Educational Policy Analysis and Strategic Research, V18, N4, 2023

The Impact of Using Model-Based Activities Based on the History of Mathematics in Geometry Instruction on Students' Geometry Anxiety*

Şükrü İLGÜN[1]
Kafkas University
Zehra DAŞTAN[2]
Ministry of National Education
Esra ALTINTAŞ[3]
Adnan Menderes University

Abstract

The aim of this study is to examine the impact of mathematical modeling activities using the history of mathematics on students' anxiety in geometry instruction. The study was conducted with 7th-grade students (n=30) studying in a public school during the first semester of the 2021-2022 academic year. In the research, nested mixed pattern from mixed research methods was used. Mathematical modeling activities based on the history of mathematics, designed by the researcher in accordance with the 7th-grade geometry curriculum, were implemented with the study group. Data were collected through written worksheets during the implementation process. Prior to and after the implementation process, a geometry anxiety scale was administered to the study group, and student opinions were obtained. The data obtained from the implementation were analyzed using content analysis. The research findings revealed a decrease in students' anxiety towards geometry and a positive change in students' perceptions of geometry.

Keywords: History of Mathematics, Model-Eliciting Activities, Mathematical Modeling, Geometry Teaching

DOI: 10.29329/epasr.2023.631.12

Submitted: 27 June 2023 **Accepted:** 13 November 2023 **Published:** 30 December 2023

---

* This is derived from the master's thesis titled "An Investigation on the Effects of Mathematical Modeling Activities and the History of Mathematics on Geometric Concepts and Students' Geometry Anxiety in Geometry Instruction for 7th Grade Students."

[1]Şükrü İLGÜN, Dede Korkut Education Faculty, Kafkas University, Kars, Turkey, ORCID: 0000-0002-2842-2032
Email: mat.ilgun@hotmail.com

[2]Zehra DAŞTAN, Ziya Gökalp Ortaokulu, MEB, Kars, Turkey, ORCID: 0000-0001-8687-0960,
Correspondence: matematik.z@hotmail.com

[3] Esra ALTINTAŞ, Education Faculty, Adnan Menderes University, Aydın, Turkey, ORCID: 0000-0003-3311-7179,
Email: esra.altintas@adu.edu.tr

Introduction

Mathematics is a vast science that cannot be fully known by a single individual (Crilly, 2018). The history of mathematics often demonstrates how mathematical knowledge has progressed and expanded from one civilization to another (Baki, 2008). Humans have constantly interacted with their environment throughout the historical process to sustain their existence. They have observed their surroundings to meet their basic needs and engaged in activities that would facilitate their lives. Therefore, they have utilized geometry when determining the boundaries of a region in agriculture or finding directions by observing the stars. Geometry has also been employed in measuring time through calendar calculations or constructing buildings and bridges in architecture. From a historical development perspective, it can be observed that geometry was studied as an integral part of mathematics until recent times. In ancient times, the term "geometry" was used instead of mathematics, which meant "earth measurement" (Ertekin & Ünlü, 2020).

The history of mathematics provides information on how mathematical knowledge has evolved and progressed over centuries. According to Bayam (2014), throughout different eras, the majority of civilizations have embraced mathematics in some form, providing numerous benefits to the advancement and development of the field. Without examining the multi-historical, multi-cultural structure of the mathematical sciences, it is not possible to be successful in mathematics. In this context, when examining the development of mathematics, it can be seen that its initial emergence on the historical stage was in the form of basic measurement and counting operations developed to meet daily life needs. The foundations of geometry and arithmetic are theoretically based on solving problems encountered in agriculture, trade, astronomy, and architectural research.

When looking at the historical process of mathematics, it is observed that it has similarities with the development of humanity. Scientists who have been engaged in mathematics for centuries have attempted to solve problems they encountered and have found different solution methods. It is evident that mathematics has progressed and developed through human effort, parallel to the needs of individuals, with the contributions of different civilizations (Şaşmaz & Aybek, 2022). Akyüz (2018) suggests in the study that it could be a useful tool to combine technology, history, and mathematics. They state that with these tools, mathematics can be made less abstract for students and can be conveyed to them through visuals. Erdoğan, Eşem, and Fındık (2015) examined middle school mathematics textbooks for the 2013-2014 academic year in their research. The research concluded that the use of mathematics history in the examined textbooks was much less than what was intended.

Mersin and Durmuş (2018) examined the inclusion of mathematical history elements in middle school mathematics textbooks in their research. The analyzed textbooks from the 2016-2017 academic year contained nineteen elements related to mathematical history. This finding indicates that there is a lack of sufficient coverage of mathematical history in the textbooks, with an average of three mathematical history elements per textbook. In the study conducted by Şaşmaz and Abek (2022), the distribution of mathematical history elements in eleven middle school textbooks from the 2020-2021 academic year was examined. Forty-eight mathematical history elements were identified, mostly located in the introductory sections of the units. However, the study concluded that these elements were not sufficient and not adequately related to the learning outcomes. These research findings indicate that the use of mathematical history elements in textbooks is insufficient. Despite the significant importance of mathematical history in the field of mathematics, the limited attention given to it in the mathematics curriculum and textbooks represents a deficiency in mathematics education.

Bakkal (2017) suggests that in today's education system, particularly in geometry instruction, there is often a reliance on rote learning. Students tend to see definitions and theorems as a pile of information without understanding their origin, necessity, purpose, and mathematical logic. However, learning about the emergence of knowledge and studying why it is needed, its purpose, and its mathematical reasoning can enhance the permanence of that knowledge. It also improves the student's level of interpretation and can positively change their perspective on other mathematical topics. In this context, it is believed that incorporating the historical development of geometric concepts and proof methods into geometry instruction can be beneficial. It is anticipated that the works and proof methods conducted by mathematicians working on geometric concepts can increase students' motivation. Thus, it is believed to be important for fostering students' curiosity and desire to explore and inquire about these geometric concepts, rather than experiencing anxiety towards them.

