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Technology-assisted circumference teaching

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Highlights

- It is very important to integrate technology into mathematics lessons.
- With the advancement of technology, computer programs can be used more in mathematics lessons.
- Especially with dynamic geometry software, students' use not only in geometry but also in different learning fields can be increased.
- Studies on dynamic geometry software at the primary school level can be increased.

Article Info: Research Article

Keywords: *Technology, GeoGebra, Circumference measurement*

Abstract

This study aimed to reveal the effect of teaching the 4th grade circumference measurement subject with the dynamic geometry software "GeoGebra" on achievement and motivation. In the research, the pre-test – post-test control group design, which is one of the quasi-test designs, was used. In the Mathematics lessons conducted with the experimental group for three weeks, the subject of circumference measurement was taught with dynamic geometry software, whereas the control group followed the current curriculum. As data collection tools, the 21-item "4th Grade Circumference Measurement Achievement Test" (KR20=.81) developed by Öksüz and Genç (2021) and the "Primary School Mathematics Motivation Scale" (KR20=.94) developed by Ersoy and Öksüz (2015) were utilized. The pre-test was applied concurrently to the test and control groups one week before the research was initiated, and the post-test was applied immediately after the research ended. In the study, a paired-samples t-test was used to compare the pre-test and post-test scores of the students in the test and control groups within the groups; whereas covariance analysis (ANCOVA) was used to compare the post-test scores of the related groups. As a result of the research, it was concluded that there was a statistically significant difference between the achievement and motivation post-test scores of the students in the experimental group who learned the subject of "Circumference Measurement" with the dynamic geometry software and the students in the control group who did not use this program on behalf of the experimental group.

1. Introduction

The changing and renewing technologies are rapidly taking place in our lives in the 21st century. These technologies affect not only how we teach but also how we learn (Bwalya, 2019) and have begun to be used in every aspect of our daily lives. During this process, it has been inevitable that the integration of technology in education and the use of various technologies (instructional tools and manipulative) have become a part of education (Ogbonnaya & Mushipe, 2020). Due to the Covid-19 pandemic, the use of technological tools and equipment in education and their functions have begun to increase. For this reason, technology affects the learning style preferences and education of students from the very beginning. Thanks

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to technology, students can access content that appeals to different sensory organs as an opportunity to increase their comprehension levels, and thus, they have the opportunity to make their own choices about which of these content they are going to use (Wassie & Zergaw, 2019).

Halis (2002) states that one of the main purposes of the use of computers, which is one of the chief technological tools used in the education process, is learning through a computer. Considering the aims of qualified and modern education, the increase in the amount of information to be learned makes the use of computers in education more necessary (Baki, Güven & Karataş, 2004). At the same time, education becomes more fun and enjoyable thanks to computers (Huang, 2003). Even though computers initially entered the education system only as a tool to help teachers, today, thanks to various software programs developed, they enable students to learn the subject at their own pace (Tor & Erden, 2004), reinforce the subject learned through exercises, do practices on their own (Yiğit et al., 2007) and even acquire knowledge by making discoveries (Özçakır Sümen, 2013). The use of technology in especially teaching Mathematics lessons, which students see as a difficult school subject (Azid, Hasan, Nazarudin, & Md-Ali, 2020; Bwalya, 2019; Cengiz, 2017; Fabian, Topping & Barron, 2018) has begun to increase rapidly.

Together with the fact that the use of computer technologies in education has been increasing day by day, the use of technology in Mathematics lessons has reached an important point (Kaya, 2017). At the same time, the integration of technology with Mathematics teaching is compatible with the constructivist learning theory in which learning is an active process; people learn by actively participating in the discovery and learning process (Slavin & Davis, 2006). NCTM (2000) emphasizes that technology is essential in Mathematics education and that it advances students' learning. Besides, the Turkish Ministry of National Education (2018) attaches great importance to students' learning to learn in the Mathematics curriculum and using technology effectively in education. Furthermore, according to Kutluca and Birgin (2007), technology-assisted Mathematics teaching increases the quality of the educational and instructional process (as cited in Zengin, 2019). This situation requires the rapid integration of technological developments in Mathematics lessons. According to Thambi and Eu (2012), Mathematics is a school subject that can be taught in harmony with technology.

Mathematics involves abstract concepts. Therefore, students may perceive the Mathematics lesson as a difficult school subjects (Baki, 1996). The fact that primary school students are in the concrete operational stage especially suggests that it is important to present mathematical concepts concretely. In this case, computers, which are important technological tools in schools, can model Mathematics and contribute to the learning of students (Genç & Öksüz, 2016). Together with the use of computers in the education process, various computer software has shown up. Dynamic geometry software is frequently used in teaching plenty of mathematical concepts (Preiner, 2008). According to NCTM (2008), dynamic geometry software has an important place for the permanent and effective learning of Mathematics.

