six students decreased, and five students' scores did not change. As a result, the education given in line with the current Ministry of Education textbooks and plans has a positive and significant effect on the data processing competence of the students.
- At the end of the teaching process of the control group, the computational thinking skill score of 22 students increased, the scores of four students decreased, and only one student's score remained unchanged.

In conclusion, the education given in line with the current Ministry of Education textbooks and plans has a positive and significant effect on students' computational thinking skills in certain areas.

3.1.4 Results Regarding the Comparison of Experimental and Control Groups

The Mann-Whitney U test was used to determine whether there were significant differences between the pre-tests applied to the groups before the Science, Technology and Society learning courses, which will be taught with different methods in the experimental group and the control group.

The results of the comparison of the pre-test scores of the experimental and control groups directed to the Mann-Whitney U test are given in Table 6.

Table 6: The Comparison of Pre-Test Scores of Experimental and Control Groups

Scale/Test	**Groups**	**N**	**Rank Avg.**	**Rank Sum**	**MWU**	**Z**	**p**
Algorithm Design Competence	Experimental	27	24,06	649,50	271,50	-1,63	0,103
	Control	27	30,94	835,50			
Problem Solving Competence	Experimental	27	27,28	736,50	358,50	-0,10	0,917
	Control	27	27,72	748,50			
Data Processing Competence	Experimental	27	25,04	676,00	298,00	-1,16	0,248

	Control	27	29,96	809,00			
Basic Programming Competence	Experimental	27	25,00	675,00	297,00	-1,18	0,239
	Control	27	30,00	810,00			
Self Confidence Competence	Experimental	27	25,33	684,00	306,00	-1,02	0,305
	Control	27	29,67	801,00			
COMPUTATIONAL THINKING SKILL	Experimental	27	24,09	650,50	272,50	-1,59	0,111
	Control	27	30,91	834,50			

As per the pre-test results of the experimental and control groups according to the MWU test, the rate of algorithm design competence was determined as p=0.103, the problem-solving competence as p=0.917, the data processing competence as p=0.248, the basic programming competence as p=0.239, and the self-confidence competence as p=0.305. Also, no significant difference was found in the calculations regarding the sub-dimensions of the scale and total (p>0.05).

Following the pre-tests of the experimental and control groups, a 7-week application process was conducted. This process was carried out in an interdisciplinary manner with a program planned within the framework of the Harezmi education model in the experimental group; However, in the control group, the teaching process was retained based on the curriculum and books of the Ministry of National Education.

At the end of the application process, CTSPS (Computational thinking self-perception scale) was applied to both groups as a post-test, and the results were subjected to the Mann-Whitney U test. Information about the test results is given in Table 7.

Table 7: The Comparison of Post-Test Scores of Experimental and Control Groups

Scale/Test	**Groups**	**N**	**Rank Avg.**	**Rank Sum**	**MWU**	**Z**	**p**
Algorithm Design Competence	Experimental	27	32,93	889,00	218,00	-2,55	**0,011**
	Control	27	22,07	596,00			
Problem Solving Competence	Experimental	27	25,83	697,50	319,50	-0,79	0,432
	Control	27	29,17	787,50			
Data Processing Competence	Experimental	27	28,19	761,00	346,00	-0,32	0,747
	Control	27	26,81	724,00			
Basic Programming Competence	Experimental	27	27,69	747,50	359,50	-0,09	0,931
	Control	27	27,31	737,50			
Self Confidence Competence	Experimental	27	27,20	734,50	356,50	-0,14	0,888
	Control	27	27,80	750,50			
COMPUTATIONAL THINKING SKILL	Experimental	27	29,70	802,00	305,00	-1,03	0,303
	Control	27	25,30	683,00			

Consequently, the algorithm design competence scores of the experimental and control groups in the post-test differed significantly (Z=-2.55; p<0.05). In addition to that, the experimental group's algorithm design competence score in the post-test was notably higher than the control group's post-test scores. As a result, the algorithm design competence of the students studying with the Harezmi education model is remarkably better than the algorithm design competence of the students in the control group.

As per the determinations, the post-test problem solving, data processing, basic programming, and self-confidence competence scores and the post-test computational thinking skills scores of the experimental and control groups did not differ significantly (p>0.05).

