ISSN: 2148-9955

International Journal of Research in Education and Science (IJRES)

www.ijres.net

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To cite this article:

Kandemir, M.A. & Demirbag Keskin, P. (2019). Effect of graphing calculator program supported problem solving instruction on mathematical achievement and attitude. *International Journal of Research in Education and Science (IJRES), 5*(1), 203-223.

International Journal of Research in Education and Science

Volume 5, Issue 1, Winter 2019 ISSN: 2148-9955

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Article Info

Article History

Received:
16 August 2018

Accepted:
07 November 2018

Keywords

Graphing calculator
Technology supported math instruction
Transformation geometry
Geometry attitude
Transformation geometry achievement

Abstract

This research was carried out to investigate the effect of graphing calculator program supported problem solving instruction on mathematical achievement and attitude in transformation geometry subject. The study was carried out with 49 seventh grade students in a middle school in Balikesir province. A pre-test post-test quasi-experimental design with two groups was used in the study. The experimental group received transformation geometry instruction supported by a graphing calculator program, while the control group received transformation geometry instruction without using any technological material for 6 weeks. Achievement of the students was assessed with the Transformation Geometry Achievement Test, while their attitudes were assessed with the Geometry Attitude Scale. For the analysis of the data obtained from the tests, independent samples *t* test and Two-Way ANOVA for Mixed Measures were used. As a result of the analysis of the data, a positive significant difference was obtained in favor of the experimental group for the mathematical achievement, while there was no significant difference between the experimental and control groups for attitudes towards geometry. Controlling the gender variable, the ANCOVA test was applied to attitude scores and a positive significant difference was obtained in favor of the experimental group. Reflective observation forms and interviews were used to collect qualitative data. Qualitative data were analyzed by descriptive content analysis and divided into themes and codes. As a result of the analysis, it was determined that the students in the experimental group generally stated that the graphing calculator program made their knowledge permanent, facilitated their learning, developed a positive attitude towards the lesson and made the lesson enjoyable.

Introduction

Change is not something special about nature, but it is also a valid rule for people and societies. Changes in science and technology that have become intertwined with our lives constantly affect societies and people and force them to change (Ersoy, 2003). The developing technology has changed the structure of the education process and brought a new understanding. Keeping up with changing time and education processes can only be possible with more learning and knowledge. Information has been seen as equivalent to the power in time, and it has created the aim of raising individuals who can use these technologies comfortably, produce information, present and share information. Acceleration of technology in each area has enabled the integration of technology in education. Rather than to bring technology to the classroom, the question of how to integrate technology into education is becoming increasingly important. This led to the emergence of different types of information (Çakır & Yıldırım, 2009).

There are many examples that prove that technology integration in learning and teaching has a crucial place (Ertmer, Gopalakrishman, & Ross, 2001; Ferdig, 2006; Russell et al., 2003). Technology integration especially develops teacher-student relationships (McGrath, 1998), supports project-based learning (Chan Lin, 2008; Park & Ertmer, 2007), and contributes to problem solving and thinking skills (Barron et al., 2003). Harris (2008) described technology integration as a widespread and efficient use of educational technologies for learning and teaching purposes. For this reason, technology integration is the constant use of technology by teachers at all stages of the lesson.

While the integration of technology in education is becoming important in the world, some changes in Turkey have started to occur as well. In Turkish mathematics curriculum, the importance of technology supported mathematics education and the necessity of technology as a supplementary factor teaching methods were emphasized (MoNE, 2013; 2018). In this case, the educational reflection of technological developments was first actualized with participation of computers in the educational environment, which is an individual and effective means of communication (Güven & Sülün, 2012). Computers are not the only tools integrated into education. With the continuous development of the computer and the increase of teaching software, the technology alternatives have increased in education. One of these tools is calculator where the renewed curriculum emphasizes (MoNE, 2013; 2018). In this research, transformation geometry instruction was performed with the help of a graphing calculator program that can be used other than dynamic geometry software. Researchers investigated whether the instruction affected the students' success on the transformation geometry and their attitudes towards geometry.

Literature Review

In this section, technology supported instruction, technology supported learning, graphic calculator, and transformation geometry instruction topics will be reviewed.

Technology Supported Instruction

Technology is now being considered by many educators as a means to enhance the quality of education. This situation naturally increases the technological advancements in the educational environment day by day. Teachers are trying to raise individuals who do not get the information ready, rather who can access the information themselves and use that information they reach in the way they want (Çakır & Yıldırım, 2009). Out of all these, technology integration that means to add technology into education has emerged. Technology integration means teachers' use of technology to improve the success of their students (Hew & Brush, 2007).

Leng (2011), in her study with 35 middle school students in Singapore, has seen that graphing calculators allow the teacher to facilitate learning when these technological tools integrated into instruction. Özgün-Koca, Meagher and Edwards (2011) in their study stated that the role of teacher and the presentation of information differ according to the usage diversity of the technology, while the technology is integrated into the lesson. Technology has to be well integrated into instruction in order to be used in schools and teaching. Trouble in the integration of technology is not only difficulties due to lack of technical support or usage information. It is also due to the lack of knowledge on teachers' technology integration. These shortcomings also affect the development of technology integration. Thus, this led to the emergence of pedagogy-oriented models of how knowledge and skills related to technology are as important as the use of technology (Yurdakul, 2011).

Technological Pedagogical Content Knowledge

Many studies in recent years have shown that it is a great disservice to students to keep technology apart from pedagogy and that this disservice may even spread to educational technologies (Cuban, 2001; Hooper & Rieber, 1995). Thus, these studies seek to expand the pedagogical content knowledge model of Shulman (1986, 1987), which includes technology (Mishra & Koehler, 2006). This combination of content, technology and pedagogy is defined as content knowledge of techno-pedagogy. This association was not fully known before their work because the existence of the relationship between these three fields was explicitly spoken for the first time in the work of Mishra and Koehler. The techno-pedagogical content knowledge is a model that was developed for teachers by adding technology on the pedagogical content knowledge identified by Shulman (1986; Yurdakul, 2011). The other components of the model consist of the combination and intersection of these components. These components include; pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge (Mishra & Koehler, 2006; Koehler & Mishra, 2008; Sahin, 2011). The component that forms the basis of the model is the component of technological pedagogical content knowledge, which has a broader and deeper meaning than the combination of only three basic components (Koehler & Mishra, 2005). The visual state of the model is given in Figure 1 below:

