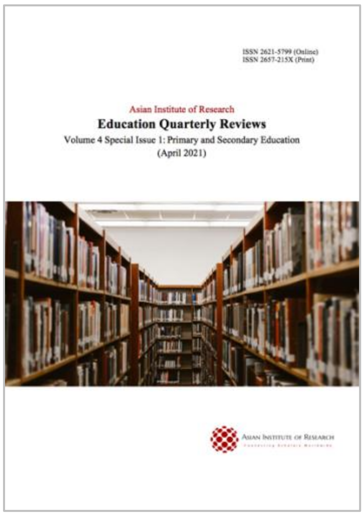

Education Quarterly Reviews

Sabuncu, Firat Hayyam, and Ipek, Jale. (2021), Computer Assisted Education's Effects of Learning the Eighth Grade Math Subjects with Geometer's Sketchpad on Students' Performance Grades and Academical Achievements and Students' Opinions: A Mixed Method Study. In: *Education Quarterly Reviews*, Vol.4 Special Issue 1: Primary and Secondary Education, 307-322.

ISSN 2621-5799

DOI: 10.31014/aior.1993.04.02.248

The online version of this article can be found at:
https://www.asianinstituteofresearch.org/

Published by:
The Asian Institute of Research

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The Asian Institute of Research
Education Quarterly Reviews
Vol.4 Special Issue 1: Primary and Secondary Education, 2021: 307-322
ISSN 2621-5799

DOI: 10.31014/aior.1993.04.02.248

Computer Assisted Education's Effects of Learning the Eighth Grade Math Subjects with Geometer's Sketchpad on Students' Performance Grades and Academical Achievements and Students' Opinions: A Mixed Method Study

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Abstract
In this study, it was aimed to show the effect of computer assisted learning on the academic achievement, performance levels and computer attitudes of 8th grade students in "Transformation Geometry" subject and determine students' opinions about this learning environment. The study was conducted with embedded design, one of the mixed method designs. As a result of the analysis, no statistically significant difference was found between the academic achievement of control and experimental groups. Experimental group students stated that the Geometer's Sketchpad (GSP) software was useful, they expressed that they learnt the subjects better and easier, learning by applying increased their self-confidence and sense of curiosity. It was determined that students were able to establish relationships between the concepts they learnt about real life and the subject of transformation geometry and realized that they could experience mathematical concepts in many areas in daily life.

Keywords: Computer Assisted Instruction, Dynamic Geometry, Geometry Teaching, Student Achievement, Mixed Research Method

1. Introduction

Many countries are trying to integrate education systems that direct the future of society with developing technology (Tuzer Unsal, 2018). According to Akekin Baskaya (2014), there is significant competition for using technology in education in many parts of the world. This competition has enabled computers to be used in all educational content and made the computers one of the indispensable elements of education.

Since computers are used for teaching purposes affect various sensory organs simultaneously, it increases the learning level and the efficiency of the information learned. Using multimedia tools together increases the learning level by compensating for the negativities arising from the usual structure of learning environments (Ceylan, 2008). The interaction of students with computers can show a structure that is liked and provides real-life skills to the student compared to differently designed teaching materials (Senemoglu, 2007).

In the constructivist learning approach the student, who "builds the knowledge," creates a learning system related to the environment through experience and interaction. By participating actively in the environment where the learning takes place, the student combines the latest information he/she learnt with what he/she learnt before and thus creates his/her learning. In this understanding, rational arrangements about the information to be learnt are realized by the learner. Therefore, constructivist learning environments should be prepared in a way that allows students to interact more with their environment and to have a more efficient and effective learning life (Pesen, 2005). The constructivist learning approach is tried to be implemented by the development of many educational software supported by information technologies (Yurdakul, 2004).

National Council of Mathematics Teachers (NCTM) has stated that technology was an appropriate element in terms of mathematical reasoning, expression, problem solving and effective communication. Therefore, widespread use of technology in almost every aspect of our lives necessitates changes in the content and nature of school mathematics programs and it is important for students to use computers to increase their mathematical understanding in accordance with these changes and its use should be supported (NCTM, 2021). According to Bintas and Akilli (2008); Dynamic Geometry Software (DGS) developed for this purpose was help students to reach a higher cognitive level by making connections between geometric shapes and making inferences. DGS enables many geometric shapes to be created in computer environment, to establish relationships between shapes, to make various measurements and comparisons. According to Hyewon and Reys (2013); an up-to-date tool like DGS provides a more motivating, interactive and student-focused method for students to explore relationships. DGS allows students to format the shapes in the computer environment and then change these shapes by dragging their corners or edges and calculate certain properties. In DGS, the relationships created once between lines and figures are preserved in all cases (Van De Walle, 2013).