"Dynamic Geometry Software" (DGS) is the common title of the software specifically developed for use in Mathematics lessons. Dynamic geometry software is a powerful tool for teaching and learning Maths. Dynamic geometry software offers unique opportunities for learning through discovery, creative problem-solving, and self-guidance (Clements & Sarama, 2001; Xistouri & Pitta-Pantazi, 2013). Dynamic geometry software is a material that enables students to learn by discovering in Mathematics lessons (Gawlick, 2005). In this way, students can imagine information and walk on the path of discovering information. Thanks to these ways, students can analyze information, and make inferences and generalizations (Güven & Karataş, 2003).

Dynamic geometry software (Cabri Geometry, Geometer's Sketchpad, GeoGebra, etc.) has begun to attract more attention all over the world with the developments in technology (Doğan & İçel, 2011). One of this software is GeoGebra, which is still being developed and is being integrated into teaching and learning processes (Antohe, 2009). Thanks to GeoGebra, visualization, and representations can be easily provided in Mathematics lessons (Budai, 2011). GeoGebra is an open-source software that was developed by Markus

Hohenwarter in 2001 and that later brought geometry, algebra, and analysis to a single interface by the initiative of an international group (Canevi, 2019; Hohenwarter & Lavicza, 2007; Preiner 2008). At the same time, GeoGebra sets an important place in establishing the relationship between geometry and algebra (Hohenwarter & Jones, 2007). Indeed, the student who draws a triangle on the drawing board can also see the points of that triangle and the coordinates of the line segments on the algebra window. Through GeoGebra, different representations of concepts can be manipulated directly by the user. For instance, a geometric object can be altered easily with the help of the mouse. Concurrently, its algebraic representation changes spontaneously. A similar situation is valid for each representation (Preiner, 2008; Ünlütürk Akçakın, 2016). In addition to this, it is a free multiplatform and consists of user-friendly tools. It provides multiple representations of concepts. It allows to save and export output files in multiple formats and add images. It has automatic proving capabilities. Furthermore, it is multilingual in all its menus and commands. It enables the production of instructional materials that involve self-standing dynamic worksheets as interactive java applications that can be published on a website. Together with all these, it has an active international user community that provides instructional materials and technical support (Escuder & Furner, 2011; Majerek, 2014; Velichova, 2011; Wassie & Zergaw, 2019).

In many of the studies present in the literature, it can be noticed that GeoGebra provides effective learning in Mathematics teaching (Barçın, 2019; Boo & Leong, 2016; Bwalya, 2019; Doğan & İçel, 2011; Genç, 2010; Hussin, Yusoff, Mustaffa & Mokmin, 2018; Özçakır Sümen, 2013; Ünlütürk Akçakın, 2016; Zengin, 2019). However, it is observed that these studies are generally carried out in educational institutions at the secondary school level and above. There are just a few studies investigating the effect of GeoGebra software on students' Mathematics achievement at the primary school level. As a result of the literature review, the study conducted by Özçakır Sümen (2013) concluded that the computer-assisted instruction in which GeoGebra software was used increased the students' Mathematics achievement in the subject of "Symmetry". For this reason, thanks to the studies to be further carried out at the primary school level, it is deemed important to increase the availability of the GeoGebra software program at the primary school level and the use of this program, which is generally used for the subject area of geometry, in different subject areas (measurement).

The fact that there are not many dynamic geometry software programs for Mathematics lessons, especially at the primary school level, and that there are not any studies found on the calculation of circumference in the literature, is thought to increase the significance of this subject even more. In teaching geometry concepts, enabling students to see the shapes supports their perception of knowledge (Aydın, Kertil, Yılmaz & Topçu, 2006). Although the teacher makes very accurate and good drawings regarding the shapes within the classroom, it is very difficult for students to perceive the rotated representations of these shapes drawn in different positions (Barçın, 2019). For this reason, it is anticipated that performing the studies on geometric shapes especially by using computer software is thought to enable students to comprehend them more easily and structure geometry in a better way.

