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Evaluation of Harezmi Education Model Applications According to Student Opinions: An Exploratory Sequential Mixed Design

Mine Çeliköz[1] Dilek Güven Hastürk[2]

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Harezmi Education Model (HEM), one of the applications based on an interdisciplinary approach, is an education model that allows students to develop 21st century skills such as algorithmic thinking, problem solving, and working in a team (MEB, 2021). Since 2016, HEM is an education model that integrates computer and science with social sciences, uses programming and teaching tools effectively, produces by having fun with robotics and game design, and constantly updates itself. In this research, it was tried to determine the opinions of students in secondary schools that implement HEM regarding HEM practices. The research using Mixed Research Method and Exploratory Sequential Design was conducted in three stages. The opinions of 9 students were consulted through the semi-structured student interview form prepared in the first stage, and the qualitative dimension of the research was carried out. Then, using the qualitative findings obtained, a scale was developed to determine student opinions regarding HEM practices. In the last stage, quantitative findings were obtained by applying the scale to 308 secondary school students, and based on this finding, it was tried to determine whether the qualitative findings were generalizable. As a result of the research, it was determined that the students' opinions about PEC applications were quite positive, and while their opinions were similar in terms of gender, their opinions differed in terms of school type and grade level. Students stated that although HEM applications had some shortcomings, they benefited from this training and were satisfied with the training they received. In their suggestions regarding HEM practices, students mostly stated that their scope, duration and comprehensiveness should be increased. In addition to these suggestions, some remedial suggestions were presented in the research.

Keywords: Harezmi Education Model, Interdisciplinary approach, Secondary school students

INTRODUCTION

Many philosophical movements have emerged from ancient Greek civilization to the present day. Holism, which means "bütünsellik" in Turkish, is one of these philosophical movements. According to Holism, the universe and human beings are a whole, both materially and spiritually (Miller, 2005). Aristotle describes this as “The whole is more than the sum of its parts” (Demir, 2015). The reflection of this movement in behavioral sciences emerged with Gestalt psychology in the second half of the 20th century. According to the Gestalt approach, learning occurs when parts come together to form a whole. This is because parts only gain meaning when they form a whole (Mungan, 2021). Knowledge acquisition begins with the perception of what is meaningful for the individual. Blending this knowledge with others and deriving new knowledge is possible through ensuring wholeness (Şimşek, 2008). Presenting knowledge holistically requires an interdisciplinary approach.

The concept of interdisciplinary refers to the integration of two or more academic disciplines or fields of study. Jacobs (1989) defines interdisciplinary approach as "a programmatic understanding that consciously harnesses the methods and knowledge of multiple disciplines for the examination of a concept, subject, problem, or experience" (cited in Yıldırım, 1996). Interdisciplinary approach acknowledges the richness of individual disciplines, their interconnectedness, and the recognition of that real-life problems may not always have a single correct answer (Perkins, 1994; cited in Özkök, 2005).

Nowadays, due to the rapid advancement of science and the subdivision of scientific disciplines, it is not possible to determine the boundaries of scientific knowledge and disciplines with precise lines. Therefore, collaborative studies resulting from the convergence of multiple disciplines are more common (Şahbaz & Çekici, 2012). For instance, the field of gastronomy, which is one of the most popular areas in recent times, can be associated with the art of culinary due to its ability to adapt dishes to evoke taste sensations, with the field of chemistry for examining and analyzing the composition and properties of food ingredients, and with the economics for seeking methods to procure the best products at the most economical prices. Additionally, as gastronomy includes everything edible and drinkable, it also comprises agriculture, commerce and industry (Samancı, 2020). In this context, it is possible to bring together and integrate various disciplines in the education process. For instance, interdisciplinary programs in education can be created by starting from the common points of disciplines such as history, geography, sociology, psychology and citizenship in the social sciences; biology, physics and chemistry in the natural sciences (Yıldırım, 1996). Furthermore, these disciplines can be integrated with areas such as technology and art. Each integrated discipline also directs educational programs and teaching processes (Demir, 2017; Şişman, 2012; cited in Özhamamcı, 2013). At this point, what needs to be taken into consideration is supporting a theme or subject, which is determined in the

[1] Yıldız Teknical University, mcelikoz25@gmail.com, orcid.org/ 0000-0003-1582-331X
[2] Ministry of Education, dilekguvenhasturk@gmail.com, orcid.org/0000-0002-6778-8678

interdisciplinary approach, by diverse perspectives, knowledge and skills, along with utilizing data as a whole that will reach the target from various aspects (Yıldırım, 1996).

Interdisciplinary approach has become an integral part of the education system in the recent years. There are two main reasons for this. First, the traditional structure based on a single discipline challenges the success of constructivist programs. Second, there is a need for individuals with high-level thinking skills who can address problems from multiple perspectives, apply what they have learned to real-life problems, and the idea that experienced complex structure of issues can only be understood through interdisciplinary education programs (Karakuş et al., 2012). Additionally, the acquisition of many skills prioritized by the education system becomes even easier through interdisciplinary approaches. Indeed, the development of high-level skills such as creative thinking, critical perspective, technology literacy, problem-solving skills, and productivity, which are defined as 21st-century skills (Milli Eğitim Bakanlığı [MEB], 2021), is found closely related to the transition from disciplinary to an interdisciplinary approach. According to Yıldırım (1996), mind maps in which multifaceted schemas relate to each other positively develop higher-level thinking skills in an interdisciplinary approach. Thus, a positive educational process emerges with a unifying force in areas where disciplinary approaches are inadequate. On the other hand, according to research, students learn faster in interdisciplinary learning processes and are more successful in developing multiple perspectives in approaching problems (Doğan, 2014). In turn, multiple perspectives provide an environment for analytical thinking, interpretation, and collaborative learning (Alparslan, 2021). Active participation of students facilitates understanding of lessons while increasing their interest in interdisciplinary education and learning motivation (Durmuş & Alpkaya, 2019).

The facilitating effect of the interdisciplinary approach on learning has made it necessary to consider this approach in curriculum development efforts. Therefore, instructional programs are designed to include comprehensive and shared learning outcomes as much as possible. The Harezmi Education Model (HEM) project, implemented by the Ministry of National Education in 2016, also creates a supportive model that embraces interdisciplinary approach and complements existing educational programs. HEM is an education model that integrates computer and science with social sciences, effectively utilizes programming and teaching tools, involves fun and productive activities such as robotics and game design, along with continuously updating itself (MEB, 2021).

HEM is currently implemented in a total of 707 schools in 59 provinces, with 444 of them being in Istanbul as of 2021 (MEB, 2021). The primary aim of the model is to embrace collaboration where different disciplines are equally involved, by reinterpreting the interdisciplinary approach (MEB, 2021). In addition, it has many objectives such as developing skills like algorithmic thinking, coding, problem-solving, creative thinking, collaborative work, and communication skills. These targeted skills are compatible with the current education curriculum and supportive of 21st-century skills. The implementation of the model is based on at least three teachers working in different subjects presenting the same topic from different perspectives in the same learning environment. According to Koçoğlu (2018), HEM enhances students' abilities to apply what they have learned to daily life and to find solutions to problems from different perspectives. Students solve life-related problems by using technology, blending knowledge from different disciplines, and following scientific problem-solving steps. HEM can be implemented at all class levels and it is planned for two hours of application, two hours of preparation, and an evaluation per week and (Ceylan et al., 2020).