When conducting literature review, the studies related to the history of mathematics were initially examined. Bütüner (2014) states in the study that the history of mathematics can be utilized to motivate students and facilitate their conceptual learning. It is stated that by learning that mathematics is not just about rules and formulas, students will realize that the history of mathematics is enjoyable. According to Mersin and Durmuş (2018), the use of mathematical history can be an effective teaching method, and they emphasize the importance of integrating mathematical history into mathematics classes. Küçükoğlu and İncikabı (2020) aim to determine students' thoughts about the nature of mathematics and the formation of mathematical knowledge in their study. The results of the study revealed that students had different understandings of the definition of mathematics, and they believed that mathematics originated from trade. According to Karakuş (2009), the history of mathematics is a source that includes various problems that can enhance students' problem-solving skills. Karakuş aimed to use the topic of mathematical history in the learning environment of mathematics classes. The Babylonian method was used for calculating square roots. This allowed students to discover different solution methods in problem-solving. On the other hand, Bayam (2012) aimed to determine the impact of mathematics history-based instruction in the 6th-grade mathematics class on student achievement and attitudes. Significant differences were observed in the achievement test results for the experimental group. In Tokay's study (2019), the aim was to determine the effects of using mathematical history on fourth-grade students' achievement and motivation. According to the results, it was observed that the use of mathematical history in the lesson increased students' academic achievements and motivation in mathematics. Yenilmez (2011) conducted a study to determine the thoughts of mathematics teacher candidates regarding the mathematical history course. The study used a questionnaire and an information form. The results of the research indicate that teacher candidates consider the knowledge they acquire in this course to be most beneficial in terms of numbers, geometry, and solving equations. Furthermore, it is observed that teacher candidates express their willingness to share the history of mathematics and the lives of famous mathematicians with their students in mathematics classes. In this context, when examining the research conducted on mathematical history, it is seen that there is a lack of studies focusing on geometry topics.

In the literature review, studies related to mathematical modelling were also examined. Mathematical modelling encompasses not only the solutions to simple mathematical problems but also the solutions to problems that aim to describe and interpret the environment we live in. It aims to foster mathematical thinking in addition to mathematical operations (Gündüzalp, 2019). It is observed that studies on mathematical modelling and education in Turkey date back particularly to twelve years ago. It can be said that there has been a significant increase in studies conducted in the field of mathematical modelling during this twelve-year period (Albayrak & Çiltaş, 2017). When examining postgraduate theses related to mathematical modelling, it was found that the majority of thesis topics focused on determining perspectives on problem-solving and modelling (Yıldız & Yenilmez, 2019). In Taşova's study (2011), the visual process in which students engage in mathematical modelling is examined. The results indicate that students demonstrated high performance in modelling activities. Therefore, suggestions are made regarding the organization of teaching programs and textbooks with modelling activities. Ay's study (2009) aims to examine students' understanding of negative integers through history-based modelling activities. The research revealed progress in students' understanding and interpretation of the topic of negative integers. During the implementation of the activities, it was observed that students were more productive in group work and showed greater interest in the lessons. It is evident that there is only one research study on history-based modelling activities in mathematics, and this study specifically focuses on the topic of integers.

While modeling activities are extensively discussed in the field of mathematics in general, it is also important to consider the extent of modeling studies specifically related to geometry. In this context, studies related to modeling in geometry are also mentioned. In Dağdelen's study (2012), it is revealed how students relate concepts related to geometric shapes and symmetry that arise from origami applications. This research found a significant difference in favor of the group that received origami-based instruction. Thus, it demonstrates that origami-based instruction is more effective compared to the existing instructional method. It was also determined that students made mathematical inferences and were able to make generalizations through these applications. The purpose of Bulut and Erkan's study (2020) was to examine modeling difficulties through a mathematical modeling activity related to area measurement in regular geometric shapes. Operational difficulties encountered during the process were classified as the use of area and length units, the use of measurement units, and the use of decimal numbers. Yıldız (2020) examined modeling competencies in the solution process of a geometry problem in the study. Participants were given a situation involving the proof of area in triangles in a geometry problem and were asked to solve it and provide explanations with concrete models. The research revealed that teacher candidates mostly solved the geometry problem correctly and created concrete models.

The aim of this research is to examine the teaching of geometric concepts through mathematical modeling activities using the history of mathematics and to investigate the impact of this instruction on student anxiety. Geometry is one of the important elements that nourishes, develops, and contributes to the progress of mathematics. Geometry concretizes abstract concepts in mathematics, such as numbers and algebra, through shapes, models, and objects.

The objective is to explore the formation and development process of geometric concepts in mathematical history and to support the everyday use of these concepts through mathematical modeling activities. Thus, the aim is to highlight the historical stages of these geometric concepts and their effects on today's world, emphasizing their applications in our daily lives. It is hoped that this approach will increase students' interest in geometry and reduce their anxiety towards the subject.

The importance of this research is to emphasize the use of mathematics history in geometry instruction. It aims to demonstrate that by incorporating the historical processes of geometric concepts into geometry teaching, mathematics is a self-renewing and developing science. It aims to show how geometry shapes our lives, how it plays a role in the development of civilizations and cultures. It also highlights the cultural dimension of geometry and demonstrates why there is a need for geometric concepts. By following the historical process of the work done by mathematicians, the teaching of theorems and proofs will be more enduring. It will help comprehend proof, refutation, and mathematical thinking methods. It will enable students to learn mathematicians' working principles and integrate them into their own work. It will also lead to an understanding of the relationship between geometry and other sciences. As a result, students who understand the importance of geometric concepts and topics will increase their interest in geometry.