3.2. Results Related to Students' Conceptual Knowledge Regarding Their Computational Thinking Skills

The seven-week application process, which was designed with the Harezmi education model regarding social studies teaching, was completed on April 22 in the 2021-2022 academic year. Interviews were held after the application to determine the permanence of students' conceptual knowledge in the context of computational thinking. Out of 27 students who were included in the application of the Harezmi education model in the 2021-2022 academic year, four students were not included in the interviews because they changed schools in the 2022-2023 academic year, and three students due to their absenteeism. Because of the decision of the school administration, classes are organized compositely at the beginning of each new academic year. For this reason, three different group interviews were conducted with the students at different times.
In the interviews with the students, the following questions were asked;

- What does algorithm mean?
- Can you give an example of an algorithm?
- What does problem solving mean to you?
- What does error mean?
- What does data mean? What does it mean to you?
- Can you give examples of data types?
- What would you like to say about programming?
- What does loop mean?

As per the results of the interviews with 20 students regarding the conceptual recall of students' computational thinking skills, the students produced 96 significant answers. Their answers were coded and themed by the content analysis method. Information regarding the themes, codings and frequencies are given in Table 8.

Table 8: Results Related to Students' Conceptual Recall

Topic	**Theme**	**Codings**	**Frequency**	**Total Significant Frequency**
Algorithm	Solution	Way	2	16
		Step by step	3	
		Process	4	
		Water clock	2	
		Stage	5	
		No significant answer	4	
Problem Solving	Succeed	Overcome	2	20
		Recognize	4	
		Battle	4	
		Finding the barrier to operability	3	
		Existence of the problem	2	
		Problem status	5	
Error	Problem	Mistake	2	15
		Deficiency	4	
		Problem	6	
		Failure	3	

Data	Information	Assembled	3	19
		Verbal data	2	
		Written data	2	
		Mathematical data	4	
		Source	3	
		Digital data	4	
		Information	1	
		No significant answer	1	
Programming	Tool	Computer	4	16
		Coding	5	
		Programming	3	
		A different language	2	
		Engineering	2	
		No significant answer	5	
Loop	Process	Start over	4	10
		Recycling	2	
		Programming	4	
		No significant answer	10	
TOTAL			116	96

Some answers given by the students are;

-.ST1:..... I remember the pasta cooking algorithm, I always call it up...

-ST2:.... I remind myself of the water clock experiment...

-ST3:..... I remember it as doing something in a certain logical order. All material at our disposal may be complete. But it is important that we use it in the right order. That's how Algorithm stuck in my mind...

-ST4: When I think about problem-solving, I recognize it as solving a problem in life...

-ST5:... I think of solving the problem and succeeding. In other words, when I hear the word problem, I think of topics related to the solution rather than the existence of the problem. I want to find a way around it...

-ST6:... The thing that is preventing something from working...So there must be a problem...The effort or struggle to solve it...

-ST7:...I think problem solving requires an aim...

-ST8:... Now I know what data is. Because we use that word a lot in informatics class or something...

-ST9:...it can be of different types...verbal, mathematical...

-ST10:...Programming is also a language. It has spelling and pronunciation, like music notes...

-ST11:... Software engineering comes to my mind when I think of programming. It is very simple. You make a program for what you want to do. The codes will work if the program is correctly written, like Arduino.

3.3. Results Regarding Teachers' Opinions

The science, visual arts and information technology teachers were also involved in the 7-week application process carried out in the 2021-2022 academic year within the scope of the HEM-based social studies teaching course, together with the researcher-social studies teacher. Interviews were held to determine what the teachers remembered about the application seven months after and the feedback they received from the students included in the application. During the interviews, the following questions were asked to the teachers;

- What do you remember about the Harezmi education model we implemented last year? What would you like to say?
- Have you heard anything from the students about the application made last year in the new academic year?
- Do you think that the Harezmi education model made a change in students?
- Would you like to be involved in such a study again? Why?

The data obtained through the interviews with the science, visual arts, and information technologies teachers and the investigative social studies teacher were analyzed by the content analysis method. As a result of the analysis, the codings and themes were created, and the frequencies were determined. The results obtained by data analysis are given in Table 9.