The results of the study conducted by Hannafin et al. (2008) with 6th grade students using GSP on the spatial abilities of the students revealed that students who learn with GSP activities learn geometry more easily and contribute more to the development of their spatial abilities. In the study of Cetin (2018) where the “transformation geometry” learning processes using DGS of the middle school 7th grade students were examined, it has been determined that DGS is effective in exploring and reasoning mathematical relationships, concept learning and conceptualizing, modelling, making use of multiple representations and concentrating the attention of the students by increasing their motivation. In the study of Thangamani and Eu (2019) where GSP’s effects on students’ success in creating symmetries of two-dimensional shapes were investigated, it has been determined that DGS improves students' academic achievements and attitudes. In the study of Sinclair and Moss (2012) where the effects of dynamic geometry environments on children's geometric thinking were investigated, it has been determined that children's thoughts developed and the diversity of three-sided polygons called “triangles” increased considerably.

1.1. Significance of the study

When the studies conducted in Turkey were examined, it was seen that there was no scientific research examining the effects of transformation geometry sub-learning area and student views by using the 8th grade CAI method according to the renewed mathematics curriculum. In this respect, it was thought that the study would contribute to the literature and it was determined that the use of DGS in middle school mathematics lessons was important in determining students' attitudes towards computers, evaluating their academic achievements and revealing students' views about CAI environment.

The fact that this study will try to exemplify the use of DGS in mixed research design according to the constructivist theory increases the importance of the study.

The aim of this study was to investigate the effect of CAI on "Transformation Geometry" on the academic achievement, performance levels and computer attitudes of 8th grade students in mathematics and determine students' opinions about CAI environment designed with DGS. For this purpose, the following research questions were examined:

1. Does CAI of middle school 8th grade math subjects with Geometer's Sketchpad have an effect on students' academic achievements and attitudes towards computers?
2. What are the experimental group students' opinions on computer assisted geometry learning?

2. Method

This study was based on embedded design, one of the mixed method designs. The mixed method was expressed as a combination of quantitative and qualitative approaches of a study method by Tashakkori and Teddlie (1998). According to Creswell (2003), mixed method is a method of collecting qualitative and quantitative data in a study and analyzing these data according to their importance. In this way, the researcher can better explain the information obtained from the experimental process by collecting qualitative data in addition to an experimental study (Plano Clark and Creswell, 2015). Embedded mixed design is the method in which the perspectives of individuals are combined or sequentially added to experimental data (Creswell, 2016).

2.1 Participants

The research group consisted of a total of 48 students studying in the 8th grade in a public secondary school in Manisa province of Turkey in the academic year of 2016-2017 fall term. In order to determine the homogeneous groups before the study, the success mean points of the 8th graders for the last four years were taken from the e-School system. The findings obtained are given in Table 1.

Table 1: Mean Success Points of Classes for Previous Years According to the Data Taken from the e-School System

Class	8-A	8-B	8-C	8-D	8-E	8-F
Number of Students	24	24	24	28	24	24
Average	74,624	74,359	77,534	71,134	81,608	72,446

As seen in Table 1, it has been determined that 8-A class has the mean of 74,624 and 8-B class has the mean of 74,359. Based on these data, it could be thought that the academic achievement levels of 8-A and 8-B classes were close to each other. Since the same mathematics teacher has been teaching in these two classes, it was thought that they could be suitable classes for the study. In order to determine whether the 8-A and 8-B classes were statistically equivalent or not, the Transformation Geometry Achievement Test was applied to both classes as a pretest and the data sets were analyzed. The findings obtained are given in Table 2.

Table 2: Independent Sample T-Test for Equivalence of Control and Experimental Groups

Group	N	Mean ($\bar{X}$)	Std. Deviation	df	t	p	r
Control	20	3.8310	3.39384	40	0.550	0.585	0.04
Experimental	22	3.1505	4.48705				

According to the results of the Independent Sample T-Test, no statistically significant difference was found between academic achievement test pretest score averages of the control group and the experimental group ($t(40) = -0.55$, $p = 0.585$, $r = 0.04$). The effect size value shows that there is a small difference between the mean scores of the groups ($r = 0.04$). It was determined that the groups chosen before the study were statistically equivalent to each other. Based on these data, 8-A class was assigned to the experimental group and 8-B class was assigned to the control group randomly.

2.2 Quantitative Method

The subject of "transformation geometry" was chosen because of the fact that reflection, symmetry, rotation and translation are among the basic concepts of geometry and it was determined that students have misconceptions about it in the literature. The dynamic geometry software, GSP, was chosen because it is an interactive teaching tool and enables constructivist teaching environments. Transformation geometry sub-learning areas were investigated before the implementation of the study, which was designed using a pretest-posttest control group quasi-experimental design. All the outcomes related to the subject have been determined by examining the curriculum and making use of the studies on sub-learning areas. Considering the opinions of the experts who have worked in the field, it was decided that a 3-week curriculum of 12 hours in total was sufficient for the students to achieve the relevant outcomes. The table of transformation geometry outcomes is given in Table 3.