By using mathematical modeling activities to apply geometric concepts in everyday life situations, it aims to address students' curiosity or concerns when encountering geometric concepts and shapes and attract their interest. It also aims to explain why these concepts and shapes are needed. It is believed that exploring the studies and proofs related to these concepts in the history of mathematics, as well as how they are used in daily life through mathematical modeling activities, will be beneficial. In this context, this research hopes to reduce students' anxiety towards geometry.

In light of the research objective, the research problem can be stated as follows:

To what extent does presenting geometric concepts through mathematics history-based modeling activities affect students' geometry anxiety?

The sub-problems of this research are as follows:

1. Sub-Problem: Does geometry instruction through history-based modeling activities have an effect on reducing students' geometry anxiety?

2. Sub-Problem: Does geometry instruction through history-based modeling activities have an effect on students' opinions about geometry?

Method

In this study, which aims to examine the geometry anxiety levels of 7th-grade students through history-based modeling activities in geometry, both qualitative and quantitative techniques were used together. The research design employed a nested mixed methods design (Creswell & Clark, 2014). Both qualitative and quantitative data were collected simultaneously. After the collected data were analyzed, the interpretation phase was conducted.

In the quantitative part of the research, a weak experimental design called the one-group pre-test - post-test design was used. The basic characteristic of weak experimental designs is the absence of randomization. In the one-group pre-test - post-test design, the effect of the experimental procedure is investigated on a single group. Measurements related to the dependent variable are determined using the same measurement tools with the same participants as the pre-test before the implementation and as the post-test afterwards (Büyüköztürk et al., 2010).

In the quantitative part of the research, within the framework of the Ministry of National Education (MNE) Middle School Mathematics Curriculum, history-based modeling activities in geometry were implemented as a pre-test – post-test using the Geometry Anxiety Scale to determine their impact on the geometry anxiety of 7th-grade primary school students. The design used in the research is summarized in Table 1.

Table 1. Example of the Single Group Pre-test-Post-test Design in the Study

Group	**Pre-test**	**Operation**	**Post-test**
Z	$Ö_1$	X	$Ö_2$
Study Group	Geometry Anxiety Scale (*Dependent Variable*)	Geometry History-Based Mathematical Modeling Activities (*Intervention*)	Geometry Anxiety Scale (*Dependent Variable*)

This research includes one independent variable and one dependent variable. In this study, the independent variable is geometry-based modeling activities, and the dependent variable is students' geometry anxiety.

The case study was used in the qualitative part of this study. Thus, an in-depth investigation of one or several cases is desired (Yıldırım & Şimşek, 2011). Case study was conducted to describe, understand, develop possible explanations, or evaluate details (Büyüköztürk et al., 2010). The qualitative part of this research consists of the opinion forms of the study group, as well as audio and video recordings. In addition to the video recordings taken during the implementation process, written documents used by students in the activities are also available.

Population and Sample

The population of the study consists of 7th-grade students in a province during the 2021-2022 academic year. The research sample consists of a total of 30 students, 13 (43.3%) girls and 17 (56.7%) boys, who are enrolled in a middle school in this province. The school where the implementation was conducted is a middle school with a higher number of students, teachers, and classrooms compared to other schools in the province, and it consists of students with different socioeconomic backgrounds. Additionally, the students' academic achievement levels vary. Consistently with the research objective, maximum diversity sampling was employed to reveal the commonalities or differences among students and to address the research problem within a broader framework.

Table 2 shows the distribution of scores based on the students' first exam results in 1st semester in the mathematics course prior to the implementation process.

Table 6. Mathematics Score Distribution of the Study Group

Score	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**	**90-100**	**Total**
Frequency	5	5	3	2	7	3	1	4	30
Percentage	16,6	16,6	10	6,6	23,3	10	3,3	13,3	100

In Table 2, it can be seen that there is at least one student from each score group in the study group. The aim was to achieve maximum diversity among students with different academic achievement levels. Thus, the objective was to identify commonalities among student groups that exhibit variations (Yıldırım & Şimşek, 2008).

Data Collection Tool

The data collection tools of the study were provided in two sections as quantitative and qualitative data collection tools. For the quantitative data collection tools of this study, the anxiety scale developed by Ünlü (2014) was administered to students as a pre-test and post-test before and after the implementation process. In Ünlü's study, the Cronbach-α’s internal consistency coefficient of the scale was reported as 0.906. Table 3 shows the Cronbach-α’s internal consistency coefficient of the Geometry Anxiety Scale administered to the study group as a pre-test and post-test during the implementation process.

Table 3. Cronbach-α’s Internal Consistency Coefficient of the Geometry Anxiety Scale Pre-test-Post-test

	Pre-test	Post-test
Cronbach α	,777	,847
Item Count	17	17

In this study, it was determined that the 17-item geometry anxiety scale used as the pre-test had a Cronbach-α's internal consistency coefficient of 0.777. The geometry anxiety scale used as the post-test had a Cronbach-α's internal consistency coefficient of 0.847.

Data from the geometry anxiety scale administered to the study group consisting of thirty students before and after the intervention were utilized by scoring the responses.