Table 9: Results on Teachers' Opinions

Topic	**Theme**	**Codings**	**Frequency**	**Total**
Harezmi Education Model	Interdisciplinarity	Different Disciplines	4	17
		Collaboration	4	
		Cooperation	4	
		STEM education	2	
		Problems in Life	2	
		Experiment	1	
Student Feedback	Activity	Willingness to work	4	10
		Tribute to the application	4	
		Student-teacher relationship	2	
Change in Students	Concretization	Arduino	2	11
		Scratch	2	
		Visualization of data	1	
		Experimental assignment	2	
		Scientific self-confidence	4	
The New Harezmi Education Model Application	Motivation	Efficacy	4	20
		Usefulness	2	
		Culture of collaboration	3	
		Reproduction of information	3	
		Learning culture	4	
		Problem-solving skill	3	

The initials of the course names were given as pseudonyms in the answers of the teachers (Science teacher - ST, Visual arts teacher - VAT, Information technologies teacher - ITT). Some of the answers of the teacher are as follows;

VAT: ... I got to know the Harezmi education model fully through the work we did last year. I said it last year. I strongly believe in the motivation created by unity. And the practice we did last year that I saw touched students' hearts. Interdisciplinary work is what I remember most clearly about the model when we start to talk about it. Uniting around a solution to a problem...

ITT:... The application we made last year was both relevant and functional. I understood that better this year. The questions of the students who were in the Harezmi practice class last year are much more meaningful this year. Last year, we actually broke the ground. It's about programming and Arduino. However, our practices were mostly about general things, but I saw that awareness has emerged in children...

ST:.. Frankly, I remember that the application of the Harezmi education model was a beautiful but problematic process. I think the planning process was tiring. But some things stuck in children's minds. There was a student who said: "Algorithm is the importance of ordering" in one of the lectures the other day where we had some experimental activities. I said: "Well done!" and asked how he did paraphrase it like that. "Teacher, we learned the algorithm last year, you know, in the practice of Harezmi," he said. I was surprised. But children don't forget what they do willingly. I think the Harezmi education model gives this chance to children...

VAT:... Of course, some students often ask whether we can continue with the Harezmi education model and do an activity. Especially students who are good at painting ask this. Meanwhile, I think they see this model as an opportunity to show their talents....

ITT:... This year, we are working with the scratch application as part of the course. Some students still say, "Teacher, please invite our social studies teacher."...

ST:... Students began to ask for project assignments early this year, especially those who participated in the Harezmi practice last year. One of my students said: "If we determine a topic like the practice we did last year with 2 or 3 people. Each of us can take one part...". I said: "Okay". Let's see what comes out...

VAT:.. Teacher, of course, I would like to be a part of a new practice. It would be better if there were a few hours of work around a topic because a long application process makes it difficult...
ST:... Actually, I thought the same thing recently... I'm thinking of something to include the physical education teacher...

4. Discussion

In this study, in which social studies teaching was carried out in line with the principles of the Harezmi education model, the effects of the application on students were discussed from different perspectives. As a research question, it is aimed to investigate in which direction and in which sub-skills the change in students' computational thinking skills will take place. The Computational Thinking Self-Efficacy Perception scale was used to determine the change in students' computational thinking skills in the application process. The concept of computational thinking is considered one of the structures that are also known as the five grounds of the Harezmi education model and form the basis of the model. Although it has a diverse literature structure in terms of different definitions, studies and sub-dimensions, it is generally considered a skill that includes the sub-dimensions of abstraction, algorithmic thinking, problem solving, dissection, generalization, and error debugging (Üzümcü and Bay, 2018). The computational thinking skill appears in the Harezmi education model with the phrase "without using technology and computers" within five grounds. The aim here is to provide design planning for the use of CT skills in the problem solving process. The system created by computational thinking through the cycle of data collection, analysis, pattern finding, breaking down the problem, creating a model, preparing an algorithm, and producing a solution has similarities in terms of HEM (Harezmi Education Model) processes. In HEM, students are expected to collect data on the problematic situation they have determined, produce solutions by dividing the problem into parts, and draw a conclusion by creating and testing models in this process. In this respect, the social studies teaching course carried out with the Harezmi education model will have a positive effect on students' CT skills.

According to the study results, there were different levels of improvement in the CT skills sub-dimensions, jointly in the student group and the control group students, in which both social studies courses were HEM-designed. In addition to that, students in the experimental group made progress in all sub-dimensions of CT skills based on the pre-test results. As per the pre-test results of the control group students, this development was limited only to the sub-dimensions of algorithm design competence, problem solving competence, and data processing competence. In the evaluation made between the two groups, it was determined that the algorithm design competencies of the experimental group students, who had a HEM-designed teaching process, differed significantly compared to the results of the control group students. In this respect, HEM has a positive effect in terms of designing algorithms and creating patterns. No significant results were obtained in favour of the experimental group in other dimensions of computational thinking skills. With this in mind, planning a HEM-designed social studies course by considering only one dimension of the computational thinking skill would be more effective rather than considering CT skills as a whole. Although there is no study in the literature investigating the effects of HEM on CT skills, there are studies concerning CT skills.