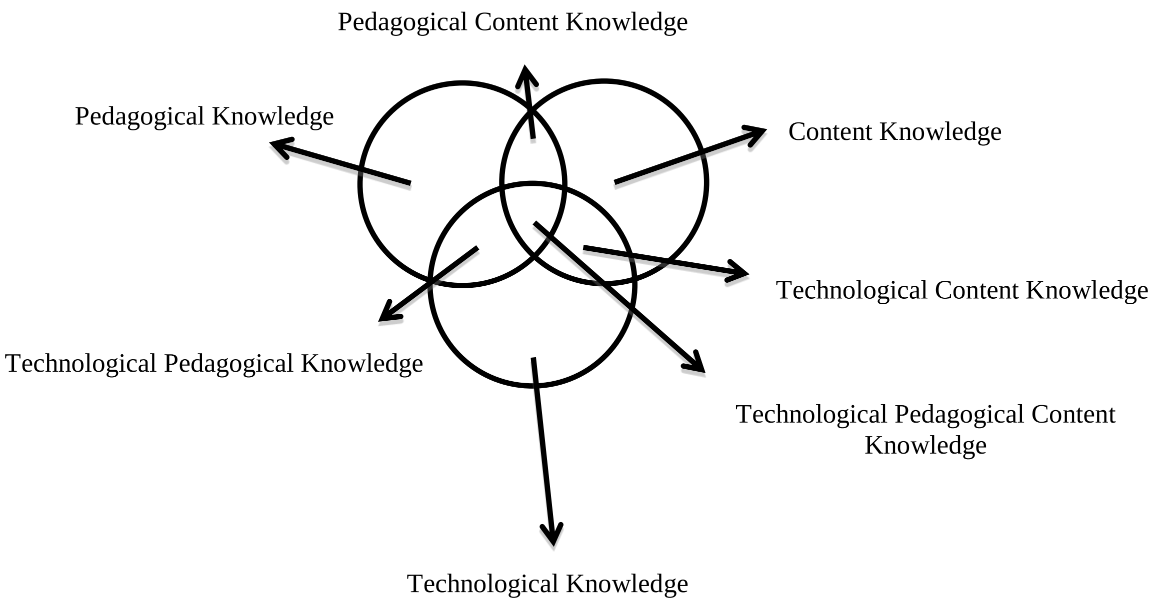

Figure 1. Technological pedagogical content knowledge (Mishra & Koehler, 2006).

If all the components shown in the figure are explained, then the content knowledge is to know the subject matter while the pedagogical knowledge is to know the teaching methods and the techniques. In this case, the technological pedagogical knowledge includes the knowledge of the teaching methods and the techniques using technology. Hillman (2014), in his work with two classroom teachers, found that the first teacher used the calculator to help students make assumptions and then verify their assumptions. The students of the second teacher, on the other hand, used the calculator as a tool to alleviate the calculation burden. Therefore, pedagogical perspectives of teachers have resulted in a great effect on how they choose to use the technology. Lee and Kim (2017) in their study stated that in the TPACK model, which puts distinctive, convergent and integrated views in a comprehensive and applicable framework, external factors are also accounted for based on strategies related to learning experiences in real life, role-playing and teachers as designers. So that, it has been found that the implementation of TPACK has an auxiliary role in the training of teachers and in deepening students' understanding of technology applications.

Technology Supported Learning

Two approaches have emerged for the use of technology in schools: these are called learning from technology and learning with technology. Learning from technology means that given contents are presented with the help of technology and that learning will occur in this way. In the definition of learning with technology, it is said that the technology should be considered as a mental partner of the learner since it is a tool to help the high-level thinking of students (Jonasse, Peck, & Wilson, 1999). Wachira, Keengwe, and Onchwari (2008) in their study stated that they could provide deep learning in mathematics when technology is used effectively as a tool. Liang (2016) in his study stated that students learn better by understanding the definition of limit with graphic calculator because of the dynamic visualization of functions.

Graphing Calculator

As technology has developed rapidly, societies have begun to adapt them in their ways. Raising individuals who think critical, understand the problem, interpret the problem, establish relations with the individuals, and are creative and curious have gained importance (Baki & Çelik, 2005). Recently, technological tools such as computer, Internet, software and calculators have started to be used in the field of education and become widespread due to the reflection of technology in education. In Turkey, as in other countries, the integration of technology into primary and secondary school mathematics curriculum has also started (Akkan & Çakıroğlu, 2011). Technology can play a fundamental role in education, especially in mathematics education. Graphing calculators, one of these technological tools, continue to maintain their importance in mathematics lessons since

1985. Graphical calculators are handheld devices that can provide computations, graphing, and numerical solutions for functions and equations (Karadeniz & Thompson, 2018).

The importance of effective use of graphic calculators in curricula is emphasized. The calculators help students make their learning more concrete and meaningful. As the developing world wants to raise problem solver individuals, the placement of the problem solving mentality can be made possible by integrating the calculators into the teaching environment. These machines are not only simple machines capable of four operations but also many advanced calculations. The benefits of integration of the graphing calculators into the education can be listed as follows (Ersoy, 2005):

- Graphic calculators are easy to access and portable, so they can be used in lessons.
- Students can deal with real mathematics through graphing calculators and link mathematics with everyday life.
- Because calculations are easy with graphing calculators, students can deal with numbers in real life problems rather than small numbers, so students can be more interested in problem solving instead of numbers.
- Graphing calculators improve predicting ability and allow you to control the answer.
- Graphing calculators provide more opportunities for mathematical modeling and transformation and can make the lesson more concrete.

The use of a graphing calculator improves mathematics learning for students. Calculators are not just for calculating. Calculators can also be used when there is computation in the problem but the purpose is not computation. For example, when calculating percentage ratios it can help find the best discount rate. Calculators are also useful for creating patterns. They improve problem solving. According to Van De Walle, Karp and Williams (2014), students who frequently use the calculator develop positive attitude towards mathematics. Karadeniz and Thompson (2018) noted that using a graphing calculator in their work allows teachers and students to spend more time discussing mathematical concepts, allowing students to meet at a common starting point.

Lee and McDougall (2010) have taught students how to plot linear equations with graphing calculators. At the end of the instruction, the teacher stated that the productivity of the learner increased and the students made the real world connections more easily. Another teacher stated that he was saving more time than paper-pencil method when he mastered the use of graphic calculators to solve mathematical problems. McCulloch (2011), in his study qualitatively examining the effects and perceptions when graphing on the calculator, found that calculators helped to monitor a productive emotional path that supports and enhances mathematical success whatever calculation was done. Çelik (2013) stated in his study that students gain time for computing when they use graphing calculators, spend more time learning mathematical concepts, and can make exploratory projects to improve their mathematical understanding.

Transformation Geometry Teaching

Transformation geometry has a feature that allows students to think creatively. Students will be able to link mathematics and art with the knowledge and skills they acquire when learning this topic. In addition, students will be able to use mathematics in their daily lives and understand the importance of mathematics. For example, seeing repeating, translating, or rotating shapes in a rug pattern will cause them to look around differently. The teacher should have a good drawing ability for effective teaching of such a subject matter that will affect the students' point of view. The fact that the teacher's drawings are bad makes it difficult to present to the students and affects their understanding (Duatepe & Ersoy, 2003).

Harper (2003), in his qualitative study with teachers, performed the teaching of geometric transformations with the help of dynamic computer software, and the results of the study showed that teachers' knowledge about geometric transformations differed positively compared to the pre-intervention. Çetin, Erdoğan, and Yazlık (2015) in their study of Geogebra-supported transformation geometry teaching obtained a meaningful difference in favor of the experimental group. Under the transformation geometry, concepts of reflection, translation, image, and symmetry line in the translation, reflection, symmetry and rotation are among the subjects to be handled in the 7th grade, while rotation, center of rotation and angle of rotation are among the subjects to be handled in the 8th grade (MoNE, 2018).

Method

This section will provide information on the research design, the purpose and objectives of the study, the study group, the data collection tools and the analysis of the data.

The Purpose and Importance of Research

The purpose of this study is to examine the effect of problem solving instruction supported by graphing calculator program on 7th grade students' achievement and attitude in mathematics lesson. Views regarding mathematics instruction supported by graphing calculator program have been examined with interviews made with students and reflective observation forms. It is aimed to evaluate the effect of the calculator supported instruction on the learning of the subject matter.