The qualitative data collection tools in this study consist of written worksheets used by students during the intervention and the students' geometry perception forms. During the intervention, for the first activity, which was the angle activity, preparatory questions were asked to the students. The definitions of angle-related concepts were presented to the students, and they were also asked about the mathematician Thales and his contributions. In the angle measurement activity, questions related to supplementary and congruent angles were posed for the students to answer. They were also asked to design their own games involving angles. For the triangle activity, preparatory questions were asked to the students. In these questions, they were required to determine the sum of the interior angles of a triangle and explain why. Additionally, they were asked about the mathematician Ahmes and his contributions to mathematics. In the triangle roof activity, the students were expected to identify different types of triangles based on their sides and angles. They were also asked to construct structures using triangles, such as roofs and bridges. For the final activity, which was the pi number activity, preparatory questions were asked to the students, particularly focusing on questions related to the pi number. In the pi-oppy activity, questions about calculating the circumference of a circle were included. At the end of the activity, students were encouraged to discuss their answers with their peers. The achievement information for these activities according to the Ministry of National Education (MNE) curriculum is provided in Table 4.

Tablo 4. Achievement Information of Activities according to the MNE

ACTIVITY	ACHIEVEMENT
Angle Activity	*M.6.3.1.3. "Explores the properties of adjacent angles, complementary angles, supplementary angles, and vertical angles; solves related problems." M.7.3.1.2. "Examines the corresponding, alternate, corresponding interior, and corresponding exterior angles formed by two intersecting parallel lines; analyzes their properties, determines the angles that are congruent or supplementary, solves related problems."*
Triangle Activity	*M.5.2.2.2. "Constructs triangles based on their angles and sides, classifies the created triangles according to their side and angle properties."* ***M.7.3.2.2.*** *"Determines the diagonals, interior, and exterior angles of polygons; calculates the sum of interior angles and exterior angles. Includes activities that explore the sum of interior angles."*
Pi Activity	*M.6.3.3.2. "Determines through measurement that the ratio of a circle's circumference to its diameter is a constant value. Emphasizes that this constant value is called π (pi). When given problems related to π, the approximate value to be used is indicated each time with expressions such as "take π as 3; take it as 22/7; take it as 3.14."* ***M.7.3.3.2.*** *"Calculates the length of a circle and an arc of a circle."*

Data Collection Process

The implementation was conducted for a duration of 8 weeks, with sessions lasting 40+40 minutes. The modeling activities based on historical mathematical concepts used in the research were prepared by the researcher in accordance with the Ministry of National Education (MNE) achievements. The activities consisted of three parts: angles, triangles, and the number pi. During the implementation process, students formed groups of two.

Data Analysis

To determine the appropriate statistical analysis, it was tested whether the study group followed a normal distribution. According to Büyüköztürk (2010), tests for normality vary depending on the group size. If the group size is greater than fifty, the Kolmogorov-Smirnov test is used; if it is less than 50, the Shapiro-Wilk test is used for normality analysis. The study group consisted of thirty students, so the Shapiro-Wilk test for normality was employed. The analysis of the results of the written exam in mathematics conducted before the implementation process for the study group is presented in Table 5.

Table 5. Normality Analysis of the Study Group

Number of students	Average	The Lowest	The Highest	Standard Deviation	Shapiro-Wilk	p
30	52,33	20	100	24,20	,937	,077

According to Büyüköztürk (2010), if p > .05, the groups exhibit normal distribution; if p < .05, they do not show normal distribution. As seen in Table 5, the Shapiro-Wilk normality analysis indicates that the study group exhibits normal distribution (p > .05). In such cases, tests requiring normal distribution should be used (Büyüköztürk, 2010). Therefore, the *Dependent t-Test*, which is a parametric test, was used to compare the pre-test and post-test anxiety levels.

The data analysis in the study was conducted under the headings of quantitative and qualitative data analysis. For the quantitative data analysis of the study, the anxiety scale developed by Ünlü (2014) was administered to students before and after the activities. The anxiety scale, consisting of seventeen items, was applied to the study group consisting of thirty students. The scale data were analyzed using statistical software packages in computer environments.

Content analysis was employed for the analysis of qualitative data in this study. Content analysis was used to summarize the coded words with smaller content categories (Büyüköztürk et al., 2010).

Findings

The findings of the study were examined in two sections: quantitative findings and qualitative findings. For the quantitative findings of this study, a geometry anxiety scale was administered to the study group before and after the implementation of geometry history-based modeling activities. The findings related to the first sub-problem of the research, "Does geometry history-based modeling activities have an impact on reducing student anxiety?" were obtained through the pre-test and post-test anxiety scale administered to the study group. The *Dependent t-Test*, a parametric test, was used to compare the pre-test and post-test anxiety levels. The results are presented in Table 6.

Table 6. Anxiety Scale Pre-test– Post-test

	n	X	ss	t	sd	p
Pre-test	30	3,4374	,92394			
Post-test	30	2,3843	1,09528	-6.684	29	,000

It is seen that the difference between the pre-test and post-test scores of the study group were statistically significant ($t = -6.68$; $p < 0.05$) as shown in Table 6. According to the results of the study group consisting of thirty individuals, it was observed that the anxiety levels of students were statistically significant after the implementation of geometry history-based modeling activities.

For the qualitative findings of this study, student views were obtained before and after the implementation. The findings related to the second sub-problem of the research, "Does geometry history-based modeling activities have an impact on students' perceptions of geometry?" were obtained.

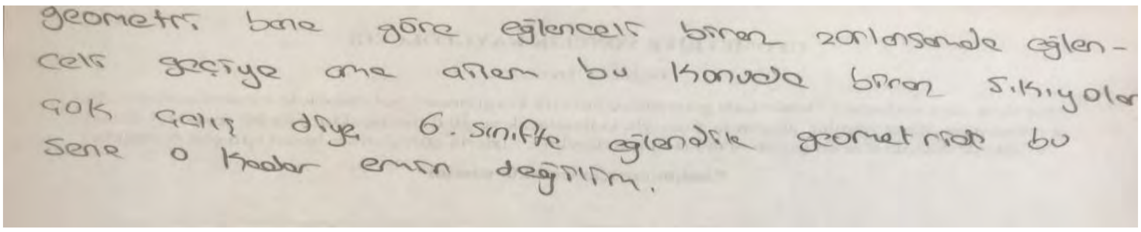
Before the implementation, the question "What are your thoughts on geometry topics and geometry questions?" was posed to the study group. Student views are presented under four main categories in Table 7.