Table 3: Transformation Geometry Learning Outcomes

Learning Area	**Sub-Learning Area**	**Total Hours**	**Outcomes**
Geometry and Measurement	Transformation Geometry	2	**1.** Creates images of points, segments and other planar shapes under rotation.
Geometry and Measurement	Transformation Geometry	3	**2.** Discovers that each point on the shape in rotation is subjected to clockwise or counter-clockwise transformation at a certain angle around a point, and that the shape and its appearance are identical.
Geometry and Measurement	Transformation Geometry	4	**3.** Draws a polygon in the coordinate system by specifying its image under translation, translation along any line, reflection according to one of its axis and rotation around the origin.
Geometry and Measurement	Transformation Geometry	3	**4.** Creates images of the shapes as a result of up to two consecutive translation, reflection or rotation.

Before the implementation, information about the use of GSP was given to the math teacher of the school by the researcher and several practices were carried out together. Transformation geometry achievement test and computer attitude scale were applied to the both groups as a pretest. Then, 3 hours of training was given by the math teacher in drawing points, segments and polygons, calculating side lengths and areas, creating a coordinate system and determining the coordinates of geometric shapes in order to introduce the GSP software to the experimental group students and to gain them skills in using it in the IT Laboratory. There were 20+1 computers in the laboratory. After the implementation started, the subject of Transformation Geometry was taught to both groups simultaneously by the same math teacher at the school. The control group was taught in the classroom using traditional teaching methods. The experimental group was taught the same subject in the IT Laboratory. The lessons were taught by math teacher with daily lesson plans, worksheets and GSP drafts prepared by the researcher in accordance with the curriculum. Worksheets containing paper-pencil activities, thinking activities and GSP activities were distributed to each student before the lesson. GSP activities were also copied to the desktop of student computers by the researcher before the lesson started. Students created what was asked of them in the worksheets and wrote their findings and generalizations on the worksheets. When it was the turn of the relevant GSP activity in the worksheets, the students opened these drafts on their computers and worked on them. After each activity on the worksheets was completed, the students discussed the findings they obtained and the students who volunteered solved it on the smart board. After the existing worksheets were finished, new worksheets were distributed to the students. The researcher was not present in the IT laboratory during the lesson, but he was ready outside in order to immediately intervene in the malfunctions that may occur in the computers or the smart board and to ensure the effective use of the course time.

The quantitative method of the research is given in Table 4.

Table 4: The Quantitative Method of the Research

Groups	**Number of Students**	**Before Experiment**	**Teaching Method**	**After Experiment**
Experimental	24	Pretest Transformation Geometry Achievement Test Computer Attitude Scale	Computer Assisted	Posttest Transformation Geometry Achievement Test Computer Attitude Scale
Control	24	Pretest Transformation Geometry Achievement Test Computer Attitude Scale	Traditional	Posttest Transformation Geometry Achievement Test

The experimental implementation was carried out in 12 lesson hours for 3 weeks. In the both groups, the subjects were started and completed at the same time. After the implementation, transformation geometry achievement test was applied to both groups as posttest. In addition, computer attitude scale was applied to the experimental group students as a posttest.

2.3 Data Collection Tools

In order to collect quantitative data in this study; students' grade point means of the last 4 years obtained from the e-School system, Transformation Geometry Achievement Test prepared by the researcher to measure the effect of CAI on students' academic achievement, Computer Attitude Scale in order to measure students' attitudes towards computers, worksheets and GSP activities prepared by the researcher were used.

2.4 Worksheets and GSP Activities

Worksheets and activities were designed considering the constructivist theory principles and parallel to the transformation geometry sub-learning area. Thus students were actively been participated in the course by using the features of GSP that requires entry-level experience. At this stage, the mathematics course curriculum, textbooks and studies in the literature were used. Worksheets, containing guiding explanations about the activities that students would study and that could be used in computer environment with the activities prepared for GSP software, were also included activities where drawings could be made with crayons. The examples in the worksheets were prepared in a way similar to the examples in the textbook and include examples of situations they encounter in daily life and real life problems. Students made inferences by working on 36 worksheets and 25 GSP activities. It is aimed that students should observe the transformations of shapes on reflection, rotation and translation, discover the relationships between them, explain the results and reach generalizations with the questioning nature of the worksheets and its open-ended questions. All activity drafts, worksheets and daily lesson plans based on them were examined by two expert academicians who had studies in the field. According to the feedback received from them, necessary corrections were made and the materials were finalized.

2.5 Transformation Geometry Achievement Test

Transformation Geometry Achievement Test was prepared in accordance with the transformation geometry sub-learning area objectives determined in the curriculum. A candidate test consisting of 40 questions, selected from the Ministry of National Education achievement tests and national exams in previous years, was created. In order to increase the content validity and reliability of the test, the number of candidate test questions was planned to be high. A table of specifications for the candidate test was created by taking the joint opinions of three expert researchers who have worked in this field. Thus, it was determined which cognitive process the related outcome of each item belonged. 15 test questions were excluded from the candidate test, thus the final test consisting of

25 questions was prepared. Since the questions were prepared by the Ministry of National Education according to the outcomes and selected with expert opinion, no additional reliability and validity study was conducted.

2.6 Computer Attitude Scale

As a result of the review of the literature, it was observed that there was a correlation between the attitudes towards computers and academic achievement of the students who participated in the CAI implementations. Therefore, it was decided to use Computer Attitude Scale developed by Yuksel (2010) in a current study. The 5-Point Likert Scale, which was prepared to measure middle school students' feelings and opinions about computers, consists of 28 items and 3 factors (computer usefulness, anxiety towards computer, self-confidence in using computer).