The renewed middle school mathematics curriculum emphasizes the need for students to gain competence in science and technology. Competence in science is having knowledge and methodology to explain the world in order to produce results based on evidence, while competence in technology means application of knowledge and methodology to meet the perceived human desires and needs. Along with the changing world, mathematics curricula aim to educate qualified people in science and technology (MoNE, 2018). Due to the fact that it is seen in many researches that the technology tools increase permanence in memory, visualize the concept and facilitate comprehending, it is thought that the effect of the calculator use in the geometry subjects is thought to be an important data source in terms of teaching effects of technology tools. Because the calculator use is recommended in the mathematics curriculum but it is not known what kind of result will be produced when the teaching integration is done for the subjects of geometry that is the sub-learning field. Taking all of these into account, it is possible that this research might be a source of data for the curriculum. In particular, it is considered that the lesson plans used in our research, activity sheets, transformation geometry achievement test, the instruction of transformation geometry supported by calculator program, and applications will be a guiding source.

With the integration of technology in education, many technological tools have been added to teaching (computer, tablet, calculator, dynamic software etc.). This has brought attention to the issue of how technology affects teaching and has raised curiosity about the success of students, their attitudes and their self-efficacy. Considering all these reasons, an answer to the following question was sought within the scope of this research:

"What is the effect of problem solving instruction supported by the graphing calculator program on students' academic achievement and attitudes toward mathematics in transformation geometry?"

The research has four sub-questions.

Q1. Is there a significant effect of transformation geometry instruction supported by graphing calculator program on students' academic achievements in the geometry?

Q2. Is there a significant effect of transformation geometry instruction supported by graphing calculator program on students' attitudes towards the geometry?

Q3. Is there a significant relationship between the experimental procedure applied to the students and the students' attitudes towards geometry when controlled the gender variable?

Q4. What are the opinions of the 7th grade students of middle school about the geometry instruction supported by the graphing calculator program?

Research Design

Mixed method research design was used in the research. Mixed method research is defined as the researchers' use of qualitative and quantitative methods in their work (Creswell, Clark, Gutmann, & Hanson, 2003). A pre-test post-test quasi-experimental design with two groups was used in the study. The quasi-experimental method is defined as "the pattern in which the subjects assigned unbiased to the experimental and control groups are measured before and after the experimental application" (Büyüköztürk, 2001; Kerlinger, 1973). Pre-test post-test design with control group is that one group out of non-randomly selected two groups is assigned as experimental group and the other is assigned as control group, an intervention is applied to the experimental group and it is not applied to the other group, and the differences between these two groups is examined (Creswell, 2016).

Explanatory research method of qualitative research methods has been used in order to get opinions of the students on graphing calculator program supported instruction and process in the study. Explanatory method in researches is actualized with surveys, interviews, observations, and test techniques. Surveys and interviews have an important place in explanatory method research (Aslantürk, 1999). Within this design, the validity and reliability of the design has been increased with data diversity. Data diversity (Triangulation) is the use of qualitative and quantitative data simultaneously but independently in order to examine the same phenomenon (Giannakaki, 2005; Greene, Caracelli, & Graham, 1989).

Study Group of Research

The study was carried out with 49 students who were in the 7th grade in a middle school that can be counted as middle or high level in the Altieylul district of Balikesir province. Cluster sampling was used in the selection of the sample. Cluster sampling is a form of sampling done with groups that are randomly selected rather than selecting individuals one by one. It can be said that all the elements of the selected groups have similar characteristics (Özen & Gül, 2007). The study group was identified as two classes in the school as two ready cluster samples.

Data Collection Tools

This section will provide information on the data collection tools of the research that are Transformation Geometry Achievement Test (TGAT), Geometry Attitude Scale (GAS), experimental group activity sheets, control group work sheets, reflective observation form, and interviews.

- Transformation Geometry Achievement Test (TGAT) was prepared by the researcher in accordance with the concepts of the transformation geometry subject in the middle school mathematics curriculum published by the Ministry of National Education in the 2013. Initially, the TGAT was formed by creating 20 questions to take account of standards towards educational objectives. While the questions were being created, researchers reviewed the related literature (Akay, 2011; Altın, 2012), the high school entrance exams (MoNE, 2010, 2011, 2012) which MoNE has done, and the questions in the textbooks under the topic of 7th grade transformation geometry based on the 2013 MoNE middle School Mathematics curriculum. After the Transformation Geometry Achievement Test was developed, three mathematics educators, a measurement and evaluation expert, and two mathematics teachers were consulted to ensure the validity of the test. Two of the questions were removed in the direction of expert opinion. Finally, a total of 18 questions consisting of 8 multiple-choice, 10 open-ended TGAT was created. A panel on how many points of multiple-choice and open-ended questions in the TGAT was formed and a common decision was taken at the end of the panel to form a scoring chart of the questions. The KR-20 reliability coefficient of 8 multiple choice questions in the achievement test was 0.86. A KR-20 reliability coefficient value between 0,7-0,9 is indicating that the reliability is good (Barchard & Hakstian, 1997). For the open-ended questions in the TGAT, the questionnaire was scored separately by the researcher and a mathematics educator and the inter-rater reliability coefficient between the scorers was 0.92. Inter-rater reliability can be defined as the degree of coherence between two or more scorers' scorings of open-ended items (Aiken, 2000; Anastasi & Urbina, 1997). In order for the inter-rater evaluation results to be credible, it is necessary that the median of the scores of the scorers is above 0.75. Under this scale, it is said that the scores of the scorers are different (Şencan, 2005). The inter-rater reliability between the scorers is 0.92, so it can be said that the reliability is high.

- Geometry Attitude Scale (GAS): The geometry attitude scale, which measures attitudes towards geometry developed by Bulut, Ekici, İşeri and Helvacı (2002) was used to determine whether there was a change in students' attitudes towards geometry as a result of the applied instructional practice. Permission has been taken to use the scale in the study. GAS consists of 24 items in total, 14 positive and 10 negative. GAS is a 5-point scale likert-type and the expressions are ordered from completely agree to completely disagree. The reliability coefficient of the scale (Cronbach alpha) was found to be 0.92.

- Experimental Group Activity Sheets: Activity sheet-1 and activity sheet-2 were prepared for the experimental group. Both of the activity sheets were prepared by the researcher and are based on the standards under the transformation geometry topic in the middle school mathematics curriculum published by Ministry of National Education in 2013 (Guven, 2012; MoNE,2013). Both activity sheets have open-ended questions. The images in the questions were taken from the 2013 middle school mathematics textbook, which was prepared by MoNE. Three mathematics education experts and two mathematics teachers were consulted for the draft form of activity sheets and work sheets. The structure of activity sheets has been organized in line with the feedback from mathematics education experts and mathematics teachers. Both activity sheets for the experimental group were created to allow students to practice in the TI-Nspire Graphing Calculator.

- Control Group Work Sheets: Work Sheets-1 and Work Sheets-2 have been prepared for use in the control group. Both work sheets were prepared by the researcher and are based on the standards under the transformation geometry topic in the middle school mathematics curriculum published by Ministry of National Education in 2013 (Guven, 2012; MoNE, 2013). Both of the worksheets consist of open-ended questions. For the validity of the sheets, two mathematics education experts and two mathematics teachers were consulted.

- Reflective Observation Form: This is a data collection tool that gives reflective thinking skills, allows the students to see the development of the learning themselves, and helps students participate in the learning process (Akkoyunlu, Telli, Menzi, & Çetin, 2016). In the study, the students of the experimental group were asked to keep the reflective journal at the end of each session, so that they could follow their own progress. The reflective observation form was developed by the researcher. The reflective observation form was first formed as 8 open-ended questions and then the two questions in the form were merged into one question by taking the opinion of two mathematics education experts and a measurement and evaluation expert. As a results of the analysis based on the answers given by the students to the questions in the pilot study and follow up meetings with experts, the number of the questions has been reduced to six.