Table 7. Student Views Before Implementation

Student Views	**f**	**%**
Concerns about not being able to solve the problem in front of their families	15	%32
Being apprehensive about geometry problems	12	%26
Thinking that geometry topics are difficult	11	%23
Worrying about not being successful in exams	9	%19
Total	**47**	**%100**

As we can see in the table 7, it is noteworthy that students express the most fundamental cause of their geometry anxiety as parental pressure (32%). They have stated that they feel hesitant about geometry problems and math questions involving shapes. They believe that geometry topics are difficult. Additionally, they express concerns about not being successful in exams, particularly in High School Entrance Exam (LGS) in the 8th-grade Some of the students' written opinions have been provided.

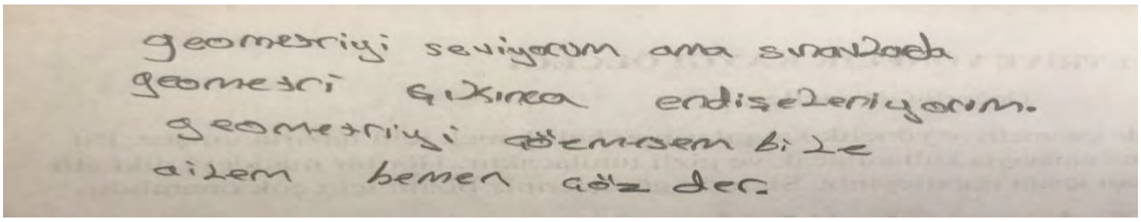
Image 1. Example of Parental Pressure


geometri bana göre eğlenceli biraz zorlansamda eğlen-
celi geçiye ama ailem bu konuda biraz sıkıyolar
çok çalış diye 6. sınıfte eğlendik geometride bu
sene o kadar emin değilim.

In image 1, the student explains the following: "Geometry is fun for me. Even though it is a little difficult, it is fun. But my parents is a little annoying about this, telling me to work hard. We had fun in 6th grade, I am not sure this year." Although students find geometry topics challenging, they express that geometry is fun. It is noteworthy that they particularly mention their family's expressions. As seen in the anxiety scale results, it is observed that they experience anxiety regarding their family.

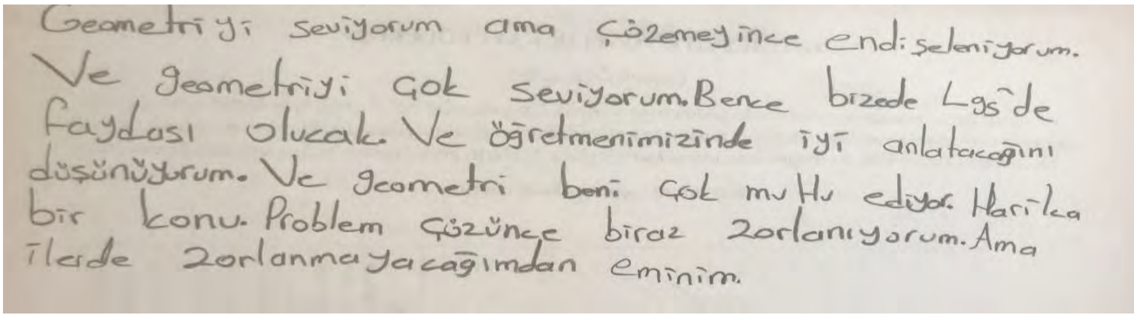
Furthermore, they state that they liked geometry in the previous academic year but have concerns about the new geometry topics.

Image 1. Example of Avoidance of Geometry Problems


geometriyi seviyorum ama sınavda
geometri çıkınca endişeleniyorum.
geometriyi çözemesem bile
ailem hemen çöz der.

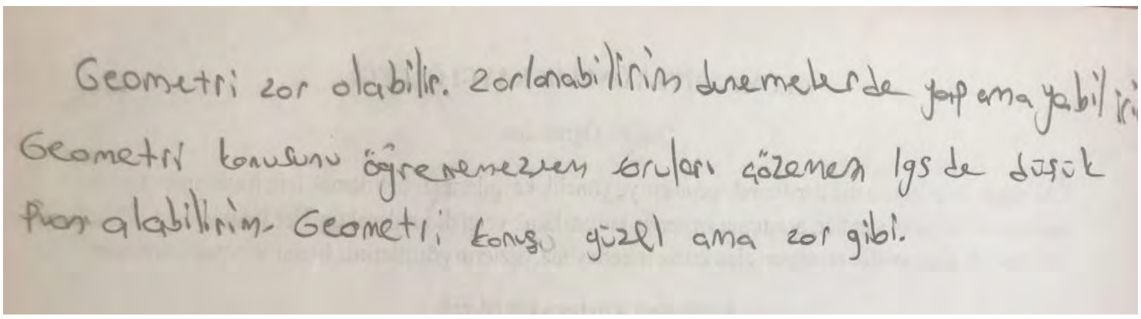
In image 2, the student explains the following: “I love geometry but I get worried when it comes up in exams. Even if I can’t solve geometry, my family tells me to solve it immediately.” It can be observed that the student who claims to enjoy geometry also experiences anxiety when faced with geometry problems.

Image 2. Example of Exam Anxiety


Geometriyi seviyorum ama çözemeyince endişeleniyorum.
Ve geometriyi çok seviyorum. Bence bizede LGS'de
faydası olucak. Ve öğretmenimizinde iyi anlatacağını
düşünüyorum. Ve geometri beni çok mutlu ediyor. Harika
bir konu. Problem çözünce biraz zorlanıyorum. Ama
ilerde zorlanmayacağımdan eminim.

