The Effect of Technology Based Teaching on Academic Achievement and Student Views on Sixth-Grade Angles

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Abstract

This paper had two objectives: (1) determining the effect of the traditional method, GeoGebra-based method, digital game-based method, and digital storytelling based method on students' academic achievement and (2) evaluating students' views on the methods related to the subject of sixth-grade angles. The research was conducted for three weeks using different training methods for each class branch. The sample consisted of 42 students. The study adopted a mixed-method research design. Data were collected using a 19-item achievement test (pretest and posttest) and a semi-structured interview guide. The data were analyzed using analysis of covariance (ANCOVA). The qualitative data were analyzed using descriptive analysis. The results showed that technology-based education helped participants exhibit better academic performance. However, participants who received GeoGebra-based education exhibited the highest level of academic achievement. Participants stated that the greatest advantage of the traditional method was solving many questions. They noted that the greatest advantage of GeoGebra-based and digital storytelling-based education was that they helped them understand and learn subjects much more effectively. They reported that digital game-based education allowed them to reinforce subjects. For participants, the greatest disadvantage of the traditional method was having to write too much. They also added that they encountered technical problems during tech-based education. Participants recommended that teachers integrate smart board technology more into their lectures.

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Introduction

The styles of perception and thinking among students are evolving due to technological devices, the internet, and the video game industry. Therefore, traditional teaching methods and techniques fall short of meeting the needs of today's students, often referred to as digital natives (Savaş et al., 2021). Moreover, technology allows educators to develop and implement new teaching strategies (Baldiris et al., 2019). Embracing technology in education is essential for meeting the diverse needs of today's students. It enables educators to create dynamic, engaging, and adaptable learning environments that cater to a wide range of learning styles and preferences, ultimately leading to improved academic performance and lasting learning outcomes (Küçükokka et al., 2022).

Mathematics, often referred to as math, encompasses abstract concepts. Consequently, it is often perceived as a challenging subject, particularly for students who are still in the concrete operations stage of cognitive development. Enriching students' learning environments with technology-based resources can cultivate a greater interest in math among them (Biber et al., 2022). In other words, if educators offer students tech-based learning settings, they will be more interested in math, which can allow educators to provide a higher quality of math education (Yi et al., 2019). Moreover, students who use technology in class become more motivated to learn math (Öztop, 2022) because they can develop problem-solving (Huang et al., 2012) and math learning skills (Cai et al., 2020).

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GeoGebra is an interactive calculus, geometry, statistics, and algebra application used at all grade levels (Majerek, 2014). It is a free and open-source software package that allows learners to recognize the connection between geometry and algebra (Hohenwarter & Jones, 2007). It serves as a crucial educational tool that facilitates the shift from a teacher-centered approach to a learner-centered one in math education (Dahal et al., 2022). It facilitates conceptual learning (Fahlberg-Stajanovska & Trifunov, 2010; Yatim et al., 2022). Moreover, it helps learners develop positive attitudes toward lectures (Türk & Akyüz, 2016) and makes them more motivated and interested (Bhagat & Chang, 2015). It also allows learners to develop mathematical representations (Alkhateeb & Al-Duwairi, 2019), mathematical reasoning (Negara et al., 2022), and mathematical communication skills (Septian & Prabawanto, 2020). Educators can use it to showcase multiple representations of concepts and design teaching materials (Kusumah et al., 2020). It also promotes inquiry and contributes to learning by increasing students' attention (Uwurukundo et al., 2022; Wassie & Zergaw, 2019). Students who perform better academically have more positive perceptions of math, making them more capable of establishing mathematical connections (Bekene-Bedada & Machaba, 2022; Septian, 2022).