- Interview: The interview is a communication process to learn the information about the attitudes, feelings, thoughts, and beliefs of the individuals frequently used in social science researches (Erbakırcı, 2005). As a qualitative data collection tool, the interview consists of open-ended questions prepared by the researcher. As a draft, there were 8 questions in the form prepared for the interview and the opinions of two mathematics education experts were taken for the validity and as a result of these opinions the number of questions was reduced to five. At the end of the experiment, six randomly selected students were interviewed on the basis of volunteerism among the 27 students in the experimental group and the interview was recorded with a voice recorder. The interview duration lasted approximately 10-15 minutes. It was ensured that the students express themselves in an impartial manner.

Data Analysis

In this section, data from Transformation Geometry Achievement Test (TGAT), Geometry Attitude Scale (GAS), Reflective Journal Form, and Interviews will be analyzed.

- Transformation Geometry Achievement Test (TGAT): Eight of the 18 questions in the test are multiple-choice, 10 are open-ended questions. The item difficulty index and item discrimination index for 8 multiple-choice questions in the TGAT were calculated. Tekin (2000) describes the item difficulty and discrimination index as follows: "The strength of a test item is the ratio of the number of persons who respond correctly to the item in the group to which the test is applied to the total number of people in the group. The measure of item strength is an inverse measure in a sense. Since the strength of an item is the percentage of those who respond correctly to that item, the larger the value of "p" is, the easier the item is. Discrimination strength is the difference between those who respond correctly to the item in the upper group and those who respond correctly to the same item in the lower group. There is no discrimination strength between an item that all individuals answer correctly or incorrectly." The indices of item difficulty and discrimination of TGAT are given in the Table 1 below:

Table 1. Item difficulty indices and item discrimination indices of multiple-choice questions of achievement test

Item No	Item Difficulty Index	Item Discrimination Index
2	0.50	0.13
3	0.59	0.13
6	0.27	0.18
8	0.40	0.13
9	0.36	0.18
13	0.68	0.13
14	0.68	0.22
18	0.22	0.13

TGAT pre-test was applied to students in the pilot study. The KR-20 reliability coefficient of 8 multiple choice questions in the achievement test was 0.86. The KR-20 value was calculated according to the formula (r= [m / (m-1)] * [(α^2t - Σpq) / α^2t]; Ergin, 1995). A KR-20 reliability coefficient value between 0,7-0,9 indicates that the reliability is good (Barchard & Hakstian, 1997). Correlation coefficient for open-ended questions was found to be 0.92 by checking the scores between the researcher and one mathematics teacher. The researcher formed pre-tests by combining multiple-choice and open-ended questions. Whether the pre-test scores were normally distributed calculated by the kurtosis-skewness and kolmogorov-smirnov tests, which showed normal distribution (p> .05). In the TGAT post-test, scores were given for multiple-choice questions and open-ended questions were scored by the researcher and a mathematics education expert. When more than two scorers score a specific behavior, performance, or question etc., one of the methods used to determine the inter-rater reliability is Kendall's coefficient (Howell, 2002). The coefficient is calculated by the formula: W = [12ΣT_1^2 / k^2 N (N^2-1)] - [3 (N + 1) / (N-1)]. In this equation, k is the number of scorers, N is the number of tasks or items scored, and T_1 is the sum of the scores given by all scorers to the each item or task. As a result of the calculation, the inter-rater reliability coefficient was determined as 0.93. Statistical analysis of the post-test revealed normal distribution and independent sample *t* test was used (p = .000 <.05).

- Geometry Attitude Scale (GAS): The scale was applied to groups as pre-test and post-test. Attitude scale consisted of 24 items including 10 negative and 14 positive. On this scale, items 2, 3, 9, 10, 11, 13, 15, 18, 19 and 20 were scored inverse because they were negative. To examine whether the data were normally distributed or not, kurtosis-skewness and kolmogorov-smirnov tests were performed and the scores were found to be normally distributed (p> .05). In order to investigate the relationship between the two groups, independent sample *t* test was applied for pre-test and post-test (p = .100> .05). Single-factor covariance analysis (ANCOVA) was applied to the geometric attitude scale scores obtained by controlling the gender variable (p = .000 <.05).
- The pre-test scores of experimental and control groups that they received from achievement and attitude scales were analyzed by means of independent samples t test to determine whether these groups were equal. Table 4 presents the results of normal distribution of pre-tests. Kurtosis values and kolmogorov-smirnov test results showed normal distribution of pre-tests.
- Two-way ANOVA for Mixed Measures analysis was used to determine whether there was a significant difference between the pre-test and post-test scores of the experimental and control groups that they received from the Transformation Geometry Achievement Test and the Geometry Attitude Scale. In order to be able to make this analysis, it is necessary that the scores related to dependent variables have normal distribution and homogeneous distribution of variances (Seçer, 2015). The skewness and kurtosis values and the kolmogorov-smirnov test results were used to determine whether the pre-test and post-test scores of the experimental and control groups that they received from the Transformation Geometry Achievement Test and the Geometry Attitude Scale had a normal distribution. Results were presented in Tables 4 and 5. When these tables are examined, it is seen that normal distribution condition was met. The Levene's test was used to examine whether the variances of the pre and post-test attitude scores obtained from the Geometry Attitude Scale were homogeneous. The homogeneity of variance was also met for the pre-test (*F* = 1.044; *p* = .312> .05) and post-test (*F* = .306; *p* = .582> .05) scores. According to the Levene's test, the Transformation Geometry Achievement Test showed that the homogeneity of variance of pre-test scores (*F* = .007; *p* = .935> .05) and post test scores (*F* = .116; *p* = .735> .05) were met. The assumptions of a two-factor ANOVA for mixed measures were met.
- The significance (*p*) was tested at the levels of 0.01 and 0.05 in the statistical analyses.
- Reflective Journal Form and Interview: Qualitative data from reflective observation forms and interview records obtained during the research were analyzed with the help of content analysis. Codes,

sub-themes and main themes from qualitative data were obtained as a result of content analysis. During coding, the sentences, words and paragraphs are extracted from the data set as analysis units and each analysis unit appears as a code. The occurring codes are subdivided into main and sub-themes as similar within themselves (Özdemir, 2010). Qualitative data are coded by the researcher and a mathematics education expert. The coding consistency between the researcher and the mathematics education expert was compared for the coding reliability and the fit was tested. In the calculations made using Miles and Huberman's (1994) formula [reliability = (agreement / agreement + disagreement) X 100], the agreement rate between the coders was found to be 0.94.

Results

In this section, in order to examine four research questions (Q1, Q2, Q3, Q4) in this study, findings from the Transformation Geometry Achievement Test, Geometry Attitude Scale, reflective observation forms, work sheets, activity sheets, and voice records during interviews will be presented. The results of the independent sample *t* test analysis of the pre-test (Transformation Geometry Achievement Test) scores for the control and experimental groups are shown in Table 2.