Considering the issue of measurement in geometry, circumference, area, and volume are the issues that come to mind at first (Dağlı & Peker, 2012). It can be confusing if the circumference involves measurement or if the formulas are taught and remembered by giving the circumference to students at the same time as the area is given (Van De Walle, Karp & Bay-Williams, 2012). For this reason, circumference measurement should be supported by more creative and vigorous activities for students. In this sense, this study aimed to examine the effect of the primary school 4th grade circumference measurement subject taught with the support of the dynamic geometry software "GeoGebra" on the achievement of the students in terms of circumference measurement and their Mathematics motivation. Following this main purpose, it was aimed to answer the following sub-problems in the study:

1. Do the lessons taught with the dynamic geometry software "GeoGebra" have a significant effect on the student's achievement in terms of circumference measurement subjects in Mathematics lessons?

2. Do the lessons taught with the dynamic geometry software "GeoGebra" have a significant effect on the student's motivation levels in Mathematics lessons?

2. Methodology

2.1. Research Model

The model of the research is a quasi-test design with pre-test and post-test control groups. This design is the testing of a dependent variable (knowledge or attitude) with an independent variable (education or knowledge presentation) before and after the intervention (Stratton, 2019). Accordingly, a quasi-test design was used in the study because no random assignment could be made. In the research, a study was planned through the test and control groups to determine the effect of teaching circumference measurement subjects in the 4th grade primary school Mathematics lesson with the dynamic geometry software GeoGebra on achievement and motivation. The equality of the groups was taken into consideration in the selection of the test and control groups. The lessons taught to the test and control groups were taught by their classroom teachers.

2.2. Population and Sample

The population of this research was composed of the 4th grade primary school students studying in Izmir. To determine the sample in the research, a purposeful sampling method was preferred.
The sample of the research was composed of two 4th grade classes in a public primary school affiliated with the Ministry of National Education and located in Selçuk district of İzmir province. One of the 4th grade classes in this primary school was determined as the experimental group and the other class was determined as the control group. Each class involved 23 students. 13 (56%) of the students in the experimental group were boys and 10 (44%) were girls; whereas 12 (52%) of the students in the control group were boys and 11 (48%) were girls.
In line with the research model, the equality of the test and control groups was taken into consideration. To determine this situation, the scores of the data collection tools applied to the groups were compared through the normality analysis, and the results of the analysis are presented in the table below.

Table 1.

Normality Analysis Results of the Data Collection Tools Used in the Research

The Data Collection Tools Used in the Research	Group	Test	Skewness	Kurtosis
Achievement Test (Circumference Measurement)	Test	Pre-test	-0.013	-0.490
	Control	Post-test	0.290	-0.899
Motivation Scale (For the Primary School Mathematics Lessons)	Test	Pre-test	0.604	0.291
	Control	Post-test	0.740	0.510

As could be seen in Table 1, the skewness and kurtosis values of the achievement test and motivation scale data applied as a pre-test and post-test to the test and control groups were within the range of +1 and -1 values. According to this finding, it was determined that the data in the achievement test and motivation scale showed normal distribution.
In the research, before the subject of Circumference Measurement was taught to the students in the test and control groups, whether there was a significant difference between the achievement pre-test mean scores were analyzed with the independent samples t-test, and the results of the analysis are presented in the table below.

Table 2.

Pre-application Circumference Measurement Achievement of the Groups

Groups	N	$\bar{x}$	Sd	Df	t	p
Experimental group (Pre-test)	23	5.52	2.08	44	1.931	0.60
Control Group (Pre-test)	23	4.34	2.03			

As could be seen in Table 2, according to the results of the independent samples t-test, it was determined that there was no significant difference between the experimental group ($\bar{x}$ =5.52) and the control group ($\bar{x}$ =4.34) (t=1.931, p>0.05). As a result of the analysis, it was observed that the students in both groups did not differ in terms of their achievement scores before the application and that they were equal groups. Before the subject of Circumference Measurement was taught to the students in the test and control groups, whether there was a significant difference between their Mathematics lesson motivation pre-test mean scores was analyzed with the independent samples t-test, and the results of the analysis are presented in the table below.

Table 3.

Pre-application Mathematics Motivation Scores of the Groups

Groups	N	$\bar{x}$	Sd	Df	t	p
Experimental group (Pre-test)	23	58.60	6.76	44	-1.516	0.137
Control Group (Pre-test)	23	61.17	4.48			

As indicated in Table 3, according to the results of the independent samples t-test, it was determined that there was no significant difference between the experimental group ($\bar{x}$ =58.60) and the control group ($\bar{x}$ =61.17) (t=1.516, p>0.05). As a result of the analysis, it was observed that the students in both groups did not differ in terms of their Mathematics lesson motivation scores before the application and that they were equal groups.