Digital games are other applications of tech-based math teaching. In recent years, digital games have become increasingly significant in the lives of children and young people. Children learn digital literacy from them. While schools do not emphasize this vital aspect (Gros, 2007), digital games contribute to learning processes because they provide blended learning by combining different learning settings, enabling latent learning. This means that students play digital games and realize that they have learned something after they are over (Prensky, 2001). Research shows that digital games can significantly improve learning (Moyer-Packenham et al., 2019) because they are so engaging that they cause the player to learn things quickly and efficiently. They also lay the groundwork for interactive learning environments and collaborative learning activities (Anastasiadis et al., 2018). Digital games help students perform better in math (Byun & Joung, 2018) because they allow them to understand math and develop what they already know (İncekara & Taşdemir, 2019; Sun et al., 2021). Furthermore, designing digital games takes so much creativity, which is one of the 21st-century skills (Aksoy & Demir, 2019).

Digital storytelling (DST) is a hybrid learning tool that is also used in math education. It is a visual medium that integrates many languages and contributes to analytical thinking (Robin & McNeil, 2013). Digital stories are a combination of traditional storytelling and multimedia tools (Figa, 2004). DST is more effective than traditional methods (Van Gils, 2005). Furthermore, it is beneficial for both teachers and students (İslim et al., 2018). Teachers should implement DST in their lectures (Tatum, 2009; Kobayashi, 2012) because it is an effective method for integrating multiple disciplines (Bahadır et al., 2021). It is a powerful tool that provides appealing and fun learning settings that contribute to effective learning (Niemi & Niu, 2021). It helps students develop comprehension, motivation, and memory skills, makes them more interested in lectures, allows them to achieve meaningful learning (Robin, 2006; Robin, 2008), and encourages them to associate math with daily life (Küçükoğlu & İncikabı, 2020). It also promotes collaborative learning, supports mathematical literacy, and facilitates competencies for the twenty-first century (Niemi et al., 2018; Gürsoy, 2021). Students who are engaged in DST are more likely to develop digital skills (Hava, 2021) as it contributes to fluency, which is one of the creative thinking skills (Tabieh et al., 2021). A digital story is created in six steps: writing drafts, developing a script, creating a storyboard, locating multimedia, creating the story, and sharing the story. (Jakes & Brennan, 2005). Digital stories are usually a few minutes long (Ceylan & Birinci, 2013; Jakes & Brennan, 2005; Kim et al., 2021).

Geometry involves lines, line segments, rays, angles, and shapes. Content ranges from drawing 2D and 3D shapes to how to measure lengths of angles, perimeters, and areas (Junthong et al., 2020). Some concepts in two-dimensional geometry require an understanding of their real-world applications. However, in classrooms, these concepts are often taught without assessing students' awareness and their ability to apply these concepts in their environment (Sarkar et al., 2020). Angles are one of those topics. The topics of “lines” and “angles” are considered necessary for students because of geometry and its real-life applications. Students are expected to understand the concepts of lines and angles, deduce line positions, discover the properties of angles on parallel lines intersected by other lines, and solve line and angle problems (Hartono et al., 2021). However, students have difficulty understanding the topic of angles (Munier & Merle, 2009). Therefore, they have too many misconceptions and make too many mistakes. Teachers need to correct those mistakes and dispel those misconceptions before they can move on to a higher level (Biber et al., 2013) because angles are a fundamental concept in geometry (Yiğit, 2014). Mitchelmore and White (2000) advocate that teachers should utilize conscious mental activities to teach the concept of angles. Göksu and Köksal (2016) argue that students may suffer from confusion if they do not internalize the relationship between geometric concepts, such as angles. Therefore, teachers turn to concept cartoons, V diagrams, mind maps, and Logo to teach angles or polygons (Bütüner & Gür, 2008; Clements & Battista, 1990). These researchers have reported that the methods they employed helped students reach higher levels of geometric thinking. In Turkey, children start learning the topic of angles at the primary school. The learning outcomes in the sixth grade are as follows:

> *“Terms or concepts: adjacent angles, complementary angles, supplementary angles, adjacent complementary angles, adjacent supplementary angles, and opposite angles*
>
> *M.6.3.1.1. Knows that a symbol represents the angle and that the starting point consists of two identical rays.*
>
> *M.6.3.1.2. Draws an angle congruent to an angle. It is necessary to draw on a squared paper. Furthermore, a protractor and similar tools can be used.*
>
> *M.6.3.1.3. Explores the properties of complementary, adjacent, opposite, and supplementary angles and solves related problems (Ministry of National Education, 2018)”.*