2.7 Interview Form

A semi-structured interview form with 9 questions was prepared by the researcher to obtain detailed information about how the experimental group students process the mathematics lessons before the implementation, to learn the positive and negative opinions about the GSP software used during the implementation, to obtain information about the implementation process, to determine students' thoughts about the computer assisted mathematics implementation and their feelings in this process, to reveal their level of associating the concepts they learnt during the implementation with their daily life and to determine their suggestions for implementation. Open-ended questions in the interviews make it possible to reach deep answers regarding the experiences, intuitions, thoughts, feelings and knowledge of individuals (Patton, 2014).

The interview form was reviewed by three academicians who had studied in the field and the form was finalized by making necessary corrections according to the feedback received. With the interview form prepared, a richer understanding about the implementation was tried to be obtained. After the 3-week practice, face-to-face interviews were conducted with the experimental group students (n = 20), lasting an average of 10 minutes. Before the interview, the participants were informed about the purpose of the research, some explanations were made about the interview process and information was given about the confidentiality of the interview. The interviews were recorded with an electronic device that can record audio after the participants' permission. The questions in the interview form were directed to the students and it was ensured that the subject was addressed in a wider perspective by asking probe questions where necessary. After the interviews, the audio recordings were listened to and the answers of the participants were recorded in writing. After the data set was obtained, the audio recordings were listened again, incomplete or erroneous expressions were arranged and the final version of the data set was created. The answers given by the students were preserved and no changes were made in the writing of the statements.

2.8 Data Analysis

In the analysis of the experimental data of the study, the significance level was determined as 0.05 ($\alpha = .05$). Data were analyzed by statistical analysis software.

Content analysis was performed on the qualitative data set obtained from face-to-face interviews with the students in the experimental group. First, the texts were divided into small units such as expressions and sentences, and these parts, which have a meaning integrity in themselves, were coded and grouped to provide a more comprehensive perspective. These codes, which were created by considering the conceptual framework in the semi-structured interview form, enabled the researcher to make evaluations in line with its purpose. The new codes that emerged within this framework were added to the list and the analysis continued with the pre-determined codes and the data detected by examining the data set were added to the previously determined code list. The expressions of the students were compared with the existing code list, as a result, either a new code was created or added to the previously detected code frequency. After the coding process was completed common aspects between the codes were determined, sub-themes that can gather the codes under certain groups and themes that can explain the sub-themes at a general level were created. The data were coded independently by a field expert under these determined themes. The differences of opinion among the coders were eliminated by discussing and the themes were rearranged by re-examining the codes according to the accepted ideas. Themes were defined and explained in plain language. The qualitative data obtained were expressed in tables and digitized by frequency analysis and percentage calculation. In addition, direct quotations from the interviews with students were included in the findings section. Students were coded as Student1, Student2, etc.

2.9 Construct Validity

It could be stated that the transformation geometry achievement test, worksheets and GSP activities developed by the researcher, have construct validity because they were prepared by taking expert opinions. Reliability studies and factor analysis of the Computer Attitude Scale used in the study were performed by the researcher who developed it. It can also be stated that the semi-structured interview form prepared by the researcher has construct validity since it was developed by taking expert opinions.

2.10 Internal Validity

The researcher made his evaluations by avoiding subjective judgments in the interpretation of qualitative findings. In addition, the researcher took the necessary care to ensure that the findings reflect the real situation in the most accurate way by evaluating the comments on the results with the field experts. In order to ensure internal validity, the research environment, framework and the role of the researcher have been carefully specified.

2.11 External Validity

The generalizability of a study is related to external validity. In this study, in order to ensure external validity, the whole process of the study and the features of the chosen methodwase discussed in detail and information was given about the data analysis stage. Each stage regarding the analysis of the data, determining the codes and themes, and how the findings were interpreted were described in detail. Thus, it could be stated that enabling other researchers to make sense of the results of this study and to conduct similar studies in a different environment will increase external validity.

2.12 Reliability

The reliability was tried to be ensured by clearly expressing the role of the researcher in the research, by defining participants who are data sources, by taking the necessary precautions to reach the right information, by giving descriptions of data collection and analysis methods, by specifying the theoretical framework used in data analysis, by carefully displaying information obtained from different data collection tools and by digitizing qualitative data.

2.13 The Role of the Researcher

The researcher examined the facts objectively in the quantitative step of the embedded mixed method research. The pretests and posttests were applied together with the mathematics teacher but the researcher wasn't taken part in the lessons. After the lessons, he met with the mathematics teacher and got information about the implementation. Thus, he tried to define the facts by trying to stay outside of the research. The researcher tried to collect the data that could be explained quantitatively by using the standard measurement tools determined by keeping environmental conditions that could affect the cause-effect relationships between the variables under control and to explain the results by analyzing these data statistically. In the qualitative step, the researcher made interviews with the students in the experimental group, asked the questions prepared in this context to the participants and refrained from commenting. During the interviews, he tried to create an environment where the students could feel comfortable. He tried to keep his own assumptions and prejudices separate from the findings he obtained and expressed his personal views after analyzing the data he collected.