In image 3, the student explains the following: “I love geometry but I get worried when I can’t solve it. And I love geometry much. I think it will also be useful to us in LGS. And I think our teacher will explain it well. And geometry makes me very happy. A great topic. I am having a little trouble solving the problem. But I am sure I won’t have any problems in the future.” It is noticeable that the student's primary concern is the High School Entrance Exam (LGS). Despite being in the 7th grade, they express anxiety about the LGS exam they will take in the 8th grade. The student explains that their purpose in learning geometry is to be able to solve problems in practice exams and to avoid getting a low score in the LGS. They consider geometry topics to be interesting but challenging.

Image 3. Example of Difficult Geometry Topics


Geometri zor olabilir. zorlanabilirim denemelerde yapamayabilirim
Geometri konusunu öğrenemezsem soruları çözemem lgs de düşük
puan alabilirim. Geometri konusu güzel ama zor gibi.

In image 4, the student explains the following: "Geometry can be difficult. I may be difficulty in exams, I may not be able to. If I don't learn geometry, I can't solve the problem, I can get low scores in LGS. Geometry subject is nice but seems difficult." The student who expressed that geometry topics are difficult is seen to experience anxiety about not being able to solve geometry questions. Students who mentioned struggling with certain geometry topics specifically mentioned not knowing what to do first and where to start in geometric questions. Additionally, the statement "I forget the formulas of the topics" stands out.

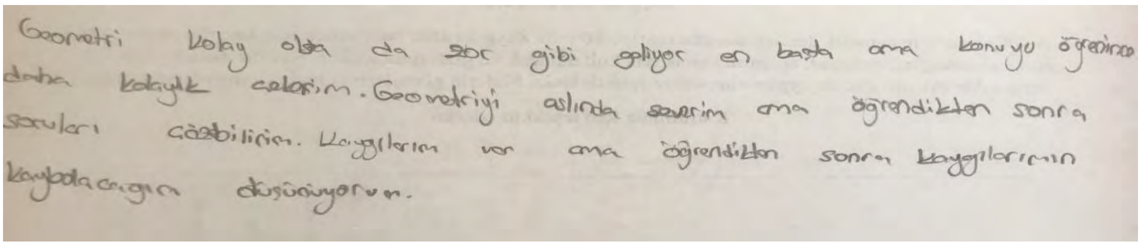
During the implementation process of the research, three activities were completed. The first activity was the angle activity, the second activity was the triangle activity, and the final activity was the pi activity. After the implementation, the students who formed the study group were asked to write their opinions about geometry again. Student opinions are presented in Table 8 under three main headings.

Table 8. Student Views Before Implementation

Student Views	f	%
Thinking that geometry topics become easier as they are learned	17	%47
Thinking that they will be more successful in exams	11	%31
Being able to solve half of the geometry problems	8	%22
Total	**36**	**%100**

In Table 8, it is observed that students expressed that geometry becomes easier as they learn geometry topics (47%). They stated that they can solve up to half of the geometry problems. Additionally, they believe that they will be more successful in exams.

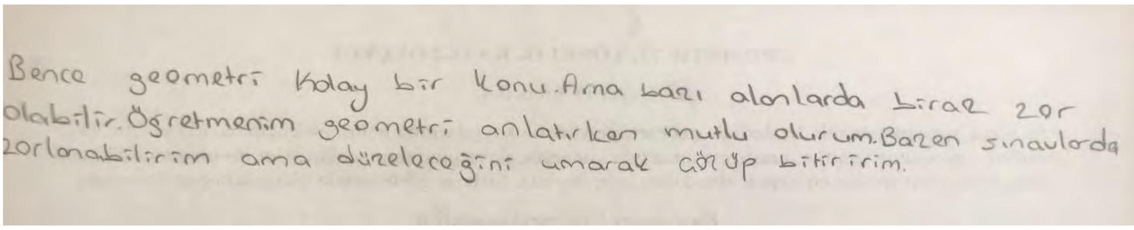
Image 5. Example of the Answer of Geometry Topics Become Easier as You Learn Them



In image 5, the student explains the following: "Even though geometry is easy, it seems difficult at first but it gets easier once you learn the subject. I actually like geometry but I can solve the questions after learning. I have concerns but I think my concerns will disappear after learning."

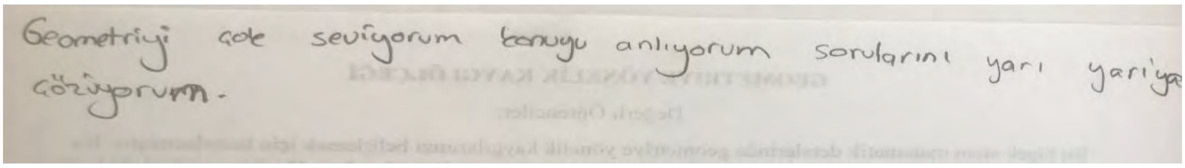
The student mentioned that geometry topics initially seemed difficult but became easy after learning the subject. They stated that their anxiety decreased after learning the topics and they can solve geometry problems. Additionally, the student expressed that they enjoy geometry.

Image 6. Example of Being More Successful in Exams


Bence geometri kolay bir konu. Ama bazı alanlarda biraz zor olabilir. Öğretmenim geometri anlatırken mutlu olurum. Bazen sınavlarda zorlanabilirim ama düzeleceğini umarak çözüp bitiririm.