Students have to learn the topic of angles perfectly because it forms the basis of other topics in geometry. This study had two objectives: (1) determining the effect of the traditional method, GeoGebra-based method, digital game-based method, and digital storytelling based method on students’ academic achievement and (2) evaluating students' views on the methods related to the topic of sixth-grade angles. The following are subquestions:

1- How does technology-supported teaching affect 6th-grade students’ academic achievement in the subject of angles?
2- What are the students' views according to the applied methods?

Method

Research design

This study adopted a mixed-method research design involving the collection and analysis of both quantitative and qualitative data (Fraenkel et al., 2012). Creswell and Plano-Clark (2006) argue that using a mixed-method research design is better at helping researchers understand a problem than using the qualitative or quantitative method alone. Johnson and Onwuegbuzie (2004) also maintain that mixed-method research designs provide more precise and clear information. Therefore, they recommend that researchers employ mixed-method research designs to unveil different aspects of a phenomenon (Fırat et al., 2014). The quantitative stage of the present study investigated whether students' achievement levels depended on the method applied. The qualitative stage of the present study focused on students’ views on the advantages and disadvantages of the methods and their suggestions. The quantitative stage adopted a quasi-experimental design, which is employed to determine how different the change observed in a group is from the change observed in another group (Büyüköztürk, 2007). The qualitative stage focused on students’ views.

Study group

Participants were recruited using convenience sampling, which is a time- and cost-efficient method by which researchers select participants most suited to the research purpose (Baltacı, 2018). The sample consisted of 42 sixth graders divided into four groups: Class A consisted of nine students who received an education based on the traditional method (TM). Class B consisted of nine students who received an education based on GeoGebra-based teaching (GM). Class C consisted of 11 students who received an education based on digital games (DG). Class D consisted of 13 students who received an education based on digital storytelling (DST). The researcher delivered all the lessons.

An analysis of variance (ANOVA) test was performed to determine the difference in pretest scores between the groups. Table 1 shows the results.

Table 1.
ANOVA pretest results

Dependent Variable	Source	Sum of Squares	df	Mean Square	F	p
Pretest	Between Groups	9.244	3	3.081	1.133	.348
	Within Groups	103.327	38	2.719		
	Total	112.571	41			

The results showed no significant difference in pretest scores between the groups [F (3.38)= 1,133; p>.05].

Data collection tools

The data were collected in two steps. First, all participants took the achievement test as a pretest before the intervention. First, a specification table was developed for content validity. Second, experts were consulted. The researchers revised and finalized the form based on expert feedback. The achievement test consisted of 19 multiple-choice questions derived from the previous scholarship exam administered by the Ministry of National Education (MoNE). Experts were consulted to develop a semi-structured interview guide. All interviews were held in the same way because different teaching methods were applied to each group. The guide consisted of three questions: What did you like most about the method? What did you dislike most about the method? What do you recommend to improve the method?

Data analysis

The achievement test answers were evaluated as correct, incorrect, or blank. The data were analyzed using the Statistical Package for Social Sciences (SPSS). Table 2 shows the pretest and posttest descriptive statistics.

Table 2.
Pretest posttest descriptive statistics

	Groups	n	X	Std. Deviation	Skewness	Skewness Std. Error	Kurtosis	Kurtosis Std. Error
Pretest	TM	9	4.0000	1.32288	1.250	.717	4.000	1.400
	GM	9	4.4444	1.58990	.010	.717	-.663	1.400
	DG	11	5.2727	1.67874	-.214	.661	.298	1.279
	DST	13	4.9231	1.84669	.320	.616	1.169	1.191
Posttest	TM	9	13.4444	3.12694	-1.383	.717	.972	1.400
	GM	9	17.1111	1.69148	-.021	.717	-1.902	1.400
	DG	11	14.4545	2.54416	-.848	.661	.621	1.279
	DST	13	13.8462	2.47811	-.142	.616	-.542	1.191

Researchers can analyze skewness and kurtosis values for normality in cases where the sample is small (Tabanchnick & Fidell, 2013). The skewness coefficient is divided by the skewness standard error, while the kurtosis coefficient is divided by the kurtosis standard error. If the value ranges from -1.96 to +1.96, the distribution is considered normal or close to normal. In the present study, the distribution was normal or close to normal (Table 2).