3. Findings

The quantitative and qualitative data collected during the research process were analyzed in accordance with the research problems and findings were obtained. The findings of the quantitative sub-problems were shown in tables. Findings of qualitative sub-problems were expressed with patterns by adhering to the themes and codes obtained as a result of the content analysis.

3.1 Does CAI of middle school 8th grade math subjects with Geometer's Sketchpad have an effect on students' academic achievements and attitudes towards computers?

3.1.1 Is There a Difference Between the Academic Achievements of the Control and Experimental Groups?
Covariance analysis is a technique that enables the control of another variable called common variable (pretest) that has a relationship with the dependent variable (posttest) apart from the independent variable (CAI) whose effect is tested. It extracts the changes originating from the co-variable from the dependent variable and then explains whether the change in the dependent variable is due to the independent variable. In the analysis, pretest was determined as a covariate because it was the variable that showed the highest correlation with the posttest. Thus, the variance caused by the external factor whose effect is observed on the dependent variable can be controlled and the power of the test is increased.

It was determined that all the assumptions required for the analysis (the need of a linear relationship between the dependent variable and covariate, the scores of the dependent variable for each of the groups are normally distributed and their variances are homogeneous, the regression slopes -coefficients- are equal within the groups) were met before ANCOVA Covariance Analysis was performed.

Table 5: ANCOVA Analysis of the Pretest Corrected Posttest Scores According to Groups

Source	Sum of Squares	df	Mean Square	F	p	η^2
Pretest	606.036	1	606.036	23.787	.000	.362
Groups	1.251	1	1.251	0.049	.826	.001
Error	1070.051	42	25.477			
Total	7037.688	45				

According to ANCOVA results given in Table 5, no statistically significant difference was found between the pretest-corrected posttest scores of the students studying in the control and experimental groups ($F(1,42) = 0.049$, $p > .05$, $\eta^2 = .001$). The finding of Eta-square (η^2) .001, which is the effect size, can be interpreted as 1% of the variance of achievement test scores originates from GSP supported education. This finding means that GSP supported instruction has a very low effect on Transformation Geometry Achievement Test scores.

3.1.2 Does Use Dynamic Geometry Software in Mathematics Teaching Have an Effect on Attitude Towards Computer?
Before the implementation, Computer Attitude Scale pretest was conducted to determine whether there was a difference between the groups' attitudes towards computers.

Table 6: Mann-Whitney U Test for the Computer Attitude Scale Pretest Results of the Groups

Group	N	Mean Rank	Sum of Ranks	U	p	r
Control	24	19.58	470.00	170.000	.039	-0.31
Experimental	22	27.77	611.00			

According to the results of the Mann-Whitney U test given in Table 6, a statistically significant difference was found between the Computer Attitude Scale pretest mean scores of the groups ($U = 170{,}000$, $p = 0.039$, $z = -2.069$, $r = -0.31$). The effect size value indicates a moderate difference ($r = -0.31$).

Computer Attitude Scale posttest was conducted to determine whether there was a change in the attitudes of the experimental group towards computers after the implementation.

Table 7: Wilcoxon Signed Ranks Test of the Experimental Group's Computer Attitude Scale Before and After Implementation

Posttest-Pretest	N	Mean Rank	Sum of Ranks	z	p	r
Negative Rank	4	12.00	48.50	-1.893*	.058	-0.41
Positive Rank	15	9.47	142.00			
Ties	2	-	-			

* Based on negative ranks.

According to the results of the Wilcoxon Signed Ranks Test given in Table 7, the use of CAI in mathematics teaching has no effect on computer attitude (T = 48.50, p = 0.058, z = -1.893, r = -0.41). The effect size value shows that there is a moderate difference between pretest and posttest (r = -0.41).

It was also examined whether there was changes in the attitude mean scores of the sub-factors of the Computer Attitude Scale before and after the implementation of the experimental group students. It was found that only one of the three sub-factors changed.

Table 8: Wilcoxon Signed Ranks Test Regarding Pretest and Posttest Mean Scores of the Experimental Group's Computer Attitude Scale "Self-Confidence in Using Computer" Sub-Factor

Posttest-Pretest	N	Mean Rank	Sum of Ranks	z	p	r
Negative Rank	3	10.00	30.00	-2.623*	.009	-0.56
Positive Rank	16	10.00	160.00			
Ties	3	-	-			

* Based on negative ranks.

As seen in Table 8, a statistically significant difference was found in the attitude scores of the experimental group students before and after the implementation, belonging to the "self-confidence in using computer" sub-factor determined in the Computer Attitude Scale (p = 0.009, p <,05, r = -0.56). Considering the rank totals of the difference scores, it is seen that the observed difference is in favor of the posttest mean scores. This finding means that there is a positive increase in students' self-confidence attitudes while using computers. The effect size value indicates a moderate difference (r = -0.56).