One of the focal points of the HEM project is to enhance algorithmic thinking skills and named after Al-Khwarizmi, the inventor of the algorithm (Üngör et al., 2020). An algorithm is a process that is closely intertwined with problem-solving skills and takes into account each logical pathway to solve a problem, demonstrating these methods with easy-to-understand and expressible codes (Gülbahar et al,, 2017). One of the most important aspects in algorithms is to be able to select the shortest and most accurate path (Üngör et al., 2020). For students to be able to reach multiple solution paths and select the most suitable one among the paths they have reached, they need to be able to think multidimensional first and foremost. Multidimensional thinking is possible via interdisciplinary approaches. While HEM enhances algorithmic thinking skills, it also brings together diverse disciplines in the context of the problem being solved. Individuals can produce various solutions when they benefit from different information while solving problems. The utilization of different information on the same problem highlights the positive impact of interdisciplinary approach on problem-solving skills. In this context, in HEM, students first identify a

problem, then design an algorithm for solving the problem using the knowledge of different disciplines, and outline the solution steps. Thus, students have the opportunity to demonstrate their creativity while generating innovative solutions through the flexible structure of HEM. Teachers determine the problems to be worked on and solved throughout the term together with the students, both at the beginning and during the process. This collaborative approach between students and teachers continues with their peers throughout the process. In HEM, students are accepted not as competitors but as team members. In accordance with the collaborative learning approach, the development positive attitudes, academic success, self-confidence and common goals are ensured in students (Felder & Brent, 2007; Slavin, 1980).

HEM, which was initially introduced as a pilot program in the Turkish Education System in 2017, is currently implemented in schools at different levels that meet the specified criteria under the coordination of Provincial Directorates of National Education. Furthermore, the demand for HEM from both schools and teachers/students is increasing day by day. In this case, a necessity emerges to determine the perspectives of stakeholders regarding the progress of applications of HEM, which have come to the forefront as a project study, potential shortcomings and the satisfaction level among the stakeholders. When the relevant literature is reviewed, it is possible to encounter some research on HEM applications. Although quantitative in number, it is observed that these studies are conducted based on the opinions of different stakeholders in schools and at different educational levels. (Ceylan et al., 2020; Koçoğlu, 2019; Seçer, 2021; Tokmak, 2022; Yavuz, 2023). This study aims to determine the views of students who participated in HEM applications at the secondary school level. The findings of the study are expected to contribute to the improvement and dissemination of HEM; provide valuable insights for HEM teachers, program developers, and relevant decision-makers. In this regard, the aim of the study is to determine the contributions of HEM applications to students and their perspectives on these applications, and to determine whether these findings are generalizable. The following research questions have been formulated in accordance with the purpose of the study:

1. What are students' opinions regarding HEM applications in the context of qualitative data?
2. What are students' opinions regarding HEM applications in the context of quantitative data?
    2.1. What are the levels of students' opinions?
    2.2. Do students' opinions vary according to certain personal variables?
    2.3. What recommendations do students have regarding HEM applications?
    2.4. What are the semantic connotations of students' perceptions regarding HEM applications?

METHOD

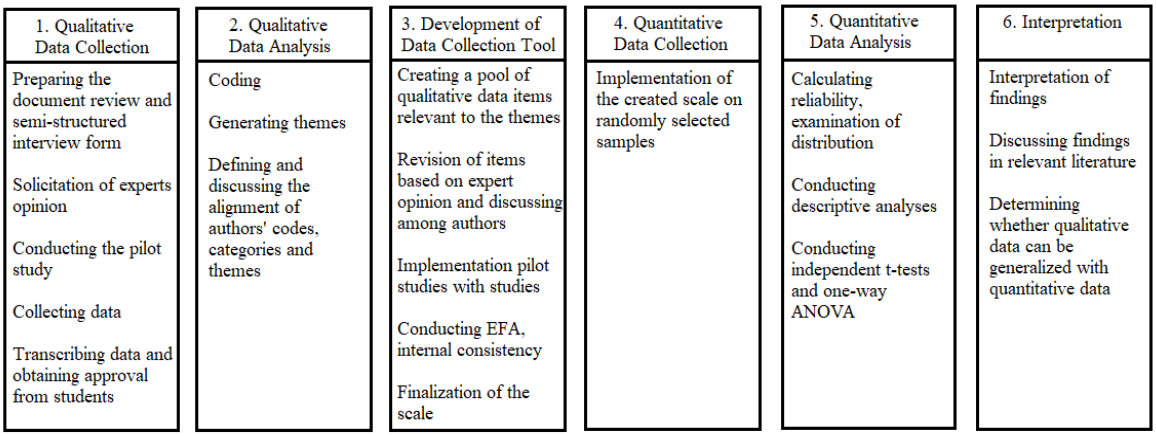
In this section, the design of the study, the participants, the data collection tools and the techniques used in the analysis of the data are given.

Research Design

In this study, the Exploratory Sequential Design, one of the Mixed Methods Research designs, was employed. In the exploratory sequential design, qualitative data is first collected and a scale is created from the obtained qualitative data. Subsequently, the scale is applied to a larger study population to determine the generalizability of the qualitative findings (Creswell & Plano Clark, 2020).

In this study, interviews were conducted with students who had previously participated in the HEM Education to reveal their considerations on this education, and qualitative data was obtained. Based on the data obtained from students' perspectives, a quantitative measurement tool was prepared, and it was determined whether these opinions were relevant for other students engaged in HEM education. Due to the absence of a prior scale that could broadly represent HEM practices based on student perspectives and the investigation of the generalizability of qualitative data, the research was conducted employing an Exploratory Sequential Mixed Methods design. Since, quantitative data were collected in light of qualitative data in the study, the qualitative dimension is central to the study and symbolized as QUAL ⊙ quan. The research process is illustrated in Diagram 1.

Diagram 1: Research Process



Participants

Qualitative Studying Group:

In the research, the perspectives of 9 secondary school students who have participated in HEM applications have been consulted to obtain qualitative data. In the selection of these students, Criterion Sampling Method and Convenient Sampling Method have been used. Criterion sampling method is a method in which the study group is determined based on criteria previously determined by the researcher (Baltacı, 2018). According to this sampling method, the criteria have been established as students' sufficient experience with HEM applications, genders, types of schools, grade levels, and socio-economic levels. The students meeting the established criteria were reached using the convenient sampling method. For this purpose, first, the schools where HEM was implemented were reached through county coordinators, and then the students were reached based on the guidance of their teachers on a voluntary basis. The interviews were conducted by researchers in a time and place outside of school with parental approval. The academic achievements of the students interviewed are at an average or above level. The majority of the students are interested in mathematics and state that it is their favorite subject. Additionally, three students have special interest and talent in the field of art and music. In accordance with ethical rules in the research, the names of the students consulted were kept confidential, and their opinions were presented by coding as P1, P2, P3, etc. Demographic information of the students in the study group is provided in Table 1.

Table 1: Demographic Information of the Qualitative Sample Group

Variable	Category	n	%
Gender	Female	4	44.4%
	Male	5	55.5%
Type of School	Imam Hatip Secondary School	4	44.4%
	Regular Secondary School	5	55.5%
Grade Level	6th grade	4	44.4%
	7th grade	5	55.5%
Socio-Economic Level	Middle and Higher	5	55.5%
	Lower	4	44.4%
Favorite Subject	Mathematics	7	38.8%
	Religious studies	3	16.6%
	English	2	11.1%
	Turkish	2	11.1%
	Science	2	11.1%
	Physical Education	1	5.5%
	Computer Science	1	5.5%

Quantitative Study Group:

The universe of the quantitative dimension of the research comprises 2200 students who completed the Harezmi education in Istanbul during the 2021-2022 academic year (MEB, 2022). Due to the objective of ensuring that each student had an equal chance of participating in the study, the Simple Random Sampling Method was employed throughout the quantitative phase of the research. In simple random sampling, the probability of all students participating in the sample is equal (Ural & Kılıç, 2005). In this regard,

communication was established with the county coordinators in charge of Harezmi Education. Following this, attempts were made to reach the students via the teachers who implement the Harezmi program. During this process, data were obtained from students in regular secondary schools and Imam-Hatip secondary schools in 16 different districts of Istanbul during this process. A 95% confidence interval and a 5% margin of error were taken into account in determining the sample of the research, and the sample size was calculated as 327 students. However, due to some students graduating from secondary school, changing schools, and acting on a voluntary basis, only 308 students could be reached.

Along with their demographic information, quantitative data collected from students are presented in Table 2. When Table 2 is examined, high percentages are observed in the categories in regular secondary schools and at the 6th grade level due to the extensive use of HEM. Although students spend 2 or 3 years in this educational process, the majority (90%) have experienced HEM practices within a one-year period. It is observed that internet access is provided in the majority of schools, and a special classroom is allocated for HEM applications.