In image 6, the student explains the following: "I think geometry is an easy subject. But it can be difficult in some areas. I feel happy when my teacher explains geometry. Sometimes I may have difficulty in exams, but I hope that it will get better and I solve it." The student mentioned that geometry is generally easy but struggles with certain topics. They acknowledge that they may face challenges with geometry problems, but despite that, they have the motivation to solve and complete the questions.

Image 7. Example of Solving Geometry Problems Halfway


Geometriyi çok seviyorum konuyu anlıyorum sorularını yarı yarıya çözüyorum.

In image 7, the student explains the following: "I love geometry much, I understand the subject, I solve half the questions." The student expressed a great love for geometry and stated that they understand the topics. However, they mentioned that they only solve the questions halfway. It is noteworthy that students indicate understanding the concepts but experiencing anxiety during problem-solving. Due to the different shapes and expressions in each geometry question, students may have difficulty establishing similarities between these shapes and expressions. It has been observed that students may initially feel anxious when faced with different geometry question patterns belonging to the same competency group.

Results, Discussion, Conclusion and Recommendations

The results regarding the findings of the research are presented in order of sub-problems and discussed within the relevant literature context.

For the first sub-problem of the research, a geometry anxiety scale was administered to the study group before and after the implementation. *Dependent t-test* was used to compare the pre-test and post-test anxiety levels. According to the test result, it was observed that the geometry anxiety levels of the study group decreased. In Bayam's (2014) study, students who enjoyed attending classes on the history of mathematics expressed that they overcame their fears of mathematics. This result is consistent with our research, which also suggests a decrease in geometry anxiety among students through the teaching of geometry with the history of mathematics. Bütüner's (2014) study found a positive development in students' attitudes towards mathematics after the implementation. This supports the results of our anxiety scale. İdikut (2007), in a study investigating the effect of using the history of mathematics in mathematics teaching on students' attitudes towards mathematics and their achievement, found a significant difference between the post-test achievement scores of the experimental and control groups. This result also parallels our research findings. Ay (2019) observed that during history of mathematics-based modeling activities, students worked more efficiently and showed more interest in activities related to real-life situations. This result is similar to our research findings.

Regarding the results of the second sub-problem, it is observed that the students' views on geometry changed positively when looking at the opinion forms obtained before and after the implementation. Bayam (2014) stated that students mentioned enjoying learning through activities and that their interest in mathematics increased. Yenilmez's (2011) study found an increase in students' interest in mathematical concepts through mathematics history-based lessons. It was also determined that they liked mathematics more and their motivation towards mathematics increased. Moreover, it was observed that their admiration for mathematics increased based on this information and their desire to explore other sciences intensified. Our research aligns with the parallelism of increasing students' motivation in history of mathematics-based lessons. Tokay (2019) states that the use of mathematics history in lessons has a positive impact on students' motivation. The student views obtained after the implementation in our research are parallel to Tokay's research findings.

Based on the obtained results, some recommendations are provided for practitioners and researchers:

- ✓ This research was conducted at the middle school level. Investigating the research in high school and undergraduate levels can contribute to the literature.
- ✓ How this research is used in other countries can be examined.
- ✓ Middle school mathematics teachers can organize in-class activities to reduce students' anxiety levels towards geometry by identifying their specific geometry-related anxieties.
- ✓ Educational environments enriched with mathematics history can motivate students.
- ✓ Students who learn the working principles of mathematicians can be encouraged to use these principles in their study programs.
- ✓ Students who study the scientific works of important figures in the history of mathematics can be directed towards scientific research.
- ✓ It has been observed that students who formed paired groups during the implementation process were more effective and productive. Collaborative learning can be used in most possible mathematics lesson processes.
- ✓ Outside the implementation process, student groups have been observed to engage in peer activities and found them efficient. Peer education can be encouraged in teaching processes.
- ✓ The research includes geometry history-based modeling activities. The use of activities can be examined in other mathematics learning outcomes.

- ✓ Students who experience anxiety when encountering geometric shapes can reduce their anxiety through history of mathematics modeling activities and can achieve more success by using geometric concepts in all mathematics topics.

Policy Implications

Geometry is one of the important elements that nourishes, develops, and contributes to the progress of mathematics. Geometry concretizes abstract concepts in mathematics, such as numbers and algebra, through shapes, models, and objects. The objective is to explore the formation and development process of geometric concepts in mathematical history and to support the everyday use of these concepts through mathematical modeling activities. Thus, the aim is to highlight the historical stages of these geometric concepts and their effects on today's world, emphasizing their applications in our daily lives. It is hoped that this approach will increase students' interest in geometry and reduce their anxiety towards the subject.

The importance of this research is to emphasize the use of mathematics history in geometry instruction. It aims to demonstrate that by incorporating the historical processes of geometric concepts into geometry teaching, mathematics is a self-renewing and developing science. It aims to show how geometry shapes our lives, how it plays a role in the development of civilizations and cultures. It also highlights the cultural dimension of geometry and demonstrates why there is a need for geometric concepts. By following the historical process of the work done by mathematicians, the teaching of theorems and proofs will be more enduring. It will help comprehend proof, refutation, and mathematical thinking methods. It will enable students to learn mathematicians' working principles and integrate them into their own work. It will also lead to an understanding of the relationship between geometry and other sciences. As a result, students who understand the importance of geometric concepts and topics will increase their interest in geometry.

Conflict of Interest

There is no conflict of interest between the authors of the article.

Ethical Statement

Ethics committee approval has been obtained from the Kars MEM ethics committee of scientific research with the decision numbered No: E-91782061-605.01-34371733 on 11.10.2021.

References

Albayrak, E., & Çiltaş, A. (2017, Ekim). Türkiye'de Matematik Eğitimi Alanında Yayınlanan Matematiksel Model Ve Modelleme Araştırmalarının Betimsel İçerik Analizi. *Uluslararası Türk Eğitim Bilimleri Dergisi*.