3.2 What are the Experimental Group Students' Opinions on Computer Assisted Geometry Learning?

"How did you used to learn geometry lesson before this practice?" The findings obtained from the experimental group students' answers to this question are given in Table 9.

Table 9: Experimental Group Students' Opinions Regarding the Learning of Geometry Topics Before Implementation

Theme	Sub Theme	Frequency (*f*)	Percent (%)
Learning the Subject Using Technology	By writing / drawing on the board	16	80
	By writing in the notebook	16	80
	From smart board	16	80
	From textbook	11	55
Learning Method of the Subject	By solving example	13	65
	Teacher is telling	13	65
	By solving the test	4	20
	Question-answer	3	15
	By memorizing	2	10
	By giving homework	1	5

One of the students used the following expressions on the theme of "learning the subject using technology":
“The teacher was drawing on the board. We were writing in the notebook according to him and we were working according to what the teacher told on the board. Sometimes he showed it on the smart board, sometimes we used the textbook." [Student9]

It was concluded that the lessons were taught using the traditional teaching method in the classroom, various implementations were opened from the smart board and the subjects were learnt by making use of some educational websites and DGSs were not used.

“What are your positive thoughts about Geometer's Sketchpad? Can you explain the reason?” The findings obtained from answers to this question are given in Table 10.

Table 10: The Views of the Experimental Group Students on Geometer's Sketchpad

Theme	Sub Theme	Frequency (*f*)	Percent (%)
For Use	I don't need to write / draw	5	25
	There’s more opportunity	3	15
	Noise in the classroom has decreased	1	5
For Learning	I learnt / understood better / quicker / easier	13	65
	We learnt by applying	12	60
	Made easy to learn	7	35
	Proves / becomes permanent	3	15
For Individual	Very good / nice / positive / useful / helpful	12	60
	I liked it	4	20
	I felt better / confidence	2	10

One of the students used the following expressions on the theme of "for use”:
"When I press the menu in the software, it comes out automatically without having to draw." [Student4]

One of the students said the following about the theme of "for learning”:
“This software has given us better results in this regard. We understood this issue better. It improved us better. Because we create shapes ourselves. We draw, create and reflect the shapes exactly ourselves." [Student17]

One of the students used the following expressions regarding the theme "for individual":
“It was very helpful. Because in the past, we could not get this much information even though the teacher told us. When the teacher showed more examples, it became more efficient. We learnt better. While doing it on the computer, I felt like a teacher." [Student6]

Based on the answers given by the students, it could be stated that the students found the GSP software useful in general; it helped them to understand the subject better and easier because they learnt by applying it and unlike in traditional learning environments, they did not need to use paper and pencil constantly. Also learning by applying had a positive effect on students' spatial competence, made them happy and had a positive effect on their self-confidence.

"What are your negative thoughts about Geometer's Sketchpad? Did you encounter any difficulties while using this software? Can you explain why?" Based on the answers given by the students, it could be stated that most of them (90%) did not have negative thoughts about GSP and most of them (70%) did not encounter any difficulties. It could be said that a few students had difficulty and fall behind (20%).

“Would you like to do individual study or group study during the practice? Can you explain why?" The findings obtained from answers to this question are given in Table 11.

Table 11: Individual Study and Group Study Preferences of Experimental Group Students

Theme	Sub Theme	Frequency (*f*)	Percent (%)
Individual Study	Individual study	8	40
	We can learn better by ourselves	6	30
	Others may have a different view	5	25
	I feel better when I'm alone	2	10
	Not everyone can find opportunities in group study	1	5
	I can reflect my thoughts better	1	5
	I had the opportunity to review the software / did different things	1	5
	If I do wrong I'm afraid of my friend's reaction	1	5
Group Study	Group study	9	45
	We can help each other / share the thought	7	35
	Different ideas allow us to learn better	4	20
	It's more fun to do together	2	10

One of the students used the following expressions on the theme of "individual study”:
"Individual. When we are many people, not everyone has an opportunity. I can understand better when I'm single. I feel better when I'm alone." [Student3]

One of the students said the following about the theme of "group study”:
"Group study. I think it would be better that way. We can ask our friends what we do not understand. Otherwise, when we study as a single individual, we cannot ask what we do not know. Then when the teacher passes, you are left behind. So I think it should be a group." [Student19]

Based on the answers given by the students, it could be said that half of the class preferred individual study and the other half preferred group study. There were students stated that they gave importance to the ideas of their friends and group study increased social interaction and sharing. Some students preferred to work individually because it provided the opportunity to research topics they were curious about and individual learning provided them more satisfaction. Also some students who were sensitive to the issue of individual differences expressed their desire to study individually. Due to the subjective nature of students, it might be beneficial to recognize and acknowledge these differences and give students the chance to choose environments in which they can study individually or in groups.

“Were there any factors that disrupted the teaching of the lesson? If so, would you explain them?" Considering the answers given by the students to the 5th question, most of them (70%) stated that there was no factor that disrupts the teaching of the lesson. Among those who stated that there were (30%), the sub-theme "some students spoke / misbehaved" was 25%, the sub-theme was "power cut" was 5%, the "computers were slow" sub-theme was 5% and the sub-theme "there was a problem in the seating arrangement" was expressed at a rate of 5%.