Table 2: Demographic Information of the Quantitative Sample Group

Variable	Category	N	%
Gender	Female	180	58%
	Male	128	42%
The grade level at which Harezmi Education was received	5	78	25%
	6	166	53%
	7	64	20%
The duration of Harezmi Education received	1 year	278	90%
	2 years	19	6%
	3 years	11	3%
Type of school	Regular Middle School	237	76%
	Imam Hatip Middle School	71	23%
The district where education is received	Şişli	24	7%
	Bağcılar	39	12%
	Gaziosmanpaşa	39	12%
	Sancaktepe	41	13%
	Çekmeköy	49	15%
	Kartal	9	2%
	Maltepe	7	2%
	Tuzla	30	9%
	Ümraniye	32	10%
	Şile	7	2%
	Üsküdar	21	6%
	Beykoz	16	5%
	Bağcılar	9	2%
	Zeytinburnu	7	2%
	Bakırköy	4	1%
	Sultangazi	11	3%
Technologies Used in Harezmi Education	Internet access and related technologies are available	270	87%
	Internet access is not available	38	13%
The class of Harezmi Education	Transformation from another area	72	24%
	Adapting an existing classroom	236	76%
Variety of Teacher Specializations***	NSM*, SSAS**, Information Technologies	113	36%
	NSM, SSAS	137	44%
	SSAS, Information Technologies	21	6%
	NSM, Information Technologies	37	12%
Total (N)		**308**	

*NSM: Natural Sciences and Mathematics

**SSAS: Social Sciences, Arts, and Sports

***The classification of fields is in accordance with the Harezmi Education Model and has been derived from the MEB Harezmi source

Data Collection Tool

Qualitative Data Collection Tool and Process:

The qualitative data were collected through a semi-structured interview form. Initially, to prepare the interview form, relevant literature on the research topic was reviewed. Subsequently, a pool of open-ended questions appropriate for the research purpose was created. Afterwards, opinions were sought from a science teacher and a mathematics teacher with 3 years of experience in HEM applications, as well as from an expert (professor) in Curriculum and Instruction field regarding the questions. Based on the recommendations of the experts, a pilot implementation of the semi-structured interview form was conducted with one student. Notes were taken regarding the follow-up questions during the pilot implementation, the average duration of the interviews was determined, and the measuring power of the questions in the form was tested. According to the pilot application, the finalized semi-structured interview form includes 9 questions regarding understanding the student and the setting in which the model is being implemented, as well as 20 model-related questions. One of the questions is seeking to determine the semantic connotations of HEM education received by the students. For this purpose, students were asked "If you were to describe HEM in 3 words, what would you say?". The data obtained from the interviews with the students were collected in an online environment, via the Zoom platform. The interviews were recorded with the participants' consent and in the following stage, compiled into a report. Confirmatory questions such as "Can you please confirm that..." or "Did I interpret that correctly when you mentioned..." were asked during the interviews, and the prepared report was submitted to the participants for their approval. The duration of the interviews was within the range of 35–47 minutes. Prior to conducting the interviews, the parents were provided with the interview questions along with the Ethics Committee Permission document, and their consent was secured. At the beginning of the interviews, the rights of the students were thoroughly explained, and their consent was additionally secured before proceeding.

Quantitative Data Collection Tool and Process:

As quantitative data collection tools, the Scale for Determining Student Views on the Harezmi Education Model, which is developed by researchers, and the Personal Information Form were employed in the study. The developed scale is structured into 4 subscales and comprises 37 items including Input (3 items), Process (5 items), Output (24 items), and Suggestion (5 items). The Personal Information Form is prepared categorically and consists of 8 items.

During the development process of the scale, initially, the completion of the qualitative data collection and analysis process of the research was ensured. With the emergence of qualitative findings, the sub-dimensions of the draft scale and related items were created through the use of the themes obtained and the participants' opinions about the Harezmi Program within the context of each theme. In the light of the endeavour to assess the generalizability of the qualitative findings in the study, the creation of the item pool of the scale was completely dependent on the perspectives provided by participants. Direct expressions of participants regarding HEM applications were included in forming the item pool. Additionally, meticulous attention was devoted to ensuring that the perspectives emphasized by the majority and deemed remarkable were reflected in the item pool. Accordingly, item pool consisting of 102 items was created in the first stage. Then, suggestions from measurement and evaluation experts, along with Curriculum and Instruction field specialists was obtained regarding these items. Based on expert opinions and recommendations concerning the scope and consistency of the scale, the number of items was reduced to 70, and the scale was prepared for pilot implementation. Subsequently, the scale was implemented to 172 secondary school students who participated in HEM practices for one academic year in the 2021-2022 academic year. Based on the data obtained, validity and reliability analyses of the scale were conducted.

Before commencing data collection with the validated scale, an Ethics Committee Approval Letter and a corporate authorization resolution from the Ministry of National Education (MEB) were obtained. Prior to implementation, consent and approval were obtained from students and their parents. Initially, an attempt was made to reach students via Google Forms for data collection.

However, since an adequate number of responses could not be obtained through online data collection, school visits were conducted to personally explain the scale, and participation was intended to be increased on a voluntary basis. The data collection process lasted approximately 4 months.

Process Steps

Within the framework of the pilot application, an attempt was made to assess whether the data from the 70-item draft form of the scale were suitable for factor analysis and whether the sample properly represented the population. For this purpose, the Kaiser-Meyer-Olkin test (KMO = .920) and Bartlett Sphericity test (X2 = 6300.95, df = 666, p = .000) were conducted. The coefficient obtained from the KMO Test indicated that the sample size is adequate. Furthermore, the result of the Bartlett Sphericity test, with a p-value smaller than 0.05 ($p < 0.05$), indicated the presence of correlation between the scale items and sufficient relationship between the variables to conduct factor analysis. Based on these values, it was understood that the scale data were suitable for exploratory factor analysis (EFA) (Büyüköztürk, 2013; Tabachnick & Fidell, 2013).

As a result of the Exploratory Factor Analysis (EFA), it was determined that the percentage of total explained variance for the scale, which comprises 37 items measuring the 4 dimensions (Input, Process, Output, Suggestion), is calculated at 50.4%. The first factor, representing the Output Subscale, contributed 31.45% to the total variance, while the second factor, representing the Suggestion Subscale, contributed 6.60%. Similarly, the third factor, reflecting the Process Subscale, contributed 6.25%, and the fourth factor, reflecting the Input Subscale, contributed 6.10%. The total variance explanation rates of the scale are provided in Table 3.

Table 3: Explanation Ratios of the Total Variance of the Scale

Dimension	Contribution to the Variance Explained (%)	Total Variance Explained (%)
1	31.45	31.45
2	6.60	38.05
3	6.25	44.30
4	6.10	50.40

On the other hand, in the calculation of factor loadings for the scale items, a threshold value of 0.30 was employed as the cut-off point. Items with factor loadings below this level were excluded from the scale. Additionally, it was ensured that the factor loading in one factor for items appearing in multiple factors was at least 0.10 greater than that of the other factor (Büyüköztürk, 2013). In the final version of the scale, factor loadings ranged from 0.82 to 0.46 for the Output dimension, from 0.72 to 0.38 for the Suggestion dimension, from 0.69 to 0.38 for the Process dimension, and from 0.63 to 0.31 for the Input dimension. Factor loading values for the scale dimensions are presented in Table 4.