2.3. Data Collection Tools

To test the achievement levels of the students in the research, Circumference Measurement Achievement Test and Primary School Mathematics Motivation Scale were used. The achievement test was developed by Öksüz and Genç (2021) to measure the achievement levels of primary school 4th grade students in terms of circumference measurement. As a result of the reliability analysis of the achievement test, the KR-20 value was calculated as .81, and the test was composed of a total of 21 questions, 18 of which were multiple choice questions, 2 were open-ended questions, and 1 was a question seeking for a short answer.
The motivation scale used in the research was developed by Ersoy and Öksüz (2015) to measure the motivation levels of primary school students. As a result of the analysis, the reliability coefficient of the scale was calculated as .94, and it was composed of a total of 33 items, 4 of which were negative and 29 were positive, and all graded as “I agree”, “I partly agree” and “I don’t agree”.

2.4. Application

One day before the application was initiated, the GeoGebra classic 6 program was installed by the researcher on the smart board in the experimental group classroom, where technology-assisted education would be provided in the mathematics lesson. Two days before the beginning of the application, information was given to the teacher of the class by the researcher about the GeoGebra program and how to use it. Before starting the lessons, the classroom teacher gave information to the students about how to use the GeoGebra program for 1 lesson hour, answered the questions of the students about the program, and provided the students the opportunity to use it. In the experimental group, the subject of "Circumference Measurement" was taught to the students in the experimental group by using the GeoGebra classic 6 software for 8 lesson hours (between May 11 and May 20, 2022) on the smart board and with the activities carried out in accordance with the learning outcomes of the lesson. The students took an active role during these activities. An activity presented by the classroom teacher explaining the drawing of geometric shapes to the students before the lessons were taught is given below:

2.4.1. Activity: Drawing a Rectangle

When the GeoGebra classic 6 program is opened, the worksheet appears as a grid divided into unit squares.

Select the *polygon* button ( ) to draw the rectangle shape. Here, the students can be made to discuss why the polygon button is chosen instead of a regular polygon, and the knowledge that "the side lengths of the rectangle, unlike the square, are not the same" can be reinforced. A rectangle is created by placing four points at the desired place on the worksheet.

The lengths of the relevant sides can be seen in the algebra window on the left side of the screen. The opposite sides of this quadrilateral may not be equal to one another, and the sides may not be intersecting each other perpendicularly.

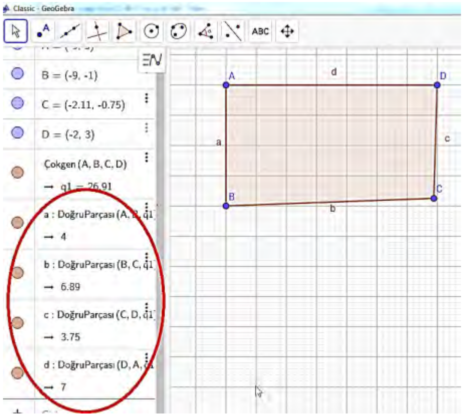

Fig. 1. Rectangle Drawing

To provide these properties of the rectangle, the button is pressed and it is aimed to make the opposite sides equal by making adjustments from the corner points of the shape. As can be seen in the 2nd figure below, a rectangular shape will be formed when it is observed that the side length properties belonging to the rectangle are obtained from this window.