Arslan Namlı's (2022) study with 5th-grade students in the context of the effect of block-based programming and computer-free computer science teaching activities on computational thinking skills, self-efficacy, and academic success shows similarities with this study in which HEM-designed social studies teaching was carried out, in terms of results. She tested the effect of the teaching activities carried out in her study using scales. And she concluded that there was no significant difference between groups in the results obtained from the CT achievement test, which was used to measure students' computational thinking skills, yet the groups showed an improvement in their CT skills. In addition, she stated as per the results of the CT self-efficacy scale that there was no significant difference between the groups regarding all CT skills; However, there were significant differences within the group and these differences were realized in terms of certain sub-dimensions which were logical inquiry, abstraction, decomposition and generalization. According to the results she obtained with the qualitative data collection tools, students improved themselves in algorithm, programming and coding compared to the pre-application. Also, the positive difference made by this study for certain sub-dimensions within the scope of CT skills is similar to the significant differences obtained only in certain dimensions by HEM-designed social studies teaching.

Bolat (2020) conducted a study with 10th-grade students to measure the effect of stem-based activities on students' problem solving and computational thinking skills and found that teaching activities made a significant difference for certain sub-dimensions regarding CT skills.

Yanış Kelleci (2020) investigated the effect of educational robotic applications in different dimensions in his study. According to his study, the experimental group students showed improvement within the scope of CT skills. However, when this positive change is evaluated in terms of the relevant sub-dimensions, it has created a significant difference in the sub-dimensions of algorithmic thinking, originality, and critical thinking. This difference was not reflected in the cooperative thinking and problem solving sub-dimensions. For this reason, when the studies discussed in the literature within the scope of the effect of different teaching activities and methods on CT skills are examined, the impact of HEM-based social studies teaching regarding CT skills is limited to sub-dimensions, and similar results are frequently encountered. The reason for this may be that the effects of the methods and teaching models used are limited to certain areas regarding CT skills, include comprehensive competencies, and need to be endorsed with a wide range of activities.

As per the results of the interviews conducted with the students seven months after the application process, students' conceptual knowledge status regarding computational thinking skills were at a good level. Based on the answers given to the questions about the concepts of algorithm, problem solving, error, data, programming, and loop, students produced 96 significant frequencies. The subjects in which the students generate the most meaningful frequencies are problem solving (20), data (19), programming (16) and algorithm (16). In addition, following the students' answers, they could still use their learning about the concepts within the scope of the Harezmi education model applications that were carried out seven months ago. One of the main underlying reasons for the excellent level of conceptual knowledge of the students on the subject can be shown as the fact that the students are in continuous learning about the existing concepts in the information technologies course. However, in the explanations made by the students together with this learning, they still made a positive impression about the permanence of the application process by taking the HEM model applications as a reference and giving examples. On the other hand, the opinions of other discipline teachers, who took part in the application process, about HEM seven months after its application, support the results obtained from the students. Teachers, who expressed that students' frequently desired to practice in the new academic year with HEM, stated that they thought the application also started a process of awareness and change in students. The same teachers, who stated that the model had positive effects on students in terms of gaining scientific self-confidence, also expressed that the model had positive results regarding cooperation, problem solving, and collaborative working culture for students. According to the study by Yıldırım and Selvi (2017), STEM applications have a positive effect on permanent learning. In the study by Akgündüz and Akpınar (2018), it was concluded that STEM applications are vital for the education of students in terms of gaining 21st-century skills and ensuring their permanence. Similarly, in the study conducted by Kıvanç Contuk and Atay (2021), the importance of the Harezmi education model, which has been implemented in our country, was emphasized in terms of student and teacher development and its positive effects on permanent learning was expressed. To conclude, the results of the Harezmi education model on permanent learning, in which students have the opportunity to learn by doing and experience and where it is possible to evaluate a problem or a discipline-specific issue within the framework of different disciplines, are favourable.

In line with the study results, suggestions can be made on the generalization of the use of the Harezmi education model, mentioning it in universities to strengthen its theoretical infrastructure, conducting studies to examine the effects of the Harezmi education model in terms of distinctive variables, conducting meta-analysis or phenomenological studies to determine its differences from the STEM education, and preparing Harezmi-designed lesson plans for the dimensions of computational thinking skills that did not get positive results in this study.

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