Table 4: Factor Analysis Results Regarding the Scale

	Item	Factor			
		1	2	3	4
Output	I discovered my interests in Harezmi education.	.822			
	I discovered my talents in Harezmi education.	.798			
	I enhanced my creativity with Harezmi education.	.796			
	I improved my communication skills with Harezmi education.	.786			
	I became more attentive to honesty in Harezmi education.	.770			
	I built my self-confidence with Harezmi education.	.755			
	I began to appreciate my lessons more with Harezmi education.	.750			
	I developed a sense of responsibility with Harezmi education.	.747			
	Harezmi education facilitated solving everyday problems in my life.	.714			
	I acquired the skill of generating ideas in Harezmi education.	.697			
	I changed my interests with Harezmi education.	.695			
	I increased my love for my school teachers through Harezmi education.	.691			
	Everything I imagined when starting Harezmi education came true.	.681			
	I improved my empathy skills in Harezmi education.	.681			
	Harezmi education made it easier for me to understand other subjects.	.672			
	I improved my eye-hand coordination in Harezmi education.	.645			
	I learned to work harmoniously with my friends in Harezmi education.	.639			
	I learned to protect the environment and living creatures in Harezmi education.	.613			
	I am happy for participating in Harezmi education.	.602			
	I expanded my circle of friends in Harezmi education.	.594			
	I was influenced in my career choice by Harezmi education.	.591			
	I find group assessments in Harezmi education to be fair.	.571			
	I learned algorithms in Harezmi education.	.555			
	I became more foresighted with Harezmi education.	.461			
Suggestion	More activities should be conducted in Harezmi education.		.723		
	The weekly class hours of Harezmi education should be increased.		.720		
	All school subjects should be like Harezmi education.		.566		
	All students should receive Harezmi education.		.557		
	Students in the same grade level should be together in Harezmi education.		.387		
Process	There is no competition among students in Harezmi education.			.691	
	Students are active in Harezmi education.			.544	
	Teachers provide sufficient guidance in Harezmi education.			.414	
	Problem-solving method is used in Harezmi education.			.402	
	Students study collaboratively in Harezmi education.			.381	
Input	The class size for Harezmi education is sufficient.				.630
	The Harezmi education classroom encourages learning.				.607
	The variety of subjects among teachers in Harezmi education is adequate.				.314

To assess the scale reliability, Cronbach's Alpha coefficient and the split-half method were utilized. In the analysis, the Cronbach's Alpha reliability coefficient was calculated as 0.92, and the Spearman-Brown reliability was calculated as 0.88. The prepared scale was evaluated as reliable, as α values above 0.70 indicates high reliability for the scales (Kılıç, 2016; Özdamar, 2013).

As a result of all validity and reliability procedures, it has been decided that the scale prepared is a valid and reliable measurement tool for determining student opinions on Harezmi Education Model (HEM) practices. Ultimately, the scale, consisting of 4 subscales and 37 items, was structured in a 5-point Likert scale format. Scores from the scale represented the following opinions: 1 (1-1.80) Strongly Disagree, 2 (1.81-2.60) Disagree, 3 (2.61-3.40) Neutral, 4 (3.41-4.20) Agree, and 5 (4.21-5.00) Strongly Agree.

Furthermore, a personal information form has been included in the scale that collects demographic data. Moreover, a question related to semantic connotation has been included at the end of the scale (in parallel with the semantic connotation question in the semi-structured interview form, which is a qualitative data collection tool), along with a question regarding gathering additional opinions and suggestions.

Data Collection and Analysis

Qualitative Data Analysis:

Descriptive and content analysis were utilized in the qualitative data analysis of the study. Prior to analysis, transcripts of participant opinions were created. During the content analysis process, transcripts for each participant were repeatedly reviewed, open coding and axial coding was utilized respectively to form the themes. Ultimately, selective coding was utilized to assign codes to the themes. To ensure the reliability of qualitative data analysis, researchers conducted data analysis independently and compared the themes and sub-themes they obtained.

As a result of this comparison, the coefficient of agreement was calculated as 0.91. Since a coefficient of agreement above 80% indicates reliable analysis (Miles and Huberman, 1994), the data analysis was deemed consistent and reliable. Through the analyses, four themes - Input, Process, Output, and Suggestion - and related categories were identified. These include the categories of students, teachers, duration, and environment under the Input theme (4); teachers, students, and methods-techniques under the Process theme (3); products, satisfaction, and semantic connotations under the Output theme (3); and Suggestion theme, which encompasses all suggestions as a single dimension.

Quantitative Data Analysis:

The analysis of quantitative data was conducted using the SPSS 22.0 program. Initially, the distribution and homogeneity of the quantitative data were examined. The analyses revealed a Kolmogorov-Smirnov p-value of 0.14 ($n>30$; $p>0.00$), Kurtosis value of 1.35, and Skewness value of -1.30. Accordingly, the findings indicate that the data were normally distributed and representative of the population (Can, 2014; Tabachnick & Fidell, 2013). Descriptive statistics, such as frequency (f), percentage (%), arithmetic mean (X), and standard deviation (sd) were used to determine students' opinions on HEM applications. Independent sample t-tests and one-way analysis of variance (ANOVA) were employed to assess differences in student opinions based on certain variables. Scheffe test was utilized to identify the source of significant differences in one-way analysis of variance. Descriptive statistics were additionally utilized to determine semantic associations.

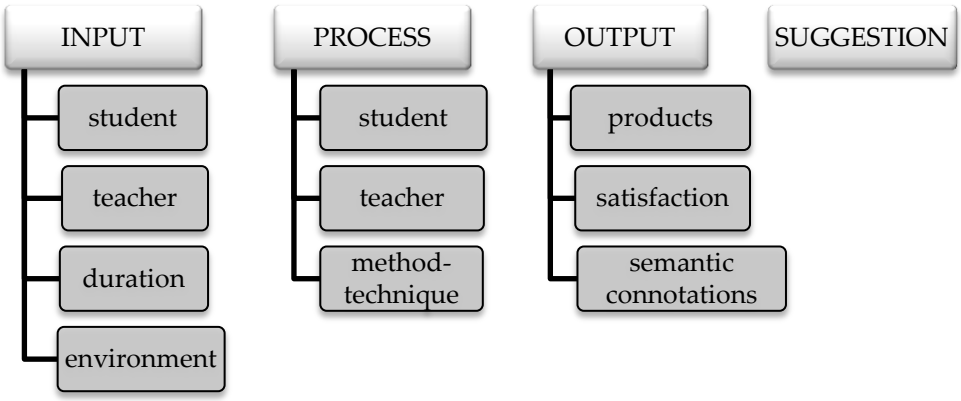
FINDINGS

The findings of the study are presented first as qualitative, then quantitative findings respectively.

Qualitative Findings

In the first sub-objective of the study, the question of "What are the opinions of students regarding Harezmi Education in terms of qualitative data?" was asked. Content and descriptive analyses were conducted to seek answers to this question. As a result of the analysis, 4 themes, namely Input, Process, Output, and Suggestion, and categories related to these themes were obtained. These themes and categories are presented in Diagram 2.

Diagram 2: Themes and categories



Input Theme:

Under the theme of Input, the categories of "*student,*" "*teacher,*" "*duration*," and "*environment*" have been established. Based on these categories, the situation at the beginning of the Harezmi Education application process and current characteristics were described. According to the findings related to the student category, it is observed that teachers selectively acted in determining the students who would receive HEM education. Teachers personally recommended and encouraged these students to participate in the HEM applications. The students who were in favorable conditions and volunteered were among those who considered this suggestion and participated in the practices. Students are either average or above average in terms of academic achievement. It is also understood that some students are talented in areas such as sports, arts, and communication. Regarding this finding, P3 stated: "*They asked the teachers who taught our class, and they selected the successful ones. ... They said that 4 people from our class would participate. I think they chose the ones with good academic performance from all 7th graders"* while P2 expressed: "*Our Turkish teacher asked if anyone played a musical instrument, and I said I play the guitar. We were called to the conference hall and had a meeting."* When the Input theme is considered in terms of teacher characteristics, it is observed that programs are conducted by teachers in the branch of Natural Sciences, Mathematics, Social Sciences, Arts, Sports and Information Technologies. The diversity of fields provides a rich learning repertoire and the students are satisfied with it. However, the majority of students do not find the variety of disciplines sufficient. P1 expressed this opinion as follows: *"I wish there were music instead of mathematics, science, and physical education...."* P2 stated, "*'I wish there were English or another foreign language. There could have been six instead of five types*." According to the findings related to the time category, students expressed their views on the day, hour, and duration of HEM practices based on their individual responsibilities and conditions. The opinions of students with favorable conditions suggested that the duration of education could be extended. P1, who presented his opinion in the form of a suggestion, said, "*One day per week is less, there could be one more day. It could be like Tuesday-Friday or Monday-Thursday. Even if it is after school, it is not tiring at all because we like this activity."* On the other hand, some students also mentioned (without complaining) that they struggled with the duration of HEM practices. Since HEM practices are conducted after school hours, these students experience time managing problems when attending additional activities to support their other lessons and when they have excessive responsibilities related to the homework of other lessons. P3 expressed his opinion on this matter: "*... I am taking additional course. There are science lessons on Tuesdays, and I get tired, but it's still better than other days. It's not a problem because it's fun. It is 1.5 hours and it is good, but I come home late and then I can't study, it's also dark.... Even if it were half an hour less, it would be better."* Lastly, within the context of environment characteristics, data were analyzed in terms of technological equipment, material richness and accessibility, and classroom environment. Accordingly, it has been determined that in HEM applications, video or visual presentations are made with a smart board or projector, the materials are generally provided by school facilities or through teachers, and a suitable area within the school is arranged for the HEM implementation. For the information about the process of acquiring materials and classroom designing process, P3 provided the following statement: "*Our teachers mostly bring the materials. They also brought materials from their own homes. They only asked us for materials for 1-2 activities.*" P8 stated: "*We created the Harezmi classroom together with the teachers*." Additionally, P9 mentioned, "*There is a place in the basement of our school, the teachers arranged it, and we have our materials and we do our classes there."* P2 said, *"There was an empty room that everyone*