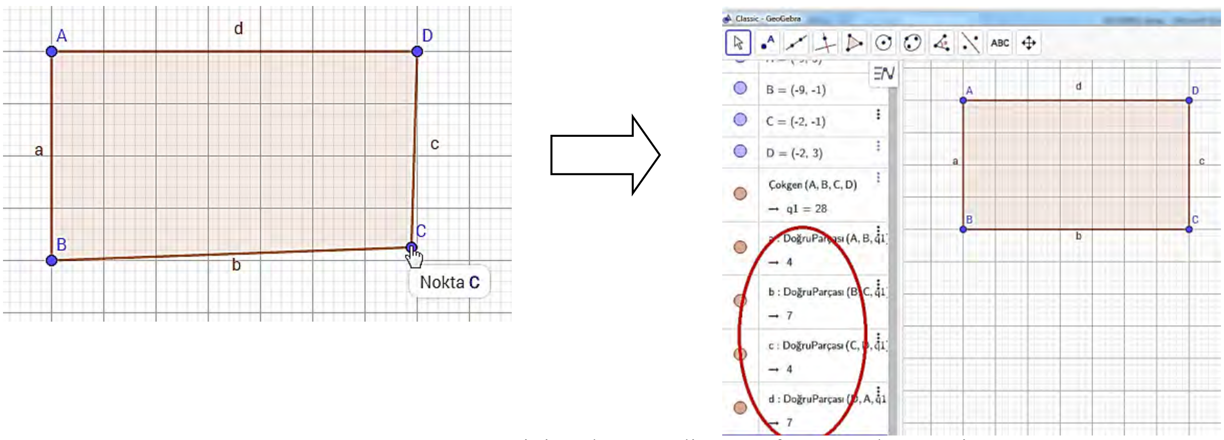

Fig. 2. Determining the Coordinates of Rectangle Drawing

Using the GeoGebra program, the rectangle can be drawn properly and without the need for adjustments. To be able to do this, if the worksheet is not unit square, you should click on the right of the page and select the *grid*. Therefore, the worksheet is divided into unit squares.

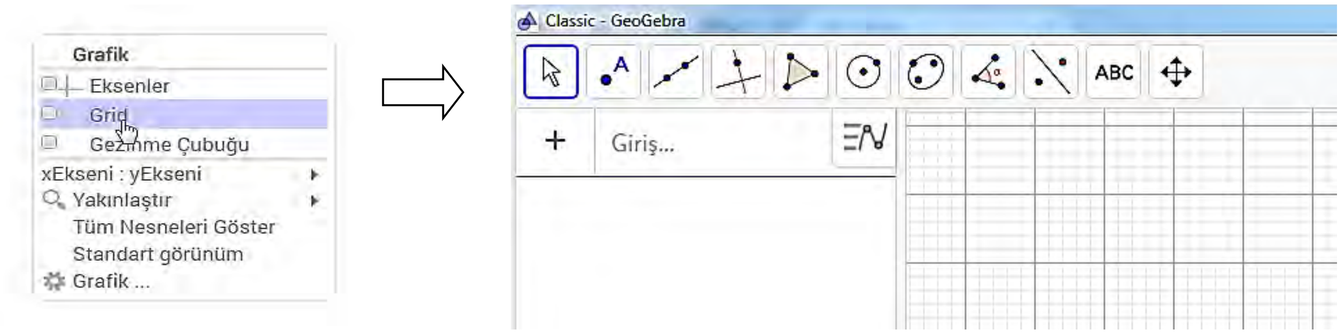

Fig. 3. GeoGebra Program Menu

In order to draw the rectangle shape, the *polygon* button ( ) is selected. In this way, a rectangle can be drawn anywhere on the worksheet thanks to the *grid* that is already present.

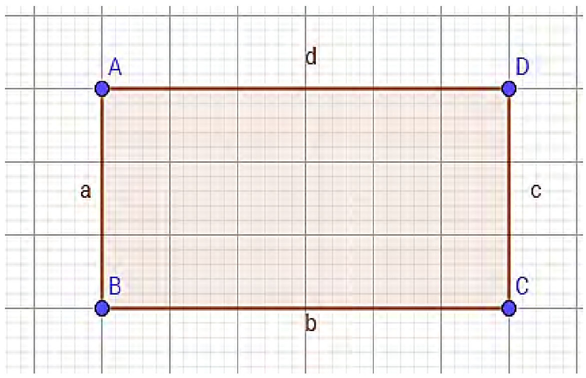

Fig. 4. Creating a Rectangle

Technological equipment was not used in the teaching of the lessons in the control group, and the lessons were taught without the intervention of the researcher. The researcher also followed the lessons in the control group, and it was observed that the lessons were based on the textbook of the lesson. In both the experimental group and the control group, the lessons were conducted by the classroom teachers.

2.5. Data Analysis and Interpretation

The statistical analysis of the data obtained within the scope of the research was performed by using SPSS 27 package program. To compare the Circumference Measurement Achievement Test and Primary School Mathematics Motivation Scale pre-test and post-test scores of the students in the experimental group and control group involved in the study group of the research, paired-samples t-test was used; and when the pre-test mean scores of the related inventories were controlled, Covariance Analysis (ANCOVA) was used to determine the effect of the teaching method applied on the students.

3. Findings and Evaluations

To measure whether there was a significant difference between the pre-test and post-test mean scores of the students in the experimental group before the application in terms of Circumference Measurement, paired-samples t-test analysis was performed. The results of the analysis are presented in the table below.

Table 4.