Table 2. Comparison of the pre-test (Transformation Geometry Achievement Test) results for control and experimental groups with independent sample *t* test

Groups				Levene's Test				
	N	$\bar{x}$	*SS*	*F*	Sig.	*Sd*	*t*	*p*
Control	22	60.82	8.03	.007	.935	47	-.506	.615
Experimental	27	61.96	7.75					

When the above Table 2 is examined, it is seen that the variance of the pre-test scores of both experimental and control groups are homogeneously distributed (F = .007 and p = .935> .05) by looking at the Levene's Test. In addition, independent samples *t* test was conducted to examine the equivalence of the pre-test scores. As a result of the analysis made, there was no significant difference between the pre-test scores of the experimental and control groups in the Transformation Geometry Achievement Test (p = .615> .05). In other words, it can be said that groups are equal according to the pre-test scores for the Transformation Geometry Achievement Test.

The results obtained by comparing the pre-test results of the Geometry Attitude Scale for control and experimental groups with the independent samples *t* test are given in Table 3.

Table 3. Comparison of the pre-test results of the Geometric Attitude Scale for control and experimental groups with independent samples *t* test

Groups				Levene's Test				
	N	$\bar{x}$	*SS*	*F*	Sig.	*Sd*	*t*	*p*
Control	22	80.36	11.56	1.044	.312	47	-1.676	.100
Experimental	27	86.63	14.08					

When the above Table 3 is examined, it is seen that the variance of the pre-test scores of both experimental and control groups are homogeneously distributed (F = 1.044 and p = .312> .05) according to the Levene Test. In addition, independent samples *t* test was performed to examine the equivalence of Geometric Attitude Scale scores. As a result of the analysis made, no significant difference was found between pre-test scores of experimental and control groups on geometry attitude scale (p = .100> .05). In other words, it can be said that groups are equal according to pre-test scores for Geometry Attitude Scale.

Findings regarding the normal distribution of the pre-test and post-test (Transformation Geometry Achievement Test) scores of the control and experimental groups are given in Table 4.

Table 4. Findings regarding the normal distribution of the pre-test and post-test (Transformation Geometry Achievement Test) scores of the control and experimental groups

Groups	Skewness	Kurtosis	Kolmogorov- Smirnov
Pre-test control	.269	-.365	.200
Post-test control	.662	-.350	.200
Pre-test experimental	.544	-.228	.199
Post-test experimental	-.349	-1.100	.200

In the Table 4 given above, skewness and kurtosis values and kolmogorov-smirnov test results of pre-test and post-test (the Transformation Geometry Achievement Test) scores of experimental and control groups are presented. The skewness values were found to be .269 for pre-test scores of the control group, .662 for post-test scores of the control group, .544 for pre-test scores of the experimental group, and -.349 for post-test scores of the experimental group. The kurtosis values were found to be -.365 for pre-test scores of the control group, -.350 for post-test scores of the control group, -.228 for pre-test scores of the experimental group, and -1.100 for post-test scores of the experimental group. Finally, the Kolmogorov-Smirnov test scores were found to be .200 for pre-test scores of the control group, .200 for post-test scores of the control group, .199 for pre-test scores of the experimental group, and .200 for post-test scores of the experimental group.

Huck (2008) states that the skewness values should be between -1 and +1 and the kurtosis values should be between -2 and +2. It is seen that the obtained kurtosis and skewness values are appropriate for this situation. As a result, the kolmogorov-smirnov test was not significant (p > .05). Therefore, according to kurtosis-skewness and kolmogorov-smirnov test, these values are normally distributed.

Findings regarding the normal distribution of the pre-test and post-test (Geometry Attitude Scale) scores for control and experimental groups are given in Table 5.

Table 5. Findings regarding the normal distribution of the pre-test and post-test (Geometry Attitude Scale) scores for control and experimental groups

Groups	Skewness	Kurtosis	Kolmogorov- Smirnov
Pre-test control	.977	.204	.148
Post-test control	.383	-1.400	.062
Pre-test experimental	.299	-.924	.200
Post-test experimental	.300	-.979	.200

In Table 5 given above, the skewness and kurtosis values and the kolmogorov-smirnov test results of the pre-test and post-test (Geometry Attitude Scale) scores of the experimental and control groups. The skewness values were found to be .977 for pre-test scores of the control group, .383 for post-test scores of the control group, .299 for pre-test scores of the experimental group, and -.300 for post-test scores of the experimental group. The kurtosis values were found to be .204 for pre-test scores of the control group, -1.400 for post-test scores of the control group, -.924 for pre-test scores of the experimental group, and -.979 for post-test scores of the experimental group. Finally, the Kolmogorov-Smirnov test scores were found to be .148 for pre-test scores of the control group, .062 for post-test scores of the control group, .200 for pre-test scores of the experimental group, and .200 for post-test scores of the experimental group. As a result, the kolmogorov-smirnov test was not significant (p> .05). Therefore, according to kurtosis-skewness and kolmogorov-smirnov test, these values are normally distributed.

Results for the First Sub-question

Whether the post-test scores of the students in the experimental and control groups that they received from the Transformation Geometry Achievement Test was significantly different compared to the pre-test scores were analyzed with two-factor ANOVA for repeated measures on the single factor. The averages and standard deviations of the achievement scores of the students that they received from the Transformation Geometry Achievement Test were presented in Table 6.

Table 6. The average and standard deviation of the post-test scores of the Transformation Geometry Achievement Test for control and experimental groups

Groups	N	$\bar{x}$	sd
Control	22	65.14	10.20
Experimental	27	79.81	10.35

According to Table 6, the average score of Transformation Geometry Achievement Test for the experimental group was 79.81 and for the control group was 65.14. Figure 2 shows the change from the pre-test scores to the post-test scores for both groups.

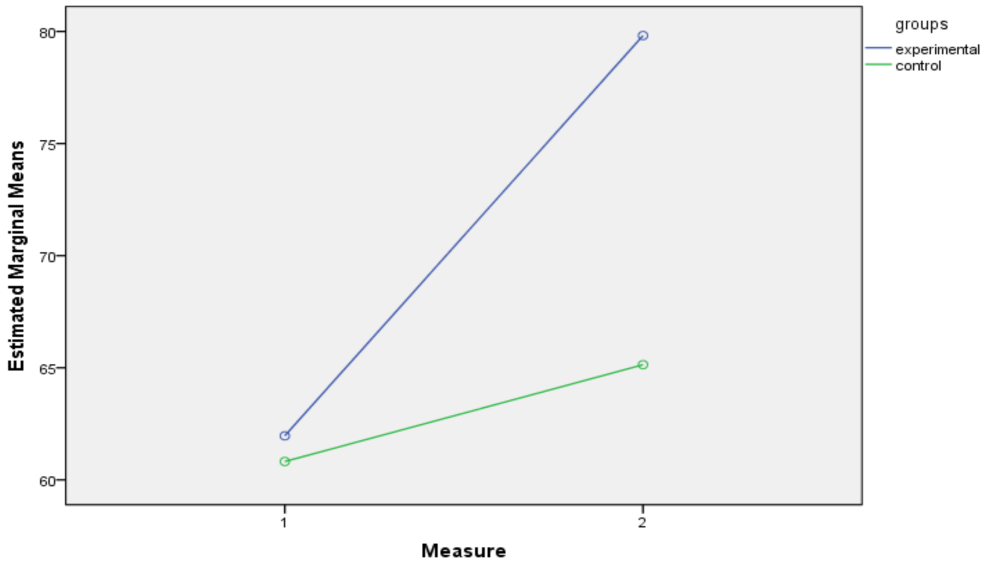

Figure 2. Change in the Transformation Geometry Achievement Test scores for the experimental and control groups

As can be seen from Figure 2, after two different instructions, the control group increased their achievement score from 60.82 to 65.14, while the experimental group increased from 61.96 to 79.81. After the intervention, there was a serious increase in the experimental group compared to the control group. To determine whether this increase was meaningful or not, the two-factor ANOVA analysis for repeated measures on the single factor was conducted and the results were presented in Table 7.