used. They gave us that room." Lastly, P3 stated, *"There is a class divided with glass on the 5th floor which is made for the Harezmi classroom,"* indicating that some schools push the physical conditions for HEM education.

Process Theme:

Under the theme of process, categories of "*student," "teacher*," and "*method-technique*" have been established. In this theme, the categories are centered and the situation in the HEM implementation process and existing characteristics are included. During the implementation process, it is observed that the student profile generally consists of students that exhibit high motivation and enjoyment in learning, collaborate with peers without competition. In addition to actively participating in the process, students work harmoniously and complement each other in areas where they are weak. P5 and 1 express this situation of learning from each other within the group as follows: "*.... We usually work as a team among 5 people. If one has a good idea, another is good at drawing, teams get along well with each other, our weaknesses do not become a struggle. We easily establish harmony, know each other, and behave respectfully. Occasionally, someone wants to be a leader but games progress quickly, so there is not much opportunity for such situations*" (P5). "*We form groups in all activities. We all know each other and do not raise our voices; whoever is good at a particular subject takes on that task. We distribute tasks equally. We also communicate and exchange materials and ideas between groups"* (P1). However, although the learning process progresses based on this collaboration, there are occasional instances of students not behaving in a harmonious manner. This situation negatively affects the productivity and motivation of the studies. In this regard, P6 mentioned that they were punished by their teachers due to disagreements during group work, stating, "*Sometimes our friends in the group talk a lot and the teachers punish us, telling us to sit quietly and not to do anything, and I get bored at that time."* Similarly, P7 conveyed a negative situation during group work with a complaining attitude, saying, "*The groups consist of 4-5 people. It would be easier if it were 3 people. Because sometimes there are many people who want to do the same task, and sometimes nobody does anything, leaving the work on a few people."* When looking at teacher behavior during the HEM implementation process, it is understood that they are willing and highly motivated. Teachers approach students supportively, helpfully, attentively, devotedly, and in a friendly manner. In this regard, P4 used the following expressions: "*Our teachers can give ideas when there is no product in teamwork. When a student is left alone, teachers team up with them. It gives confidence that they are always with us, ... We are honest because our communication with teachers is good*." In terms of the methodological and technical aspects of HEM implementations, various methods, including problem-solving techniques, video presentations, lectures, guest speakers, competitions, trips, group work, gamification, the fishbone technique, physical activities, painting/drawing, the question-answer teaching method, and demonstrations, are observed to be used due to the primary focus of project-based activities on real-life problems. It is understood that activities based on these methods are designed to develop algorithmic thinking and actively engage students. Some students who express satisfaction with the process stated: "*The lesson starts with surprises, continues with warm-up games, and then we receive education ..."* (P2). "*They give homework. After watching the videos, question-answer sessions are held. Then tasks are distributed"* (P8). "*There was a waffle activity, and we made our own waffle... We created the QR code of our own presentation"* (P5).

Output Theme:

Under the Output theme, the categories of *"product," "satisfaction*," and "*semantic association*" have been established. In this theme, efforts have been made to determine the effects of HEM education on students by focusing on these categories. All students have stated that the education they received has contributed to them in various aspects. Within the product category, students have indicated that they were positively influenced by the program in terms of algorithmic thinking skills, communication skills, sensitivity towards their environment, interest in art and sports disciplines, career preferences, problem-solving skills, time management, effective use of their hands and bodies, building self-confidence, academic achievements, learning etiquette rules, creating creative ideas and products, increasing awareness of their social roles, and becoming responsible. Some student views regarding this finding are as follows: "*... it increased my interest in technology. My interest in sports increased, and I became more sensitive to nature. ... I realized that I used to have little responsibility towards nature, ... The communication course was effective in my relationships with friends*" (P2); *"I started thinking algorithmically outside of the school, such as if this happens, then that will follow. ... We made a rap song, and I was able to create rhyming sentences*" (Student 1); *"... we went to a place with my family. He was my dad's friend and I didn't know him. I shook his hand, I wouldn't have done it before Harezmî, but I did it after learning etiquette rules in Harezmî education*" (P3). *"... I no longer go hungry, I can make waffles, I can solve my problems by*

myself. ... I was a very shy individual, but education reduced my shyness a bit and increased my self-confidence" (P5). In terms of student satisfaction, it has been found that all students have favourable opinions and are highly satisfied with HEM implementations. It is understood that initially, students did not anticipate enjoying Harezmi education this much. In fact, even two students started uncertain and unwilling but completely changed their minds during the process and the majority of them are satisfied with HEM implementations as they met their initial goals. However, a 7th grader stated without complaining that the Harezmi education did not meet her expectations because she thought it would bring more LGS (High-School Entrance Exam) oriented contributions: "*When I first started, I searched on Google. It said new generation solutions. I thought there would be mind games to solve new generation questions for math. I am satisfied with the education I received, but this was not my expectation. Of course, I couldn't reach my goal, but that's okay ...*" (P3). Among the students who expressed that their expectations were met, P7 stated, "I was expecting something really good, but it turned out to be even better," and P8 expressed his satisfaction by saying, "*What I imagined was less than this. I didn't think the teachers would be good and the activities would be like this."* Lastly, under the Output theme, semantic associations regarding HEM implementations by students are included. Once students' three-word reviews about HEM implementations were examined, "*fun*" emerged as the most prevalent connotation shared by all of the students. Students used the concepts of *"fun," "happiness," "enjoyable*," and "*excitement*" to express this emotional response. It is evident that the concepts centered around skills and active learning were emphasized upon examination of further connotations. In accordance with the semantic associations, it is understood that all students have positive opinions about HEM implementations and find the process pleasant as well as educational. Student responses regarding this finding are included in Table 5.