Pre-application and Post-application Achievements of the Students in the Experimental group

Groups	N	$\bar{x}$	S	Df	t	p	Cohen's d
Experimental group (pre-test)	23	5.52	2.08	22	-9.128	<.001	0.41
Experimental group (post-test)	23	14.73	3.79				

As could be seen in Table 4, it was found that the arithmetic mean of the achievement pre-test scores of the experimental group was 5.52; whereas as a result of teaching the circumference measurement subject with the dynamic geometry software "GeoGebra", the arithmetic mean of their achievement post-test scores was 14.73. In accordance with this finding, it was determined that the difference between the achievement pre-test and post-test scores of the experimental group was statistically significant ($t=-9.128$, $p<.05$). In this case, it could be said that teaching the "Circumference Measurement" subject with the dynamic geometry software "GeoGebra" to the students in the experimental group positively affected the achievement levels of the students. In addition to this, considering *Cohen's d* value, it could be stated that teaching the "Circumference Measurement" subject with the dynamic geometry software "GeoGebra" created a moderate effect size.

To measure whether there was a significant difference between the pre-test and post-test mean scores of the students in the control group in terms of Circumference Measurement, paired-samples t-test analysis was performed. The results of the analysis are presented in the table below.

Table 5.

Pre-application and Post-application Achievements of the Students in the Experimental group

Groups	N	$\bar{x}$	S	Df	t	p	Cohen's d
Control Group (pre-test)	23	4.34	2.03				0.13
Control Group (post-test)	23	7.26	3.15	22	-4.214	<.001	

As could be seen in Table 5, it was found that the arithmetic mean of the achievement pre-test scores of the control group was 4.34; whereas as a result of teaching the circumference measurement subject within the current curriculum, the arithmetic mean of their achievement post-test scores was 7.26. In accordance with this finding, it was determined that the difference between the achievement pre-test and post-test scores of the control group was statistically significant ($t=-4.214$, $p<.05$). In this case, it could be said that teaching the "Circumference Measurement" subject with the current curriculum to the students in the control group positively affected the achievement levels of the students. However, considering *Cohen's d* value, it should be noted that teaching the "Circumference Measurement" subject with the current curriculum created a low effect size.

To determine whether there was a significant relationship between the Circumference Measurement Achievement Test scores of the students in the test and control groups participating in the study, Covariance Analysis (ANCOVA) was performed. For this, first of all, the assumptions of the Covariance Analysis (ANCOVA) were examined. As indicated in Table 2, it was seen that the data showed a normal distribution.

Besides, for the equality of error variances, which are among the assumptions of the covariance analysis, the Levene Test was performed, and post-test scores were found (F_{1-44}=1.21, p=.278). Therefore, it was determined that there was no significant difference between the error variances (p>.05). In addition, one of the other assumptions of covariance analysis is that the curves of the covariance regression lines are equal (Field, 2005). According to the results of the analysis, it was revealed that the curves of the covariance regression lines in the test measurements were equal (F_{1-42}=3.31, p=.076).

After ensuring the assumptions of the covariance analysis, the pre-test, post-test, and adjusted post-test mean scores of the students in the test and control groups in terms of the Circumference Measurement Achievement Test (CMAT) were obtained, and the results are presented in Table 6 below.

Table 6.

Circumference Measurement Achievement Test Mean Scores of the Students in the Groups

Groups	Pre-test	Post-test	Adjusted Mean Score
Experimental group	5.52	14.73	14.79
Control Group	4.34	7.26	7.20

According to Table 6, it was found that the adjusted post-test achievement mean scores of the students in the experimental group were 14.79, while the adjusted post-test mean scores of the students in the control group were 7.20.

The results of the Covariance Analysis, which was conducted to test the significance of the difference between the adjusted achievement mean scores of the test and control group students, are presented in Table 7.

Table 7.

Comparison of the Achievement Mean Scores of the Students in the Groups

Source of Variance	Sum of Squares	df	Mean Square	F	Sig. (p)	η2
Pre-test	1.725	1	1.725	.139	.711	.003
Group	610.886	1	610.886	49.270	<.001	.534
Error	533.145	43	12.339			
Total	6744.000	46				
Total (Adjusted)	1178.000	45				

As could be seen in Table 7, it was found that there was a significant difference between the adjusted post-test mean scores compared to the achievement pre-test mean scores of the students in the experimental group to which the Circumference Measurement subject was taught with the dynamic geometry software GeoGebra ($\bar{x}$ =14.79) and the adjusted post-test mean scores compared to the achievement pre-test mean scores of the students in the control group taught in line with the current curriculum ($\bar{x}$ =7.20), and it was revealed that this difference was on behalf of the experimental group (F_{1-46}=49.270, p=<.001). This finding showed that teaching with the dynamic geometry software GeoGebra caused a significant difference in the academic achievement levels of the students in terms of circumference measurement in Mathematics lessons. It was also observed that the Eta-square (η2) effect size value was high (.53).