“What are your thoughts on computer assisted mathematics teaching? What did you feel while doing this study? (e.g. curiosity, success, failure, amusement, boredom, surprise, difficulty, happiness) Can you explain the reason?" The findings obtained from answers to this question are given in Table 12.

Table 12: Thoughts of Students on Computer Assisted Mathematics Teaching

Theme	Sub Theme	Frequency (*f*)	Percent (%)
Newness	I was curious about the next parts of the lesson	16	80
	Those who do not like mathematics love with computers	1	5
	More attractive	1	5
	It enabled us to process the lesson fast	1	5
Self Confidence	I've been / have felt more successful	15	75
	I understood / learnt better / easier / quicker	12	60
	Lessons were easy / made easy	6	30
Satisfaction	I had fun / it was fun	16	80
	I was / felt happy	15	75
	I was never bored	5	25
	I like using a computer	5	25
	I was excited	4	20
	What I could do gave me confidence	1	5
Willingness	Better / good / useful	15	75
	It gets more catchy	2	10
	I attended the lesson more	2	10
	No fear of getting on the board because you do it on the computer	1	5
Negative Thoughts	Sometimes I struggled / felt unsuccessful	7	35
	It is not catchy when you do not write	1	5
	I can't use the computer well	1	5
	I was bored sometimes	1	5
	Clicking on the wrong place needs to select the points again.	1	5

One of the students used the following expressions on the theme of "newness":
"This is the first time we have done such a study. So I wondered what we were going to do." [Student14]

One of the students said the following about the theme of "self-confidence":
"I helped some of our friends when they couldn't do it, for example when they couldn't rotate, I realized that I understood better and I felt successful." [Student15]

One of the students used the following expressions regarding the theme "satisfaction":
"It was very nice, it was fun. I felt happy because computer assisted learning is better." [Student12]

One of the students used the following expressions on the theme of "willingness":
"Computer assisted instruction is better." [Student2]

One of the students said the following about the theme of "negative thoughts":
"Sometimes I had a hard time, looked at it from my friends, even how it was done. I was not happy." [Student20]

Based on the answers given by the students, it could be said that the vast majority of students found computer-assisted mathematics teaching more useful, had fun in the lesson, felt happier, wondered what they would learn in lessons, felt more successful, understood and learnt better but some students had difficulty from time to time. In this context, it could be stated that CAI increased students' interest in the lesson more, made them love mathematics, facilitated to understand the subject better and found the lesson enjoyable compared to the traditional teaching method.
"Do you encounter the concepts you learnt about Transformation Geometry in your daily life? If so, would you explain them?" The findings obtained from answers to this question are given in Table 13.

One of the students used the following expressions on the theme of "rotation”:
"Yes. Ferris wheel. The rotation of the clock, the angle between the hours." [Student4]

One of the students said the following about the theme of "reflection”:
“So, reflection; we are going for a drive with my father. He sees the back through the car mirror, it reflects. I see myself when I look at the puddle." [Student19]
One of the students used the following expressions regarding the theme "translation":
"When we push the table and the desk and when we pull them back, they will be translated." [Student13]

One of the students used the following expressions on the theme of "translational reflection”:
"Our footprints in the sand may be translational reflection." [Student6]

Based on the answers given by the students, it could be said that they could make connections between the concepts they have learnt about transformation geometry with the situations they encountered in daily life, they could better understand the geometry of the various movements of objects, in short, they realized that there was mathematics in situations that they can encounter at any moment in daily life and that mathematics was a part of life.

Table 13: Opinions of Students Related to Situations in Daily Life with Transformation Geometry Concepts

Theme	Sub Theme	Frequency (*f*)	Percent (%)
Rotation	Ferris wheel	9	45
	The rotation of the wheel	5	25
	Rotation of the hour and minute hands	4	20
	Rotation of the propeller	3	15
	Rotation of the carousel	2	10
	The rotation of the earth	1	5
	Rotation of the washing machine drum	1	5
	Rotation of the tap	1	5
Reflection	Symmetry / reflection in the mirror	16	80
	Reflection in the lake	7	35
	Reflection in the rear-view mirror of cars	3	15
Translation	Translation of the table and desk	3	15
	Translation of the chair	2	10
	Translation of the box	1	5
	Translation of the pencil	1	5
	Translation of the wheelbarrow	1	5
	Translation of the tile stones	1	5
Translational Reflection	Footprints in the sand	2	10
	Patterns on carpets	1	5
	Coordinates in games	1	5

“Do you think this software will contribute to teaching mathematics? Can you explain why?" The findings obtained from answers to this question are given in Table 14.