The adjusted posttest mean scores were calculated by keeping the effect of the pretest scores under control. Table 3 shows the results.

Table 3.
Adjusted posttest mean scores

Group	n	X	Adjusted mean
TM	9	13.4444	13,210
GM	9	17.1111	17,022
DG	11	14.4545	14,638
DST	13	13.8462	13,915

Group GM had a significantly higher mean posttest achievement test score than the other groups (Table 3).

An analysis of covariance (ANCOVA) was performed to check the differences in posttest scores between the groups. ANCOVA corrects for prior differences between groups. It also increases statistical power by reducing error variance (Büyüköztürk, 1998). Post hoc comparisons were also made.

The qualitative data were analyzed using descriptive and content analysis. The researchers developed codes independently. They came together and discussed the codes until they reached a consensus. Having two researchers for analysis revealed different and similar aspects of the data. The presence of more than one researcher in data analysis requires coding reliability (Yıldırım and Şimşek 2013). Coding reliability was calculated using the formula developed by Miles and Huberman (1994): [Agreement / (Agreement + Disagreement)]x100. The reliability coefficient was 88%, which was adequate (Yıldırım & Şimşek, 2013). Three experts coded the qualitative data.

Procedure

The research lasted 12 classes. The presence of a researcher or an individual's belief that they are being observed can lead to changes in their behavior, affecting results and creating expectations. This phenomenon is referred to as the Hawthorne effect. The application of groups by different practitioners creates the John Henry effect, manifesting itself as an increase in performance due to the subconscious feeling of competition between groups (Kocakaya, 2012). In order to avoid all these effects, the lessons were taught by their current teachers. Moreover, the researchers did not inform the participants that they would be involved in an experimental study and compared with each other. Thus, the researchers took precautions against the John Henry effect. First, all participants were briefed about the study. Second, the pretest was administered to them. Third, the first researcher delivered all the lessons. Fourth, the posttest was administered to all participants. Fifth, the semi-structured interviews were conducted.

Traditional method

The traditional method involved the delivery of teacher-centered lessons. The textbook published by the MoNE was used as the material during the lessons. In addition, the researcher held Q&A sessions from time to time.

GeoGebra based method

The researcher used ten ready-made GeoGebra materials in line with the learning outcomes. The materials were obtained from GeoGebra' s official website. M5, M9, and M10 were used to achieve the learning outcome of two rays with the same starting points forming an angle. M7 and M9 were used to obtain an angle drawing equivalent to the angle. M1, M2, M3, M4, M6, and M8 were used to explore the properties of complementary, adjacent, supplementary, and opposite angles and to solve related problems.

Participants used the smart board to maximize the dynamics of GeoGebra. Participants were actively engaged in the lessons. For example, GeoGebra Material-1 helped participants use sliders. By moving the sliders, the sum of the adjacent supplementary angles was shown to be 180°. With this, participants were able to make generalizations by performing many experiments. Using GeoGebra Material-2, participants dynamically observed and made sense of the topic of adjacent angles.

Digital game based method

During the lessons, the researcher used eight digital games (problem-solving, performing operations, filling in the blanks, true-false questions, and knowledge contests). Six digital games (2, 3, 4, 5, 6, and 8) were used to teach the angle of two rays with the same starting points. Three digital games (4, 5, and 6) were used to teach how to draw an angle equivalent to the angle. All digital games were used to help participants explore the properties of complementary, adjacent, supplementary, and opposite angles and to solve related problems. For example, Digital Game 1 involved participants attempting to find the correct answer by using the arrow keys. In each game, the player is allowed to give three wrong answers. The player who gives three wrong answers loses the game. After each wrong answer, the game is restarted. The games can be played on the Smart Board. Digital Game 2 has fill-in-the-blank questions. The game can be played individually or in groups. After entering an answer, the game gives feedback and then poses the next question.