In order to measure whether there was a significant difference between the Motivation Scale mean scores of the students in the experimental group before and after the application process, the paired-samples t-test analysis was performed. The results obtained as a result of the analysis are presented in the table below.

Table 8.

Pre-application and Post-application Motivations of the Students in the Experimental group

Groups	N	$\bar{x}$	S	Df	t	p	Cohen's d
Experimental group (pre-test)	23	58.60	6.76	22	-13.355	<.001	1.31
Experimental group (post-test)	23	87.43	7.44				

As could be seen in Table 8, it was found that the arithmetic mean of the motivation pre-test scores of the experimental group was 58.60; whereas as a result of teaching the circumference measurement subject with the dynamic geometry software "GeoGebra", the arithmetic mean of their motivation post-test scores was 87.43. In accordance with this finding, it was determined that the difference between the pre-test and post-test scores of the experimental group was statistically significant in terms of motivation ($t=-13.355$, $p<.05$). In this case, it could be said that teaching the "Circumference Measurement" subject with the dynamic geometry software "GeoGebra" to the students in the experimental group positively affected the motivation levels of the students regarding Mathematics lesson. In addition to this, considering *Cohen's d* value, it could be stated that teaching the "Circumference Measurement" subject with the dynamic geometry software "GeoGebra" created a high effect size.

In order to measure whether there was a significant difference between the pre-test and post-test mean scores of the students in the control group in terms of the Primary School Mathematics Motivation Scale, paired-samples t-test analysis was performed. The results of the analysis are presented in the table below.

Table 9.

Pre-application and Post-application Motivations of the Students in the Control Group

Groups	N	$\bar{x}$	S	Df	t	p	Cohen's d
Control Group (pre-test)	23	61.17	4.48	22	-8.464	<.001	0.70
Control Group (post-test)	23	76.69	7.36				

As could be seen in Table 9, it was found that the arithmetic mean of the motivation pre-test scores of the control group was 61.17; whereas as a result of teaching the circumference measurement subject within the current curriculum, the arithmetic mean of their motivation post-test scores was 76.69. In accordance with this finding, it was determined that the difference between the pre-test and post-test scores of the control group was statistically significant in terms of motivation ($t=-8.464$, $p<.05$). In this case, it could be said that teaching the "Circumference Measurement" subject with the current curriculum to the students in the control group positively affected the motivation levels of the students in terms of Mathematics lesson. Furthermore, considering *Cohen's d* value, it should be noted that teaching the "Circumference Measurement" subject with the current curriculum created a high effect size for the student's motivation.

In order to determine whether there was a significant relationship between the Primary School Mathematics Motivation Scale scores of the students in the test and control groups participating in the study, Covariance Analysis (ANCOVA) was performed. For this, first of all, the assumptions of the Covariance Analysis (ANCOVA) were examined. As indicated in Table 2, it was seen that the data showed a normal distribution. Besides, for the equality of error variances, which are among the assumptions of the covariance analysis, the Levene Test was performed, and post-test scores were found ($F_{1\text{-}43}$=0.05, p=.816). Therefore, it was determined that there was no significant difference between the error variances (p>.05). In addition, one of the other assumptions of covariance analysis is that the curves of the covariance regression lines are equal (Field, 2005). According to the results of the analysis, it was revealed that the curves of the covariance regression lines in the test measurements were equal ($F_{1\text{-}42}$=3.42, p=.099).

After ensuring the assumptions of the covariance analysis, the pre-test, post-test, and adjusted post-test mean scores of the students in the test and control groups in terms of the Primary School Mathematics Motivation Scale (PSMMS) were obtained, and the results are presented in Table 10 below.

Table 10.

Motivation Mean Scores of the Students in the Groups

Groups	Pre-test	Post-test	Adjusted Mean Score
Experimental group	58.60	87.43	87.35
Control Group	61.17	76.69	76.78

According to Table 10, it was found that the adjusted post-test motivation mean scores of the students in the experimental group were 87.35, while the adjusted post-test mean scores of the students in the control group were 76.75.

The results of the Covariance Analysis, which was conducted to test the significance of the difference between the adjusted motivation mean scores of the test and control group students, are presented in Table 11.

Table 11.