Table 14: Students' Opinions Regarding the Contribution of the Implementation to Teaching Mathematics

Theme	Sub Theme	Frequency (*f*)	Percent (%)
Contributions to Course Management	Done by applying	8	40
	Provides a visual environment	4	20
	Creates more time to solve the test	2	10
	Saves from writing	1	5
	Eliminates the worry of forgetting the notebook and book	1	5
	Allows to save and review the recorded ones	1	5
Contributions to Permanence	Provides better learning / understanding opportunities	11	55
	Ensures that what has been learnt is permanent	6	30
Emotional Contributions	Makes it more fun	2	10
	Makes you love math	2	10

One of the students used the following expressions on the theme of "contributions to course management”:
“It is better to learn by seeing. It is better to do it by applying." [Student1]

One of the students said the following about the theme of "contributions to permanence”:
“I learnt better reflection and coordinates. Last year I was having difficulties in these matters. I learnt better this year.” [Student8]

One of the students used the following expressions regarding the theme "emotional contributions”:
"For example, students who do not like mathematics can start to love mathematics thanks to such a software." [Student9]

Based on the answers given by the students, it could be said that GSP software made the learning environment student-centered, provided better learning opportunities and helped the information they learnt to be more permanent due to the visual environment and implementation opportunities provided to students. CAI would contribute to students' development of a more positive perspective on mathematics lesson, help students overcome their fear of mathematics and make the lesson more enjoyable.

“Finally, do you want to add anything or do you have any suggestions about education? If so, what are they?" The findings obtained from answers to this question are given in Table 15.

Table 15: Suggestions Expressed by Experimental Group Students about Education

Theme	Sub Theme	Frequency (*f*)	Percent (%)
Suggestions	It's getting more efficient with the computer	6	30
	Everyone should learn geometry with a computer (Sketchpad)	3	15
	Should be applied to other students as well	3	15
	Makes it easier to learn	2	10
	Every lesson should be taught with a computer	2	10

One of the students used the following expressions on the theme of "suggestions”:
“Sketchpad should always be used in mathematics and geometry. Every student, every class should use it." [Student13]

Based on the answers given by the students, it could be said that the implementation of CAI was more efficient, it should be applied to all students in other lessons, and it provided easier learning of the subjects due to its student-centered approach. It is understood that the students participated in the study generally welcomed the experimental implementation. There were no students who expressed negative opinions.

4. Discussion and Conclusion

The results of the first research question indicated that when the posttest scores of the control and experimental groups were compared, no statistically significant difference was found between the posttest scores. Although there was no difference between the achievement levels of the groups, it was stated in the interviews with the experimental group students that the CAI method was generally useful. Also it was stated that the practice-based learning process, which included visual elements that put the student at the center, provided a better understanding of the subject, students felt more successful and happier, found the lesson more enjoyable compared to the traditional teaching method, and this practice should be done in other classes and schools. It was determined that there was a statistically significant difference between the mean scores of the computer attitude of the groups before the implementation and this difference was in favour of the experimental group. It was analyzed whether there was a difference between the pretest and posttest attitude mean scores of the experimental group after the implementation and a significant difference was found in favour of the posttest results of the experimental group in the "self-confidence in using computer" factor, which is one of the sub-factors of the Computer Attitude Scale. These findings revealed that the CAI implementation increased the confidence of the students while using the computer. Findings related to the theme of "self-confidence" determined as a result of qualitative analysis also supported the findings obtained from the experimental implementation.

The results of the second research question indicated that the students taught previous lessons in the classroom with traditional teaching method, CAI applications were not performed and the teacher only used the smart board among the IT tools. The students found the GSP software useful, they stated that they learnt the subjects better and easier and learning by practicing increased their self-confidence, they felt happier, CAI increased their curiosity and they had fun in the lesson. It was determined that the experimental group did not have a negative opinion about GSP to a large extent and only a few students had difficulty using it. Half of the students stated that they preferred individual study and half of the students preferred group study. It was determined that students' preferences to study individually or in groups should be respected in order to create equal opportunities in education and to take into account individual differences. Students were able to establish relationships between real life and the concepts they learnt about transformation geometry. They also realized that they could encounter mathematical elements in many areas in daily life. The students stated that it would be beneficial to implement CAI application in other mathematics lessons, even in other lessons and schools.

The contribution of the media to learning is a controversial issue in the field of instructional technology. While Clark (1995, p.23) argues that “media will never affect learning and media is neither sufficient nor necessary for learning”; Kozma (1994) argues that the media learning relationship is an area that has not been discovered yet and the potential of this relationship should be examined by research. This ongoing debate is called the Clark-Kozma debate in the field of instructional technology. Tamim et al. (2011), as a result of the second-level meta-analysis of instructional technology studies spanning a period of 40 years, revealed that using technology in teaching increases learning. It is unnecessary to make a general claim that the use of technology can improve or not affect learning (Becker, 2010). Instructional technology can support learning for some groups of participants, on some topics and under some conditions; however, this is true for all pedagogical interventions (Mann, 1999, p. 5). In this context, Kirschner and van Merriënboer (2013) advocates that methods that work should reveal under which conditions, in which educational situations, and “how” it helps to achieve that goals rather than examining "what works" in instructional technology research. It is clear that more collaboration is needed between researchers and teachers to explain the nature of learning and the technology-learning relationship.

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