Digital storytelling based method

The researchers prepared eight digital stories about the learning outcomes of the topic of angles. They designed the digital stories on Renderforest, which is a video editing and management solution that helps create websites, graphics, logos, and mockups on a unified dashboard (Sari & Fathoni, 2022). Five digital stories (1, 3, 6, 7, and 8) were used to obtain the starting points of an angle of the same two rays. Four digital stories (1, 3, 7, and 8) were used to teach how to draw an angle equivalent to another angle. Four digital stories (2, 4, 5, and 6) were used to explore properties of complementary, adjacent, supplementary, and opposite angles and to solve related problems. For example, one of the digital stories is a fiction of a real-life neighborhood relationship used to explain the concept of adjacency. All the digital stories associated the topic of angles with daily life to arouse curiosity. The researcher paused the digital stories occasionally during the lesson. She asked them to watch the digital stories and encouraged them to make comments and discussions.

Validity and reliability

The achievement test had a Cronbach's alpha (α) score of 0.789, indicating reliability. The researchers conducted a literature review to develop the semi-structured interview guide. They generated a pool of questions. Then, they consulted three experts and revised the questions based on expert feedback. In addition, three experts were consulted when coding for the analysis of the interview questions.

Findings

The research findings are presented under two main headings in line with the research problems.

Findings regarding the effect of technology-supported instruction on 6th-grade students' academic achievement in the subject of angles

Table 4 shows the ANCOVA results.

Table 4.
ANCOVA results

Source	Type III Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
Corrected Model	87.537a	4	21.884	3.546	.015	.277
Intercept	1125.249	1	1125.249	182.312	.000	.831
Pretest	11.163	1	11.163	1.809	.187	.047
Groups	76.297	3	25.432	4.121	.013	.250
Error	228.368	37	6.172			
Total	9292.000	42				
Corrected total	315.905	41				

The pretest scores were taken under control. The results showed a significant difference in posttest scores between the groups [F (3.37) = 4, 121; p<.05] (Table 4). Table 5 shows the posthoc results.

Table 5.
Posthoc Comparisons

Comparison							
Group	Group	Mean Difference	SE	df	t	p_{tukey}	Cohen's d
DG	DST	0.723	1.02	37.0	0.708	0.893	0.291
	TM	1.428	1.16	37.0	1.232	0.611	0.575
	GM	-2.384	1.13	37.0	-2.101	0.172	-0.960
DST	TM	0.705	1.10	37.0	0.641	0.918	0.284
	GM	-3.108	1.08	37.0	-2.868	0.033	-1.251
TM	GM	-3.813	1.18	37.0	-3.242	0.013	-1.535

Note. Comparisons are based on estimated marginal means

Table 5 shows the results of the pairwise comparisons regarding the effect of the dependent variable (posttest scores) on the independent variable (group) after controlling for the effect of covariate (pre-test scores). The mean difference between groups DG and DST was 0.723 with a standard error of 1.02. The difference was statistically insignificant (p=0.708). The effect size (Cohen's d) was small (0.291). The mean difference between groups DG and TM was 1.428 with a standard error of 1.16. The difference was statistically insignificant (p=0.611). The effect size was moderate (0.575). The mean difference between groups DG and GM was -2.384 with a standard error of 1.13. The difference was statistically significant (p=0.172). The effect size was small to moderate (-0.960). The mean difference between groups DST and TM was 0.705 with a standard error of 1.10. The difference was statistically insignificant (p=0.918). The effect size was small (0.284). The mean difference between groups DST and GM was -3.108 with a standard error of 1.08. The difference was statistically significant (p=0.033). The effect size was moderate to extensive (-1,251). The mean difference between groups TM and GM was -3.813 with a standard error of 1.18. The difference was statistically significant (p=0.013). The effect size was large (−1.535). Overall, the post-hoc comparisons showed significant differences in posttest scores between the groups. Group GM performed significantly better than the other two groups. However, there was no significant difference in the mean posttest scores between groups DG and DST and DG and TM.