Table 5: Semantic associations of students regarding HEM implementations

Participants	Enjoyable	Pleasurable	Happiness	Excitement	Algorithm	Responsibility	Skill	Talent	Activity	Education	Environmentalist	Naturalist	Instruction	Perseverance	Success	Knowledge	Trust
P1	✓		✓													✓	
P2	✓			✓												✓	
P3					✓	✓	✓										
P4	✓							✓								✓	
P5	✓								✓	✓							
P6	✓								✓		✓						
P7	✓											✓	✓				
P8	✓													✓	✓		
P9	✓	✓															✓

Suggestion Theme:

Suggestions regarding HEM implementations based on students' experiences have been provided under the Suggestion theme. Suggestions have been managed in the "*Input*" and "*Process*" dimensions. In this context, some students suggested improving the physical conditions and technological equipment of the classrooms, increasing the diversity of teachers' specialties, extending the duration of HEM activities, enabling more students at various grade levels to benefit from HEM education, conducting other lessons like Harezmi education in a fun, stress-free, and activity-based manner, adopting friendly and trust-based approaches by other teachers in lessons similar to those in Harezmi education, and finally, arranging classes by students grade-level peers. Some student opinions regarding the suggestions are as follows: "*I wish the teachers would treat us as they do in Harezmi.... The classroom is enough, but the space could be larger. Activities are not technology-oriented"* (P3). *"I wish all the lessons at school were like Harezmi education because playing games makes it stick in my*

mind" (P1). *"…. I would like to participate again, but they don't select 8th graders, so I'm sorry I have 1.5 months left*" (P2). On the other hand, it has been observed that two students think differently from the others regarding conducting lessons in a collaborative and activity-based approach. Accordingly, based on their individual characteristics and preferences, P7 expressed their opinion as: "*Other lessons at school should be conducted like this, but there shouldn't be group assignments all the time,*" while P6 stated: "*It would be boring if all the lessons were like that, always the same topic, always activities and exhaustion….*"

Quantitative Findings

The second sub-objective of the study aims to answer the question of "What are the opinions of students regarding HEM implementations in the context of quantitative data?" Descriptive statistics, independent T-test, and one-way analysis of variance (ANOVA) were conducted to investigate the current situations and differences among them.

Secondary School Students' Perspectives on HEM:

According to the second sub-objective of the study, an investigation was conducted initially into students' opinions regarding HEM implementations. Descriptive statistics were employed to ascertain their viewpoints. The findings have been presented in Table 6.

Table 6: Descriptive Statistical Results of Student Opinions on HEM

	Opinion	N	X	sd
Input	The class size for Harezmi education is sufficient.	308	4.40	1.00
	The Harezmi education classroom encourages learning.	308	4.37	1.00
	The variety of subjects among teachers in Harezmi education is adequate.	308	4.70	0.76
	Total	**308**	**4.49**	**0.70**
Process	There is no competition among students in Harezmi education.	308	3.70	1.38
	Students are active in Harezmi education.	308	4.48	0.78
	Teachers provide sufficient guidance in Harezmi education.	308	4.64	0.83
	Problem-solving methods are used in Harezmi education.	308	4.47	0.65
	Students study collaboratively in Harezmi education.	308	4.78	0.59
	Total	**308**	**4.47**	**0.54**
Output	Harezmi education made it easier for me to understand other subjects.	308	3.62	1.34
	Group assessments in Harezmi education are fair.	308	4.46	0.96
	I learned algorithms in Harezmi education.	308	4.49	0.95
	I learned to protect the environment and living creatures in Harezmi education.	308	4.43	1.05
	Harezmi education facilitated solving everyday problems in my life.	308	4.37	1.06
	I became more foresighted with Harezmi education.	308	4.05	1.30
	I acquired the skill of generating ideas in Harezmi education.	308	4.48	0.98
	I learned to work harmoniously with my friends in Harezmi education.	308	4.42	1.12
	I improved my eye-hand coordination in Harezmi education.	308	4.14	1.14
	I developed a sense of responsibility with Harezmi education.	308	4.37	1.05
	I improved my communication skills with Harezmi education.	308	4.25	1.16
	I built my self-confidence with Harezmi education.	308	4.30	1.16
	I discovered my talents in Harezmi education.	308	4.03	1.32
	I discovered my interests in Harezmi education.	308	3.98	1.37
	I improved my empathy skills in Harezmi education.	308	4.22	1.22
	I expanded my circle of friends in Harezmi education.	308	4.06	1.38
	I became more attentive to honesty in Harezmi education.	308	4.22	1.21
	I changed my interests with Harezmi education.	308	3.41	1.58
	I was influenced in my career choice by Harezmi education.	308	2.78	1.58
	I enhanced my creativity with Harezmi education.	308	4.38	1.11
	I began to appreciate my lessons more with Harezmi education.	308	3.55	1.49
	I increased my love for my school teachers through Harezmi education.	308	4.33	1.11
	I am happy for participating in Harezmi education.	308	4.71	0.76
	Everything I imagined when starting Harezmi education came true.	308	3.80	1.30
	Total	**308**	**3.97**	**0.80**
Suggestion	The weekly class hours of Harezmi education should be increased.	308	3.91	1.35
	More activities should be conducted in Harezmi education.	308	4.02	1.23
	All students should receive Harezmi education.	308	3.45	1.57
	Students in the same grade level should be together in Harezmi education.	308	4.16	1.32
	All school subjects should be like Harezmi education.	308	4.77	1.37
	Total	**308**	**3.90**	**0.87**
	Overall Total	**308**	**4.07**	**0.65**

Never (1) 1.00 - 1.80
Rarely (2) 1.81 - 2.60
Sometimes (3) 2.61 - 3.40
Often (4) 3.41 - 4.20
Always (5) 4.21 - 5.00

When Table 6 is examined, it is observed that the overall average scores of students regarding HEM implementations is X=4.07 (sd=0.65). This value indicates that opinions of students are classified as "Often" (4). Upon further examination of the sub-dimensions, it is seen that the Input dimension has a mean score of X=4.49 (sd=0.70), the Process dimension has a mean score of X=4.47 (sd=0.54), the Output dimension has a mean score of X=3.97 (sd=0.80), and the Suggestion dimension has a mean score of X=3.90 (sd=0.87). Accordingly, it is understood that students' opinions in the Input and Process dimensions are in the "Always" (5) category, while in the Output and Suggestion dimensions they are in the "Often" (4) category. When considering all scale items, it is determined that the lowest mean score (X=2.78; sd=1.58) belongs to the opinion "I was influenced in my career choice by Harezmi education", while the highest mean score (X=4.78; sd=0.59) belongs to the opinion "Students study collaboratively in Harezmi education.", and (X=4.77; sd=1.37) "All school subjects should be like Harezmi education." It is observed that students "Always" with 22 out of the 37 items in the scale, "Often" with 14 items, and "Sometimes" with 1 item.

Perspectives of Secondary School Students on Harezmi Education According to Some Personal Variables:

In line with the second objective of the study, students' perspectives on Harezmi Education were examined secondly, based on certain personal variables. The personal variables of students were considered in terms of gender, school type, and grade level. Independent t-tests were used for the gender and school type variables, whereas analysis of variance (ANOVA) was employed for the grade level variable.

The independent t-test results comparing student perspectives on HEM implementations based on the gender variable are presented in Table 7.

Table 7: T-test Results of Student's Perspectives on HEM Based on Gender Variable

Dimension	Gender	N	$\bar{X}$	SD	T	p	Significance
Input	Male	128	4.55	0.57	1.293	0.19	-
	Female	180	4.45	0.78			
Process	Male	128	4.41	0.50	-1.709	0.08	-
	Female	180	4.51	0.56			
Output	Male	128	3.94	0.78	-0.512	0.60	-
	Female	180	3.99	0.81			
Suggestion	Male	128	3.85	0.92	-0.775	0.43	-
	Female	180	3.93	0.83			
Overall Total	Male	128	4.04	0.65	-0.622	0.53	-
	Female	180	4.09	0.66			

When Table 7 is examined, it is observed that female students have higher means than male students in dimensions, except the Input (X=4.45, ss=0.78), and in the Overall Total regarding their views on HEM implementations. The t-test conducted to determine whether the score difference is significant has shown that the difference is not significant at the ($p<0.05$) level. Therefore, it can be said that the views of both female and male students on HEM implementations are similar in both overall and sub-dimensions. The results of the independent t-test conducted to compare student perspectives on HEM implementations by school type are presented in Table 8.