Table 7. ANOVA findings regarding the pre-test and post-test (Transformation Geometry Achievement Test) scores of the control and experimental groups

Source of Variance	Sum of Squares	*df*	Mean Square	*F*	η^2	*p*
Between Groups						
Group	1517.577	1	1517.577	2736.210	.983	.000
Error	7302.811	47	155.379			
Within Groups						
Measurement	2979.155	1	2979.155	236.485	.834	.000
(Pre-Post Tests)	1110.175	1	1110.175	88.126	.652	.000
Measurement*Group	592.090	47	125.98			
Error						

When the above Table 7 is examined for the first research question of the study, the results of ANOVA showed that the Transformation Geometry Achievement Test scores of the students in experimental and control groups differ significantly after the intervention, that is, for the different groups, analysis showed that the common effects of repeated measured factors on the geometry achievement scores were significant [F (1, 47) = 88.126; η^2 = .652; p <.01]. This shows that the intervention in the experimental group was more effective in increasing the achievement in the transformation geometry than the practice in the control group.

Results for the Second Sub-question

Whether the post-test scores of the students in the experimental and control groups that they received from the Geometry Attitude Scale was significantly different compared to the pre-test scores were analyzed with two-factor ANOVA for repeated measures on the single factor. The averages and standard deviations of the attitude scores of the students that they received from the Geometry Attitude Scale were presented in Table 8.

Table 8. The average and standard deviation of the post-test scores of the Geometry Attitude Scale for control and experimental groups

Groups	*N*	$\bar{x}$	*SS*
Control	22	90.95	14.40
Experimental	27	92.26	14.42

According to Table 8, the average score of the Geometry Attitude Scale for the experimental group was 92.26 and for the control group was 90.95. Figure 3 shows the change from the pre-test scores to the post-test scores for both groups.

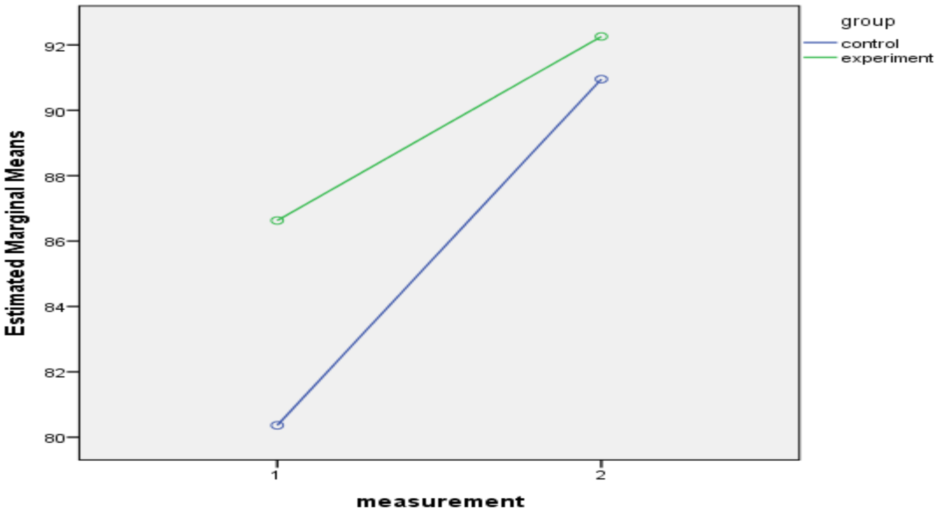

Figure 3. Change in the Geometry Attitude Scale scores for the experimental and control groups

As can be seen from Figure 3, after two different instructions, the control group increased their attitude score from 80.36 to 90.95, while the experimental group increased from 86.63 to 92.26. After the intervention, there was an increase in both the experimental group and the control group. To determine whether this increase was meaningful or not, the two-factor ANOVA analysis for repeated measures on the single factor was conducted and the results were presented in Table 9.

Table 9. ANOVA findings regarding the pre-test and post-test (Geometry Attitude Scale) scores of the control and experimental group

Source of Variance	Sum of Squares	*Df*	Mean Square	*F*	η^2	*p*
Between Groups						
Group	347.403	1	347.403	.989	.021	.325
Error	16514.720	47	35.377			
Within Groups						
Measurement	1594.744	1	1594.744	62.006	.569	.000
(Pre-Post Tests)	149.193	1	149.193	5.801	.110	.020
Measurement*Group	1208.807	47	25.719			
Error						

When the above Table 9 is examined for the first research question of the study, the results of ANOVA showed that the Geometry Attitude Scale scores of the students in experimental and control groups differ significantly after the intervention, that is, for the different groups, analysis showed that the common effects of repeated measured factors on the attitude scores were significant [F (1, 47) = 5.801; η^2 = .110; p> .01]. This shows that the intervention in the experimental group was not more effective in increasing the attitude towards the transformation geometry than the practice in the control group.

Results for the Third Sub-question

In order to run ANCOVA analysis for the third research question of the study, it has been investigated whether ANCOVA's important assumption of "the concordance of regression tendencies" rule was fulfilled. As a result of the analysis made, it was seen that the concordance of regression tendencies rule related to the interaction of gender and pre-test scores were fulfilled (F = .028, p = .3381> .05). The variance, which is an important condition of the ANCOVA analysis, was tested by the Levene's test for homogeneity (F = .197, p = .434> .05). After the effect of the interchangeable variable was controlled, the participants' averages from the post-test according to the groups are given in Table 10.

Table 10. Descriptive statistics of control and experimental groups

Group	N	Mean	Adjusted Mean
Control	22	90.95	90.02
Experimental	27	92.59	93.13

When Table 10 is examined, it is seen that the mean of the control group is 90.95 while the adjusted mean of the control group is 90.02 when the gender variable is controlled. It is also seen that the mean of the experimental group is 92.59 while the adjusted mean of the experimental group is 93.13. The single-factor covariance analysis (ANCOVA) results of the Geometry Attitude Scale pre-test and post-test scores for experimental and control groups are given in Table 11.

Table 11. Comparison of the single-factor covariance analysis (ANCOVA) results of the Geometry Attitude Scale pre-test and post-test scores for experimental and control groups

Source of Variance	Sum of Squares	*df*	Mean Square	*F*	*p*	Effect size
Groups	293.272	1	293.272	5.303	.026	.103
Pre-tests according to gender	6744.760	1	6744.760	121.957	.000	.726
Post-tests according to gender	116.034	1	116.034	2.098	.154	.044
Error	2543.994	46	55.304			
Total	421578.000	49				

The pre-test and post-test scores of the experimental and control groups on the Geometry Attitude Scale were compared with the single-factor covariance analysis in Table 9 above. According to the ANCOVA analysis in Table 9, there is no significant difference between male and female students' attitudes towards geometry (F = .042 and p = .840> .05) after gender variable was controlled. When the table was examined in terms of pre-test which is an interchangeable variable, pre-test variable were found significant. According to this, when the independent variable, gender, is controlled, there is a significant relationship between dependent variable (post-test) and independent variable (gender) (F = 121.957 and p = .000< .01).