Findings regarding students' views on the applied methods

Participants' views were presented as codes and frequencies. Direct quotes were also provided to provide an accurate and coherent picture of participants' views. Each participant was assigned a code (P1, P2, P3, etc.) for each class.

Participants' views on the advantages of the methods

Table 6 shows the results.

Table 6.
Codes and frequencies related to the advantages of the methods

Method	Codes	*f*
TM	Solving many questions	4
	Using the textbook	3
	Repetition with homework	2
	Teacher's explanation	2
GM	Better understanding-learning	7
	Having fun	2
	Using the Smart Board	1
	Dynamism	1
	Solving many examples	1
	Fluency of the lesson	1
DG	Reinforcing the topic	3
	Better understanding-learning	3
	Fluency of the lesson-not getting bored	3
	Doing a lot of repetition	2
	Attractiveness of the games	2
DST	Better understanding-learning	6
	Liking the stories	3
	Having fun	3
	Seeing the topic from a different perspective	1

TM participants believed that the greatest advantage of the traditional method was that it allowed them to solve many questions. They noted that they liked the method because they got to use the textbook and do a lot of repetition with homework. They also stated that they liked the method because the teacher could explain the topic well.

> *"We can solve many questions in our notebook" (P8/ solving many questions).*

> *"… Our teacher explains the topic, gives us the floor, and gets us to solve many questions" (P2/ solving many questions/teacher's explanations).*

GM participants believed that the greatest advantage of GeoGebra was that it helped them better understand and learn the topic.

> *"The lesson flew by, and it was a blast!" (P7/ Having fun / Fluency of the lesson).*

> *"GeoGebra is very dynamic; it helped me understand the topic better" (P2/ Dynamism / Better understanding-learning).*

DG participants believed that the greatest advantages of digital games were that they helped them go over the topic multiple times and understand and learn it better. They also stated that they were not bored at all because the lesson was so much fun.

> *"I got the hang of it better by repeating it a bunch" (P10/ Reinforcing the topic / Better understanding-learning).*

> *"The lesson flies by!" (P3/ Fluency of the lesson-not getting bored).*

DST participants believed that the greatest advantage of digital storytelling was that it allowed them to understand and learn the topic better.

"I liked the stories very much; I understood the lesson very well" (P1/ Liking the stories / Better understanding-learning).

"We listened to our teacher and had much fun" (P12/ Having fun).

Participants' Views on the Disadvantages of the Methods

Table 7 shows the results.

Table 7.
Codes and frequencies related to the disadvantages of the methods

Method	Codes	*f*
TM	Writing too much	6
	Not using materials	2
	Rarely using the Smart Board	1
	Only covering the topic	1
GM	Technical problems	6
	Getting bored	1
	Little use by the student	1
DG	Technical problems	5
	Having the same type of questions in the games	4
	Using the same type of games	2
DST	Sometimes getting bored	5
	Being unable to participate in the lesson actively	3
	The story is boring	2
	Not understanding the story	1
	Technical problems	1

TM participants believed that the greatest disadvantage of the traditional method was that they had to write a bit too much. They noted that they did not get to use teaching materials. They also stated that the teacher rarely used the Smart Board. They added that the teacher talked only about the topic, but nothing else.

"We write too much, and I get tired" (T4/ Writing too much).

"We did not use a compass in the lesson; we only covered the topic" (T1/ Not using materials / Only covering the topic).

GM participants believed that the greatest disadvantage of GeoGebra was the technical problems

"Some parts of the Smart Board did not work" (P4/ Technical problems).

"I was very bored during the lesson…" (P8/ Getting bored).

DG participants believed that the greatest disadvantage of digital games was that they involved too many technical problems. Moreover, they stated that the games had the same type of questions. They noted that the games were too similar.