Comparison of the Motivation Mean Scores of the Students in the Groups

Source of Variance	Sum of Squares	df	Mean Square	F	Sig. (p)	η2
Pre-test	6.21	1	6.21	.111	.741	.003
Group	1221.324	1	1221.324	21.752	<.001	.336
Error	2414.309	43	56.147			
Total	313543.000	46				
Total (Adjusted)	3746.804	45				

As could be seen in Table 11, it was found that there was a significant difference between the adjusted post-test mean scores compared to the motivation pre-test mean scores of the students in the experimental group to which the Circumference Measurement subject was taught with the dynamic geometry software GeoGebra ($\bar{x}$ =87.35) and the adjusted post-test mean scores compared to the motivation pre-test mean scores of the students in the control group taught in line with the current curriculum ($\bar{x}$ =76.778), and it was revealed that this difference was on behalf of the experimental group ($F_{1\text{-}45}$=21.75270, p=<.001). This finding showed that teaching with the dynamic geometry software GeoGebra caused a significant difference in the motivation levels of the students in terms of circumference measurement in Mathematics lessons. It was also observed that the Eta-square (η2) effect size value was high (.33).

4. Conclusion, Discussion, and Suggestions

The results obtained in this study, in which the effect of technology-assisted teaching of the "Circumference Measurement" subject in the 4th grade of primary school was examined, are as follows:

As a result of the lesson activities performed on teaching circumference measurement assisted by the dynamic geometry software "GeoGebra", there was a significant increase in the achievement post-test mean scores of the experimental group. Besides, when the post-test scores of the test and control group students were compared in terms of achievement, it was concluded that the achievement mean scores of the students in the experimental group were higher, and thus it could be said that the lessons taught made a positive contribution to the students. This finding is consistent with the conclusions obtained in the studies conducted by Genç and Öksüz (2016), Özçakır Sümen (2013), Ünlütürk Akçakın (2016), Kaya (2017), Canevi (2019), Zengin (2019), Barçın (2019), Doğan and İçel (2011), Bwalya (2019), Daulay et al. (2021), Jusufi and Kitanov (2019), Mukamba and Makamure (2021).

According to the motivation pre-test scores of the students in the experimental group, in which circumference measurement subject was taught with the assistance of the dynamic geometry software "GeoGebra", a significant increase was observed in the post-test scores of the students; and when the motivation post-test scores of the students in the test and control groups were compared, it was found that there was a significant difference on behalf of the experimental group. In this case, it could be noted that the motivation levels of the students in the experimental group increased as a result of the lessons taught with the dynamic geometry software "GeoGebra". This result is consistent with the conclusions obtained in the studies conducted by Uğur, Urhan, and Kocadere (2016) and Doğan and İçel (2011), in which the dynamic geometry software was found to increase motivation.

In addition, although there was no researcher intervention in the control group, a significant difference was found in the post-test scores of the students compared to the achievement pre-test scores of the group. It was also understood that the education process of the control group also had a positive effect on the achievement of the students in the Mathematics lessons taught on the subject of circumference measurement. Besides, it was concluded in the study that there were significant differences between the achievement post-test scores of the test and control group students on behalf of the post-tests after they were taught the subject of circumference measurement. Furthermore, it was observed that the students in the control group were also successful in the lessons taught within the scope of the current curriculum in the primary schools in Turkey. In accordance with this result, it can be said that the constructivist approach, which has been applied since the 2005-2006 academic year, increases the achievement levels of the students. This finding is consistent with the results of the study conducted by Mutlu and Söylemez (2019).

Due to all these results obtained from the current study, training and workshops can be held to disseminate the use of the dynamic geometry software program to wide circles, which is the subject of this research, Considering the primary school curriculum of the Turkish Ministry of National Education (2018), it was emphasized that the use of dynamic geometry software could only be used in the 2nd grade geometric objects and shapes topic. Explanations can be further included for the use of this software more and more in the primary school mathematics curriculum. For this reason, dynamic geometry software can be provided to teachers and educators so that they can integrate it into their lessons more. When the literature is reviewed, it can be seen that the studies on these software programs are mostly directed at secondary schools and high schools. Based on this fact, it is thought that increasing the number of studies directed at the primary school level can contribute to the related literature. Dynamic geometry software is used in the field of learning geometry. However, with the current study, it is exemplified that it can also be used in the field of measurement, and thus its use can be further increased for different Mathematics lesson learning areas. This study, which was conducted through the use of dynamic geometry software, was more concerned with the analysis of quantitative data. For this reason, qualitative studies on this subject can also be carried out. In the study conducted by Kaya and Öçal (2018) entitled "A meta-analysis for the effect of GeoGebra on students' academic achievements in Mathematics", it can be seen that GeoGebra has a high effect on academic achievements in Mathematics lessons. Based on this, activity books can be prepared so that GeoGebra can be used more effectively in Mathematics lessons.

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