Ay, B. (2019). An Investigation on Seventh Grade Students' Understandıng of Negatıve Integers vıa Mathematıcs History-based Model-elıcıtıng Actıvıtıes, *Ortadoğu Teknik Üniversitesi Yüksek Lisans Tezi*.

Baki, A. (2008). *Kuramdan Uygulamaya Matematik Eğitimi* (3 b.). Ankara: Harf Eğitim Yayıncılığı.

Bakkal, S. (2017). *Geometri ve İspatlar* (2 b.). Ankara: Edge Akademi.

Bayam, S. B. (2012). İlköğretim Matematik Eğitiminde Öğrencilerin Matematik Tarihi Bilmelerinin Öğrencilerin BaşarıI ve Tutumlarına Etkisi. *Yüksek Lisans Tezi*. Kastamonu.

Bayam, S. B. (2014). Matematik Eğitiminde Matematik Tarihi Gerekliliğinin Felsefi Temelleri ve Gerçekçi Matematik Eğitiminde Matematik Tarihinin Önemi. *2013 Matder 12. Matematik Sempozyumu* (s. 233 - 244). Dört Öge.

Bulut, D. B., & Erkan, B. (2020, Aralık). 7. Sınıf Öğrencilerinin Matematiksel Modelleme Süreçlerinin İncelenmesi: Geometrik. *Turkish Studies - Education*.

Bütüner, S. Ö. (2014, Temmuz). Matematik Tarihi Etkinlikleriyle Zenginleştirilmiş Sınıf Ortamlarından Yansımalar: Bir Aksiyon Araştırması. *Doktora Tezi*. Trabzon.

Creswell, J. W., & Clark, V. L. (2014). *Karma Yöntem Araştırmaları Tasarım ve Yürütülmesi* (2 b.). (S. B. Yüksel Dede, Çev.) Ankara: Anı.

Crilly, T. (2018). *Gerçekten Bilmemiz Gereken 50 Matematik Fikri* (7 b.). İstanbul: Domingo.

Dağdelen, İ. (2012). İlköğretim Geometri Öğretiminde Simetri Kavramının Origami ile Modellenmesi. *Yüksek Lisans Tezi*. Samsun.

Erdoğan, A., Eşmen, E., & Fındık, S. (2015, Haziran). Ortaokul matematik ders kitaplarında matematik tarihinin yeri: ekolojik bir analiz. *Marmara Üniversitesi Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi*, s. 239-259.

Ertekin, E., & Ünlü, M. (2020). *Geometri ve Ölçme Öğretimi.* Ankara: Pegem Akademi.

Gündüzalp, M. (2019). 11. Sınıf Öğrencilerinin Matematiksel Modelleme Becerilerinin İncelenmesi. *Marmara Üniversitesi Yüksek Lisans Tezi*.

İdikut, N. (2007). Matematik Öğretiminde Tarihten Yararlanmanın Öğrencilerin Matematiğe Yönelik Tutumlarına Ve Matematik Başarılarına Etkisi. *Yüksek Lisans Tezi*. Van.

Karakuş, F. (2009, Haziran). Matematik Tarihinin Matematik Öğretiminde Kullanılması: Karekök Hesaplamada Babil Metodu. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi, 3*(1), 195-206.

Küçükoğlu, U., & İncikabı, L. (2020). Ortaokul Öğrencilerinin Matematik Tarihi Bağlamında Hazırladıkları Dijital Öyküler Üzerine Bir Araştırma. *Gaziantep Üniversitesi Eğitim Bilimleri Dergisi*.

Martinez, A. A. (2017). *Sıfırın Altında Matematik.* Ankara: TÜBİTAK .

MEB. (2018, Ankara). Matematik Dersi Öğretim Programı İlkokul ve Ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. Sınıflar.

Mersin, N., & Durmuş, S. (2018, 3 2). Matematik Tarihinin Ortaokul Matematik Ders Kitaplarındaki yeri. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 997-1019.

Şaşmaz, H., & Aybek, B. (2022). Ortaokul Matematik Ders Kitaplarındaki Matematik Tarihi Öğelerinin İncelenmesi. *Scientific Educational Studies.*

Taşova, H. İ. (2011). Matematik Öğretmen Adaylarının Modelleme Etkinlikleri Ve Performansı Sürecinde Düşünme Ve Görselleme Becerilerinin İncelenmesi. *Yüksek Lisans Tezi*. İstanbul.

Tokay, E. (2019). Sayılar ve İşlemler ile Bazı Geometrik Kavramların Öğretiminde Matematik Tarihi Kullanımının, İlkokul 4. Sınıf Öğrencilerinin Akademik Başarısına Etkisi. *Yüksek Lisans Tezi*. Karaman.

Ünlü, M. (2014). Geometri Başarısını Etkileyen Faktörler: Bir Yapısal Eşitlik Modellemesi. *Doktora Tezi*.

Yenilmez, K. (2011). Matematik Öğretmeni Adaylarının Matematik Tarihi Dersine İlişkin Düşünceleri. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi,*, 79-90.

Yıldırım, A., & Şimşek, H. (2011). *Sosyal Bilimlerde Nitel Araştırma Yöntemleri* (8 b.). Ankara: Seçkin Yayınevi.

Yıldız, S. G. (2020). Öğretmen adaylarının geometrik modelleme tasarımı sürecinden yansımalar: Tabanın mı yoksa yüksekliğin mi yarısı? *International Journal of Educational Studies in Mathematics*.

Yıldız, Ş., & Yenilmez, K. (2019, Nisan). Matematiksel Modelleme İle İlgili Lisansüstü Tezlerin Tematik İçerik Analizi. *Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi*.