"We kept tackling the same questions over and over again." (P12/ Having the same type of questions in the games).

"The Smart Board freezes too many times. The keys are hard to press. That is why we lost the game" (T9/ Technical problems).

DST participants believed that the greatest disadvantage of digital storytelling was that they were sometimes boring. Moreover, they noted that they were unable to participate in the lesson actively.

"I got very bored watching the videos…" (P12/ Sometimes getting bored).

"…We watched the videos but we were never given the floor" (P9/ Being unable to participate in the lesson actively).

Participants' Suggestions for the Methods

Table 8 shows the results.

Table 8.
Codes and frequencies for suggestions regarding the methods

Method	Codes	*f*
TM	Making more use of the Smart Board	5
	Being more active	3
	Doing activities	2
	Not writing	1
	Solving more examples	1
GM	Making more use of the Smart Board	5
	Not writing in the notebook	2
	Doing lessons with GeoGebra	2
	Using concrete materials	1
	Using games	1
	Learning from the book	1
DG	Making more use of the Smart Board	6
	Learning from the book	2
DST	Making more use of the Smart Board	9
	Writing more	2
	Not writing	1
	Active participation	1
	Using games	1

Most TM participants recommended using the Smart Board more. They also suggested that they could be more active during the lesson, doing more activities. They added that they wanted to have to write less.

> *"We must use the Smart Board more often to solve problems" (P6/ Solving more examples).*

> *"I get very bored writing. I do not want to write" (P3/ not writing).*

Most GM participants suggested that they get to use the Smart Board more. They recommended that they take more notes in their notebooks. They stated that they could use GeoGebra in other lessons. They noted that they could get to use concrete materials and games more often. Some GM participants suggested to learn from the textbook.

> *"We should use the Smart Board more often" (P1/ Making more use of the smart board).*

> *".... We should use the textbook more" (P3/ Learning from the book).*

> *"I want to use GeoGebra in other lessons too" (P5/ Doing the lessons with GeoGebra).*

Most DG participants suggested that they get to use the Smart Board more and learn from the textbook. Most DST participants suggested that the teacher integrate the Smart Board more into her lectures. They also noted that they should participate more actively in lessons and use more games.

> *"I don't wanna take notes. Why don't we use the Smart Board" (P7/ Not writing / Making more use of the Smart Board).*

> *"We should use the Smart Board to solve examples by ourselves" (T10/ Making more use of the smart board / Active participation)*

Conclusion

This study investigated the effect of four methods (traditional, GeoGebra, Digital Game, and Digital Storytelling) on sixth graders' performance on the topic of angles. The study also focused on students' views of those methods. GeoGebra, Digital Game, and DST are tech-based methods, which is important for the technological age we are in. In addition, evaluating students' opinions is important to interpret and enrich the process. The results showed that tech-based teaching improved our participants' performance on the topic of angles. Research also shows that tech-based methods are better than traditional methods in terms of improving students' performance on math (Arvanitaki & Zaranis, 2020; Bayturan & Keşan, 2012; Çavuş & Deniz; 2022; Çetinav, 2023; Galitskaya & Drigas, 2019; Mensah & Nabie, 2021).

All participants had low achievement test scores, suggesting that they had a low level of readiness regarding angles. This result was expected because participants learned about angles in the fifth grade, but the achievement test posed sixth-grade questions about angles. In addition, all groups had similar pretest mean scores. The number of correct answers in the pretest was 4 or 5. On the other hand, the number of correct answers in the posttest was 13 to 17. Group GM had a lower mean pretest achievement test score than Groups DG and DST. However, Group GM had a higher mean posttest achievement test score than the other groups. This result shows that GeoGebra is better than digital games and digital stories. Research also shows that GeoGebra improves students' performance in geometry (Birgin & Topuz, 2021; Eftimova, 2022; Mamman & Surajo, 2021; Uwurukundu et al., 2022). Our results show that the greatest advantage of GeoGebra-based instruction is that it is a fun and dynamic method that helps students understand and learn the topic of angles much faster, solve many questions, and use the Smart Board (Çelen, 2020; Şahin & Kabasakal, 2018; Topuz & Birgin, 2020; Yorgancı, 2018; Erkek & Işıksal-Bostan, 2015). It also allows teachers to deliver their lectures fluently. However, GeoGebra-based instruction involves technical problems and bores some students. Moreover, students believe that it has little use for them. Çelen (2020) also found that students sometimes had difficulty participating in GeoGebra activities. Therefore, Şahin and Kabasakal (2018) recommended that teachers choose more appropriate activities to engage their students in their lectures. Mokotjo and Mokhele (2021) also reported that technical problems were a disadvantage of GeoGebra-based instruction.