Table 8: T-test Results of Student's Perspectives on HEM Based on School Type Variable

Dimension	School Type	N	X	SD	T	p	Significance
Input	Regular SS.	237	4.55	0.66	2.948	0.00	*
	Imam-Hatip SS.	71	4.28	0.79			
Process	Regular SS.	237	4.55	0.47	4.467	0.00	*
	Imam-Hatip SS.	71	4.19	0.63			
Output	Regular SS.	237	4.10	0.67	4.152	0.00	*
	Imam-Hatip SS.	71	3.55	1.03			
Suggestion	Regular SS.	237	3.85	0.88	-1.864	0.06	-
	Imam-Hatip SS.	71	4.07	0.82			
Overall Total	Regular SS.	237	4.16	0.57	4.553	0.00	*
	Imam-Hatip SS.	71	3.77	0.82			

With the examination of Table 8, it can be observed that there is a difference between the overall scores of regular secondary school students' perspectives on HEM implementations ($\bar{x}$=4.16) and Imam-Hatip secondary school students' overall scores ($\bar{x}$=3.77). Upon considering the sub-dimensions, differences are observed as well in the mean scores of all sub-dimensions. The mean scores of regular secondary school students are higher overall and in the sub-dimensions, except for the Suggestion dimension. According to the results of the t-test conducted to determine the significance of this difference, it was found that the mean scores of regular secondary school students in all dimensions, with the exception of the Suggestion dimension (t=1.864; p<0.05), demonstrate a significant difference (p<0.05). Therefore, it can be concluded that Imam-Hatip secondary school students and regular middle school students do not have similar perspectives on HEM implementations. The results of the independent t-test conducted to compare students' perspectives on HEM implementations across grade levels are presented in Table 9.

Table 9: Results of One-Way Analysis of Variance for Student Perspectives of HEM by Grade Level Variable

Dimension	Grade	n	$\bar{x}$	SD	F	P	Significance
Input	5th Grade	78	4.54	0.66	0.289	0.74	-
	6th Grade	166	4.46	0.76			
	7th Grade	64	4.50	0.57			
Process	5th Grade	78	4.62	0.45	5.590	0.00	5th Grade-7th Grade
	6th Grade	166	4.46	0.54			
	7th Grade	64	4.32	0.59			
Output	5th Grade	78	4.24	0.61	8.123	0.00	5th Grade-6th Grade 5th Grade-7th Grade
	6th Grade	166	3.94	0.77			
	7th Grade	64	3.72	0.97			
Suggestion	5th Grade	78	4.18	0.74	6.182	0.00	5th Grade-6th Grade 5th Grade-7th Grade
	6th Grade	166	3.83	0.90			
	7th Grade	64	3.73	0.86			
Overall Total	5th Grade	78	4.31	0.53	8.959	0.00	5th Grade-6th Grade 5th Grade-7th Grade
	6th Grade	166	4.04	0.64			
	7th Grade	64	3.86	0.73			

In the examination of Table 9, it is observed that there is no significant difference in students' perspectives of HEM applications in the Input sub-dimension of the scale, based on their grade level variable. However, the opinions of 5th, 6th, and 7th-grade students are compared in terms of other dimensions and the overall total. According to comparison, significant differences were determined based on grade level variable in the total scale dimension (F=8.95, p<.05), as well as in the Process (F=5.59, p<.05), Output (F=8.12, p<.05), and Suggestion (F=6.18, p<.05) dimensions. Meanwhile, the findings suggest that 5th grade students hold more positive views on HEM applications in contrast to 6th and 7th grade students, whereas the views of 6th and 7th grade students are similar.

Suggestions of Secondary School Students Regarding HEM Applications:

In line with the second objective of the study, thirdly, students' suggestions regarding HEM applications were examined. Students provided their suggestions through an open-ended question. Similar recommendations were merged during the analysis and represented with frequency values. The students' recommendations regarding HEM applications are presented in Table 10.

Table 10: S*uggestions of Students Regarding HEM and Frequencies*

Suggestions	f
The weekly class hours should be increased.	18
More activities (coding, trips, presentation, game) should be conducted.	17
All students should be included and the implementation should be disseminated.	14
The same student should be able to continue Harezmi education until graduation.	10
Students should be left free to work in groups or individually.	8
Arrangements should be made to facilitate participation in Harezmi education (such as transportation, schedule planning, etc.).	8
Financial and technological support should be provided to Harezmi schools.	4
Sports field should be more widely included in Harezmi education.	4
There should be only one grade level of students in one Harezmi classroom.	3
Teachers should be more energetic, enjoyable, and smiling in Harezmi education.	2
Written exams should also be conducted in Harezmi education.	2
Harezmi education should be better promoted.	1
Teachers should act fairly.	1
No response provided.	218
Total	308

The Table 10 indicates that the majority of students (f=218) did not express their opinions. The students' enthusiasm to receive more from HEM education is quite evident as their recommendations are evaluated. Accordingly, the majority of suggestions include topics such as “increasing the duration of the education”, “its inclusion as a compulsory subject in the curriculum”, “covering all students”, and “making arrangements to eliminate accessibility barriers”. Subsequently, opinions such as “increasing activities”, “diversifying disciplines”, “providing financial and technological support”, and “being with peers at their own grade level” are included among the suggestions intended to improve HEM applications. Another issue addressed in students' recommendations concerns teachers. Students expect their teachers to "not intervene too much in their work," "be more enjoyable and energetic in class," and "act fairly."

Semantic Associations of Students Regarding HEM Implementations:

In line with the second sub-objective of the research, the semantic associations regarding HEM implementations were examined lastly. For this purpose, students were asked to express HEM applications using three concepts. The semantic associations of students regarding HEM implementations are presented in Table 11.

Table 11: Word frequency information defining Harezmi education

Semantic Associations Regarding HEM Applications	f
Teamwork	77
Knowledge	59
Consciousness	51
Responsibility	41
Activity	38
Success	37
Skill/Talent	37
Curiosity	34
Enjoyment	34
Perseverance	32
Algorithm	26
Competition	23

The analysis of semantic associations revealed the use of a wide range of concepts, and only 12 concepts with a frequency value above 20 are included. By examining the Table 11, it is understood that these concepts reflect the characteristic features of HEM and evoke positive feelings and thoughts in students. Students mostly prefer to use the concept of "teamwork" (f=77) due to the collaborative learning feature; the concept of "knowledge" (f=59) for the cognitive outputs of HEM practices, and the concept of "consciousness" (f=51) for increasing students' awareness.

RESULT and DISCUSSION

This study conducted using the Exploratory Sequential Mixed Methods Design aimed to evaluate HEM practices based on the student perspectives. Due to the characteristic feature of the design used in the initial stage regarding the general results obtained in the research, it can be said that quantitative and qualitative data are parallel. Therefore, qualitative data are largely generalizable. The overall conclusion reached based on the obtained data is suggests that students benefit from this education and are quite satisfied with the received education, despite some shortcomings in HEM practices. When considering student perspectives on HEM practices in terms of some personal characteristics, the following findings are identified: (1) in terms of gender, both female and male students have similar opinions; (2) in terms of school type, the views of students from regular secondary are more positive than those of Imam-Hatip secondary school students, and (3) in terms of grade level, 5th grade students express more positive views compared to 6th and 7th grade students. The second finding could be explained by the fact that regular schools have more experience with HEM education as they were the first to implement it. Additionally, the diversity of disciplines in regular secondary schools may be a contributing factor. This assumption is further strengthened by observing the effectiveness of a diverse range of disciplines within STEM education, where interdisciplinary studies are conducted with a shared understanding (Ulum, 2020). The more positive views of 5th grade students may be due to their age, which is a period where cognitive flexibility is higher, sensitivity to the environment, the

ability to evaluate alternatives, and the imagination that allows for finding different solutions (Çuhadaroğlu, 2013), as well as being in a phase where they can have fun and learn in a different environment with older students after primary school.