When Table 11 is examined, it is found that the change in the pre-test scores obtained from the geometry attitude scale is significant for the students in the experimental group, which shows improvement in their attitudes towards geometry (F (1,49) = 121.957, p = .000< .01 and η^2 = .726). According to this finding, it can be stated that the difference observed between adjusted mean scores of the students in experimental and control group is significant, and that the graphing calculator software supported transformation geometry instruction applied to experimental group is effective in increasing students' attitudes towards geometry.

Results for the Fourth Sub-question

In this section, content analysis was carried out in order to explain the reasons of the findings regarding predictive statistics obtained from the Transformational Geometry Achievement Test, Geometry Attitude Scale, and the scales of using the graphing calculator program in the transformation geometry instruction and the final research question (Q4). The main themes, sub-themes and codes were determined with the aid of descriptive content analysis. The determined themes and sub-themes are given in Table 12.

Table 12. The frequency and percentage information about the themes and sub-themes that were obtained as a result of the descriptive content analysis

Theme	Sub-theme	Frequency	Percentage
Social and Cognitive Characteristics	The effect of the peer-to-peer collaboration on learning	12	4,16 %
	The effect of technology on cognitive learning	75	26,04 %
Sensual Learning	Attitude towards practice	50	17,36 %
	Attitude towards geometry	10	3,47 %
	Attitude towards technology	64	22,23 %
	Attitude towards collaborative learning with group	7	2,43 %
	Attitude towards learning	61	21,48 %
	Attitude towards instructor-teacher	9	3,13 %
	Total	288	100 %

The opinions that are effective in the formation of the themes and codes of the students will be given below.

Social and Cognitive Characteristics

The theme of social and cognitive characteristics is divided into two sub-themes: the effect of the peer-to-peer collaboration on learning and the effect of technology on cognitive learning. The opinions of the students on the effect of the peer-to-peer collaboration on learning are as follows:

> *It has good aspects, teachers can explain things better, friends who understand can explain to those who do not understand. (SD-1, 7-E, experimental group, interview).*
>
> *Where the teacher could not make it, it was good to work together and ask questions each other. (YA-2, 7-E, experimental group, interview).*

By communicating with their peers, students have stated that learning is more meaningful and long lasting. The following are the opinions of students about the sub-theme of the effect of technology on cognitive learning:

> *The program helped me learn the subject matter. If I had done it on the board, I would not have understood that much. (SO-5, 7-E, experimental group, reflective observation form-1).*
>
> *It was more productive, and more concrete because I had seen the application on the program. (YA-12, 7-E, experimental group, reflective observation form-2).*

Students said that when they were taught with a graphing calculator program supported instruction, they learned the problem more quickly by stating that they had more time to figure out the problem than to solve the problem. These findings obtained in the study seem to overlap with the findings of Ersoy (2005).

Sensual Characteristics

The theme of sensual characteristics is divided into six sub-themes: the attitude towards practice, the attitude towards geometry, the attitude towards technology, the attitude towards collaborative learning with group, the attitude towards learning, and the attitude towards instructor-teacher. The students' attitudes towards practice are as follows:

> *Working with the graphical calculator program made learning both fun and efficient. (YA-16, 7-E, experimental group, reflective observation form-2).*

The students stated that they were both entertained and benefitted because they practiced an applied course with the support of the graphing calculator program. This finding in our study overlaps with the results obtained by Lee and McDougall (2010). The students' attitudes towards geometry are as follows:

> *So it was fun. I liked the geometry and I already had an interest in it, but it was more enjoyable when I applied it. (GK-20, 7-E, experimental group, interview).*

The students stated that when they worked on geometry supported with graphing calculator program, they developed a more positive attitude towards geometry than their previous attitudes. This result in our study is in line with what Van de Walle, Karp and Williams (2012) have stated in their work. The following are the statements of the students regarding the attitudes towards technology:

> *Because of today's technology, we are all familiar with computers and programs, so that it is more fun. (SN-22, 7-E, experimental group, interview).*

Students stated that they liked to use technology, and that studying with the technology made them happy. The following are the statements of the students regarding the attitudes towards cooperative learning with group:

> *It's fun to learn mathematics by working with our friends in groups. (IŞ-24, 7-E, experimental group, reflective observation form-2).*
>
> *I am more willing to learn when I have a group work. (PK-25, 7-E, experimental group, reflective observation form-1).*

They stated that when they worked with the group, they became more willing to learn and developed a positive attitude towards group work. The following are the statements of the students regarding the attitudes towards learning:

> *I was so happy when I felt that I learned, it was nice to learn things. (AY-27, 7-E, experimental group, interview).*

They stated that they have developed a positive attitude towards learning when they received graphing calculator program supported instruction. The following are the statements of the students regarding the attitudes towards instructor-teacher:

> *The thing that I liked was that the teacher knew the graphics calculator software very well and taught the course very well with this technology, so my learning lasted longer. (SA-28, 7-E, experimental group, reflective observation form-2).*

Students stated that since the teacher has mastered the graphing calculator program, she integrated the software well into the instruction and that she is a good guide and a good teacher. When a teacher gives examples that understands the cognitive level of the student and makes explanations in this direction and uses analogies and different teaching strategies with TPACK, she can present the knowledge better and teach better (Uşak, 2005, 2009). The result obtained is parallel to the results that can be seen in the teaching of a teacher with technological pedagogical content knowledge (TPACK). As a result, "Social and Cognitive Characteristics" and "Sensual Characteristics" were determined as the themes of the content analysis made under the main theme of "Graphing Calculator Program Supported Instruction". In total, 9 sub-themes and codes belonging to these sub-themes were created. It was seen that the students emphasized the important characteristics in the literature.

Discussion

This section will be reviewed under two headings: discussion of quantitative sub-questions and discussion of qualitative sub-questions.

Discussion of Quantitative Sub-questions

For the first research question, when the effect of graphing calculator program supported transformation geometry instruction on the 7th grade students' mathematics achievements is examined, it was seen that the experimental group had a significant difference in the positive direction in the mathematics achievement. There are researches overlapping with the results obtained in this research. In the findings of the study conducted by Koca (2012) with 8th grade students, the experimental group was more successful than the control group. As a results of the study, researcher found that the use of calculator positively increased the overall mathematical achievement of the students. Reznichenko (2007) examined the studies in the literature on learning with graphing calculators from 1986 to 2002. Calculators and computers have been found to positively increase academic achievement by making students more active.

There are also studies with different results other than the above-mentioned research. Penglase and Arnold (1996) in the study they conducted emphasized that the calculators were not effective in learning, but that they could just be helpful in the subject learned previously. In the study the role of gender was investigated, and it was found that the use of calculator in teaching did not affect academic achievement of females and males; it just improved technical skills of males. Alkhateeb and Wampler (2002) examined the effects of the calculator on the concept of differentiation adding gender variable in their studies. As a result of the study, it was found that there was no significant difference in the academic achievement of males and females in terms of the lectures processed with graphing calculators and traditional methods.

When the studies mentioned above are examined, it is seen that in the studies made with the graphing calculators, the effect of graphing calculator on academic achievement was either significant in positive way, as in the results of this study, or was not significant at all. For the second sub-question of the study, teaching of transformational geometry with graphing calculator program increased the attitudes of 7th grade middle school students towards geometry, but this increase did not make any significant difference. While there was not a study similar to this result in the literature, in a similar study regarding mathematical modeling conducted by Perry and Todder (2009), it was seen that the change in medical students' attitudes towards computer that is an educational tool such as calculator was not significant. This result overlaps with the results obtained in this research.