The results showed that digital games improved our participants' performance in angles. Research also shows that digital games improve students' academic performance (Hung et al., 2014; Kaynar, 2020; Su & Cheng, 2013; Tokaç et al., 2019; Vitoria & Ariska, 2020). Our participants reported that digital games helped them go over the topic multiple times and learn and understand the topic better. They also noted that digital games made the lessons more fluent and allowed students to do much repetition and play engaging games. Kara (2021) recommended that content should align with expectations when using digital games. He also reported that the students found the games fun. Yong et al., (2016) determined that students were supportive and positive about using computer games during math classes. However, it is crucial to integrate digital games well into curricula. Otherwise, they will be less effective than anticipated (Wechselberger, 2009). Our participants noted that the digital games involved technical problems and the same type of questions. Some participants added the digital games were pretty similar.

Niemi and Niu (2021) stated that digital storytelling is a fun method that enhances learning (Saltık-Ayhanöz, 2021; Dinçer & Yılmaz, 2019), which is consistent with our results. Balaman and Ataman (2022) stated that the disadvantage of digital stories was the lack of materials. They also noted that the lack of materials in the absence of technological devices necessary for the preparation and presentation of materials had a complicated effect on students with attention deficits. Our results suggest that educators should prepare digital stories carefully and effectively.

All our participants wanted to use the Smart Board more often during lectures. Smart Boards have a positive effect on math achievement and student attitudes and a negative effect on math anxiety (Erdener & Kandemir, 2019). The role of teachers in the constructivist educational approach has been significantly enhanced with the integration of interactive whiteboards in math instruction. Furthermore, it has been observed that interactive whiteboards are commonly employed for mathematical exercises during math lessons (Kutluca et al., 2019). Therefore, we think that, regardless of the method, math teachers should continue to integrate Smart Boart technology into their lectures. Our TM and DST participants stated that they would like to be more actively engaged in lectures, indicating that both traditional instruction and digital storytelling adopt a teacher-centered approach.

Limitations and Suggestions for Future Research

This study has several limitations. First, the sample was small. Therefore, researchers should recruit larger samples to increase the validity, reliability, and generalizability of their findings. Second, we used a few materials, which may have caused some differences in the results. Therefore, researchers should focus on more materials.

We recommend that teachers choose more student-centered approaches to promote active engagement. In this way, students can make more discoveries and build their own knowledge. Therefore, we suggest that teachers pay attention to technical details while implementing tech-based instruction methods. This study involved materials prepared by the researchers. Researchers should allow students to design their own teaching materials in order to improve their performance. We assessed our participants' views within the scope of advantages, disadvantages, and suggestions. Thus, researchers should focus on different questions to better understand what students think about various teaching methods and techniques. We focused on our participants' achievement status. Researchers should also address the memorability of information for a more comprehensive understanding of the topic.

Ethics statement

This study was approved to comply with science ethics by Kafkas University's Ethics Committee of Social Sciences and Humanities (Session Nr.31, Decree Nr. E-3983, Date: 21.02.2022). Throughout the data collection, analysis, and reporting processes, utmost attention was paid to ethical principles regarding human privacy, data security, and confidentiality. Informed consent was obtained from all participants, and they were assured that their participation was voluntary.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of interest

None

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