The details of the overall findings reached in the study were examined within the framework of the Input, Process, and Output dimensions along with subcategories regarding the perspectives on HEM practices. In this regard, it was observed that the environmental characteristics in the "Input" dimension of HEM applications are stimulating to learning, although there are some deficiencies in materials, tools, and technical equipment, efforts have largely been made to meet the needs. A related concern was also raised in the study by Yavuz (2023), which determined the teacher perspectives on HEM practices in primary schools. Another characteristic of the HEM environment is its flexible structure. It is known that flexible classroom arrangements positively affect student motivation (Büyükşahin, 2019; Demir Yıldız & Tatik, 2019; Johnson et al., 2021). Features such as the implementation of HEM practices in a non-traditional learning environment, allowing for teamwork, being designed with student participation, and providing opportunities for independent study may have led students to enjoy learning and increase their motivation. Indeed, the prominence of concepts such as "responsibility," "fun," and "happiness" in students' semantic association concepts can be considered as an indicator of this. Along with the research results of Tokmak (2022) supporting this finding, the research results examining students' metaphorical perceptions of HEM by Ceylan et al. (2020) also indicate the prominence of these concepts. When the findings related to the duration of education, another component of the Input dimension, are analyzed, it is observed that the time allocated for HEM practices is frequently emphasized within the scope of suggestions. In both qualitative and quantitative findings of the research, students have expressed opinions such as including HEM practices in mandatory course scope, increasing the duration of implementation, etc. It is possible that these recommendations stem from the satisfaction derived from HEM practices. On the other hand, as indicated in the qualitative findings, the difficulty students face regarding the duration is generally attributed to their involvement in extracurricular programs or the intensity of school-family responsibilities. Therefore, students have mostly requested an increase in the duration, scope, and inclusivity of this education in their recommendations regarding HEM practices. Similar opinions can also be found in the literature (Yavuz, 2023). The findings obtained in the “student” category, another component of the Input dimension, appear to be parallel to this view. Students desire a procedure where all willing students can participate in HEM practices, rather than being selected based on criteria such as academic achievement, talent in art/sports, etc. In addition, whereas qualitative data obtained in the “teacher” category find the diversity of teacher fields insufficient, quantitative data indicate the opposite, showing it to be quite sufficient. Therefore, it can be inferred that this data may not be generalizable. However, considering the suggestions of the students, it is observed that students, especially those interested in sports, have indirect demands for teachers in this field.

In the Process dimension of the study, it was concluded that overall perspectives regarding the HEM implementation process are positive. In the student category of the "Process" dimension, students appear to be collaborative, engaged, active, adaptable, curious, problem-solvers who notice problems and think about solutions, along with learning by practicing, experiencing, and having fun. However, the existence of situations where some students cause discomfort to others due to not adhering to the spirit of teamwork is observed as well. Although students express relatively the request for arranging classes with peers at the same grade levels in their suggestions, it is considered that this recommendation does not align with the logic of HEM, which aims to raise individuals who notice and solve real-life problems. As a matter of fact, this kind of arrangement is considered to be a good application in terms of providing practice in coping with real-life differences. According to the conclusion reached in the “teacher” category within the Process dimension, teachers do their best to fulfil the guidance role expected from them. It is observed that the teacher-student relationship throughout HEM is more intimate and based on trust compared to other subjects. Students have expressed that they have more love, trust, and respect for their teachers as a result of this education, and that they exhibit a more honest approach towards their teachers. Accordingly, it can be said that HEM teachers fulfil responsibilities such as "showing respect to students, guiding, learning together with students, and maintaining a listening attitude towards students," as indicated in Koçoğlu's (2018) study on "responsibilities of teachers in HEM applications." In terms of the “method-technique” category of the Process dimension, it is understood that HEM is a purposeful learning process that includes problem-solving, collaborative, project-based learning-oriented and student-centered practices. The

involvement of multiple disciplines in the process is a factor supports collaborative learning. In this way, students have the opportunity to support the team in the area where they find themselves good/successful/talented (Bestelmeyer et al., 2015). Thus, students can actively participate through collaboration and interdisciplinary approaches. Both the semantic association concepts used by students and the data of the Output dimension, which focuses on student achievements, reveal the effectiveness of the process and contribute to positive views.

According to the students' perspectives in the Output dimension of the study; it has been concluded that they develop problem-solving skills, algorithmic thinking skills, self-awareness, environmental sensitivity, sense of responsibility and empathy, adaptation to society, creative thinking, academic progress, as well as psychomotor and communication skills. In various studies examining the effects of HEM practices on students, it is observed that HEM contributes to the development of students' self-confidence, academic achievements, communication skills, problem-solving abilities, collaborative work, environmental sensitivity, use of digital applications (Çimşir & et., 2022; Kıvanç-Contuk & Atay 2021), creativity (Yavuz et al., 2019), metacognitive awareness and information processing skills (Tokmak, 2022). The three main pillars of Harezmi education are interdisciplinary approach, collaborative learning, and problem-solving based learning approach. Looking at other methods apart from HEM based on interdisciplinary approach, it is seen that similar to this study, students develop higher-order thinking and communication skills (Jones, 2009), preparing them for life and supporting learning processes (Clair & Hough, 1992). While maintaining an interdisciplinary approach with a collaborative understanding, it is inevitable that self-awareness and communication skills will improve (Bennett et al., 2013). On the other hand, the increase in students' self-awareness in HEM practices using educational technologies indirectly supports the development of collaborative learning skills and self-efficacy among 21st-century skills (Ceylan et al., 2023). Whereas collaborative learning contributes to social skills (Yıldız et al., 2017), enhances problem-solving skills (Uysal, 2010) as well. In problem-solving-based teaching, the algorithm represents a series of steps that enable reaching the solution of the problem in a scientific way (Bodner, 1987). Therefore, problem-solving skills and algorithmic thinking skills develop in parallel (Demir & Cevahir, 2020; Kant & Newell, 1984). Significant differences in problem-solving skills are observed in students who receive algorithm education (Altun, 2018; Namlı & Şahin, 2017). Accordingly, it can be said that a well-organized HEM implementation can provide students with multidimensional attainments and improvements. The students participating in the research process indicate that they have largely benefited from this opportunity from their perspective and expressed their satisfaction with the practices conducted within the HEM framework. However, in the suggestions for HEM practices, the areas for improvement in HEM appear more clearly. Although the majority of students did not express their opinions in this dimension of the study, this situation may be due to the satisfaction of the students with this program.

Indeed, in the majority of the suggestions brought forward, students declare their desire to participate more in HEM practices, emphasize the need for more students to benefit from the practices, recommend for the implementation of this practice in all schools and its continuity, support in terms of financial and technological aspects, institutional solutions to problems arising from extracurricular implementation, and increasing activities. Similar demands have been voiced in related studies (Çimşir et al., 2022; Seçer, 2021; Tokmak, 2022; Yavuz, 2023).

RECOMMENDATIONS

HEM, although a relatively new educational practice, is a rapidly expanding educational model in schools. In the flexible learning environment created through interdisciplinary approaches, HEM practices offer a different experience to students who are weary of rote learning, and students have provided valuable recommendations for improving these practices. In accordance with the results of this study, the following additional recommendations can be proposed:

(1) Providing technical equipment to develop the essential skills that 21st-century individuals will mainly need, organizing activities based on both this framework and ethical and moral values, (2) integrating artificial intelligence into these practices, (3) ensuring that these practices extend beyond the school setting, allowing students to engage in project-based product development activities in distinct locations such as workshops, factories, art galleries, software firms, together with the support of various professionals in their

environment, and generating the necessary policies for these endeavors will propel HEM practices towards a more contemporary direction.

This study is limited to the opinions expressed by secondary school students and based on their knowledge and experiences regarding HEM practices in this grade level. Student perspectives encompass satisfaction, issues, recommendations, semantic associations, etc., and include qualitative and quantitative data. Different results may be obtained when different studies are conducted on various levels and sample groups. In this regard, researchers are recommended to conduct studies that can contribute to the improvement of HEM practices.

Declarations

Conflict of Interest

No potential conflicts of interest were disclosed by the author(s) with respect to the research, authorship, or publication of this article.

Ethics Approval

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Research and Publication Ethics Statement

The study was approved by the research team's university ethics committee of the Yıldız Technical University. Hereby, we as the authors consciously assure that for the manuscript the following is fulfilled:

- This material is the authors' own original work, which has not been previously published elsewhere.
- The paper reflects the authors' own research and analysis in a truthful and complete manner.
- The results are appropriately placed in the context of prior and existing research.
- All sources used are properly disclosed.

Contribution Rates of Authors to the Article

1st author contributed 50%, 2nd 50%

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