When the literature is examined, there are examples that have different results from the results of this research. Ellington (2003) investigated the effect of the calculator on students' attitudes by examining 54 studies conducted between 1983-2002, and found that the students developed a positive attitude towards calculator-supported instruction. Browning and Garza-Kling (2010) in their study in which calculators were used as a tool, they found that calculators provided useful graphical representations, feedback, and an advantage over traditional approaches. In the literature, the educational technologies such as calculators or computers have provided an increase in the attitudes of students. However, this increase was found to be positively meaningful in some studies, while in some studies not meaningful at all.

For the third sub-question of the study, it was found that there was a significant relationship between dependent variable (post-test) and independent variable (gender) when the independent variable (gender) was controlled. In other words, it can be stated that the difference between the adjusted means for the experimental group and the control group when the gender variable was under control was significant in favor of the experimental group, and that the graphing calculator program supported transformation geometry instruction applied in the experimental group was effective in increasing the attitudes of the students towards the geometry. There are many examples with overlapping results for the third sub-question of the research in the literature. One of them is Shin, Sutherland, Norris and Soloway's study (2012), in which they investigated the effect of a technology-based game on primary school students' performance in mathematics, attitudes towards the game, and attitudes towards the mathematics with considering the gender variable. It was seen that the learning of the students in every condition developed in the positive direction. In Ayodele's (2009) study, in which he investigated the effect of students' gender and school type on their mathematics and science achievement, there was no significant difference in mathematics and science achievement between females and males who went to private and state schools. In the literature in general, when the gender factor was controlled, it was seen that the attitude towards the instruction increased significantly in favor of the experimental groups in which a different practice was applied.

Discussion of Qualitative Sub-questions

This section will be examined under two headings, social and cognitive characteristics and sensual characteristics.

Social and Cognitive Characteristics

Students participating in the research stated that their attention to the lesson increased during the course and that their learning was meaningful when they were working with a technology such as a graphing calculator. In addition, students have expressed that their productivity in terms of learning is increased by the graphing calculator program. In the study of Lee and McDougall (2010), researchers found that graphing calculator-supported instruction at the right time improved students' learning efficiency and helped them make connections with the real world more easily.

The students who participated in the research reported that they had more opportunity to discuss with the group while they were learning with the graphing calculator program and that this increased the persistence of their learning. Karadeniz and Thompson (2018) found that the graphing calculator gave more time to discussion among students and that learning became meaningful. Leng (2011) in his study stated that the use of a graphing calculator allows students and teachers to communicate instantly together and create classroom discussions within the classroom, thus making the course more instructive.

Sensual characteristics

Students participating in the research have emphasized the fun and contributing features of working with the group. Students have understood the importance of working together and developed positive attitudes towards group work. The students played an active role in the group and created a social environment. The students have facilitated their own development by discussing in a comfortable environment.

Zawojewski, Lesh, and English (2003) in their studies found that group work provided the best solutions to a given problem in the shortest period of time by looking at the problem from the different angels. Antonius, Haines, Hojgaard, Jensen, Niss, and Burhardt (2007) found that group work encourages student socialization, encourages student participation in classes, and enhances motivation. The results of the present study overlap with the results of these studies. According to the students, when a technology supported instruction practiced with group work, students participate in class more active and develop a positive attitude towards the course.

The students in the research stated that they perceive the instructor/teacher as a guide and a consultant. Antonius and et al. (2007) stated that the teachers' primary task was to guide their students. The students in the present study identified the teacher as facilitator and organizer of the environment. Reznichenko (2007) in his work argued that technology gives teachers a facilitator role when the calculator is used in mathematics teaching.

The students in the research indicated that the teacher had mastered the graphing calculator program and that his teaching with technology as a good guide provided a meaningful learning. Technological pedagogical knowledge refers to the knowledge that teachers should have about information and communication technologies and use this knowledge in a meaningful and harmonious way in teaching (Kaya, Emre & Kaya, 2010). Teachers with advanced TPACK can actualize teaching in their classroom using more technological tools and by understanding students' level of understanding and thinking (Akkaya, 2009). The qualitative results of the study are in parallel with the results of TPACK teaching. In the line with the literature, it can be said that according to the opinions of the students, educational technologies such as a graphing calculator are more effective and improve students' attitudes towards lesson positively when used by teachers who are a good guide, master of the subject matter, a good facilitator, and a good consultant.

Conclusion

Graphing calculator program supported transformation geometry instruction has made a meaningful difference in the academic achievement of students. The success of the students who took part in the activities where the graphing calculator program was used improved positively compared to the previous achievements in the geometry lessons. Graphing calculator program supported transformation geometry instruction did not make a meaningful difference in the attitudes of the students towards the geometry. That is, no significant improvement has been observed in the attitudes towards the geometry in which the students are taught by using calculators. The students who had a positive attitude towards the geometry before the intervention continued exhibiting the same positive attitude after the intervention.

By controlling the gender factor, the observed difference between the adjusted mean scores of the students in the experimental and control groups was found to be significant. In other words, it can be stated that the graphing calculator program supported transformation geometry instruction applied to the experimental group was effective in increasing the attitudes of the students towards geometry. Students who participate in the graphing calculator program supported transformation geometry instruction for the first time have encountered a new technology that can be used in mathematics and learned how to use this technology. They emphasized that using calculators was effective in understanding the subject matter and made learning long lasting. The subject matter has been visualized and made concrete to increase the permanence of the learning.

The students emphasized that they had a better grasp of the graphing calculator because they were doing group work during the practice and that the group work had a positive effect on learning. It has been stated that working with the group contributes to their communication and creates an atmosphere of discussion to reach the most reliable and correct result. The students who participated in the graphing calculator program supported transformation geometry instruction stated that the graphing calculators should be used in the courses of mathematics and geometry. It was observed that students, with the help of calculators were able to quickly solve the problems that require more time than normal and it was concluded that calculators save time as well. The students stated that they had much time to understand and conceptualize the problem rather than solving the problem. Finally, the graphing calculator has made the learning environment fun and enjoyable. The students who participated in the study were found to have developed a positive attitude towards the graphing calculator program.

Recommendations

In the renewed curriculum, the necessity of using the calculator in teaching has been emphasized. Since the graphing calculator program used in our research is found to be more comprehensive, complex, and advanced, it can be integrated into the curriculum. Precautions can be taken for situations that impede the integration of the graphing calculator into mathematics programs. Teachers' opinions, beliefs, attitudes, and concerns about the graphing calculators should be investigated. Curricula can be shaped taking all these into account.

The use of technology requires the use of student-centered measurement and evaluation approaches. There is a need to prepare the tools necessary to measure students' skills of using the calculator. Student proficiencies can also be determined. Scoring guidelines can be used to determine these proficiencies. The same research can be done using different data collection tools and different research patterns. A similar study can be done with students in secondary education, pre-service teachers and in-service teachers. A similar study can be done for a different mathematics or geometry topic.

The necessary steps should be taken in order for the teachers to use the calculator in their lessons and show positive attitudes towards teaching their students. Teachers' opinion on the integration of graphing calculators into mathematics curriculum should be taken. Teacher candidates' skills in using technology should be improved. Teacher candidates can gain experience with the use of graphing calculators. During their undergraduate education, teacher candidates can take courses related to such technologies. Teaching can be provided by combining content, content education, and graphing calculators. As a result, graphing calculators have begun to take their place in curricula. This may be a promising approach to research.

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