Kalem Eğitim ve İnsan Bilimleri Dergisi 2026, 16(2), 527-553, doi: 10.23863/kalem.2026.346

The Effect of Digital Games and Animations on Middle School Students' Spatial Thinking Skills

Dr. Öğr. Üyesi Saliha CEVHER*

Trabzon Üniversitesi, Fatih Eğitim Fakültesi, Türkçe ve Sosyal Bilimler Eğt. Bölümü, Trabzon / Türkiye, salihatoros @trabzon.edu.tr, ORCID: 0000-0002-7532-550X

Prof. Dr. Mustafa CİN

Giresun Üniversitesi, Eğitim Fakültesi, Temel Eğitim Bölümü, Giresun / Türkiye, mustafa.cin@giresun.edu.tr, ORCID: 0000-0002-1246-9899

Abstract

The aim of this study is to examine the effects of middle school students' use of digital game and animation software on their academic achievement and spatial thinking skills and to assess students' opinions regarding the integration of digital game and animation software into lessons. The research employed an embedded design, a mixed-methods research design. The study group consisted of 54 sixth-grade students attending a middle school in Trabzon. The People, Places, and Environments Academic Achievement Test (PPEAAT) was used to measure the students' academic achievement, and the Spatial Thinking Skills Test (STST) was used to measure their spatial thinking skills. A semi-structured interview form was also used to collect their opinions. Data obtained from the PPEAAT and STST were analyzed using independent samples t-tests and paired samples t-tests, and the data obtained from the semi-structured interview form was analyzed using content analysis. In light of the findings of the study, no significant difference was found between the pre-test scores of the experimental and control groups in terms of academic achievement and spatial thinking skills, while a significant difference was found between

* Sorumlu Yazar. Tel: +90 554 177 23 33 | Araştırma Makalesi.
Makale Tarih Bilgisi. Gönderim: 16.06.2025, Kabûl: 16.11.2025, Erken Görünüm: Haziran, 2026, Basım: Aralık, 2026.

 ISSN: 2146-5606, e-ISSN: 2687-6574

the post-test scores of the experimental and control groups in terms of relevant variables in favor of the experimental group. Based on this result, it was concluded that the use of digital game and animation software has a positive impact on students' academic achievement and spatial thinking skills compared to the current curriculum. Furthermore, students generally have positive views of these digital tools.
Keywords: Digital game; Digital animation; Spatial thinking skill; Social studies; Scratch.

Dijital Oyun ve Animasyonların Ortaokul Öğrencilerinin Mekânsal Düşünme Becerileri Üzerindeki Etkisi

Öz

Bu çalışmanın amacı, ortaokul düzeyindeki öğrencilerde dijital oyun ve animasyon yazılımlarının kullanımının akademik başarı ile mekânsal düşünme becerileri üzerindeki etkisini ortaya koymak; ayrıca ders sürecinde bu teknolojilerin kullanımına ilişkin öğrenci görüşlerini değerlendirmektir. Araştırma, nicel ve nitel verilerin birlikte ele alındığı karma yöntem yaklaşımlarından gömülü desen doğrultusunda tasarlanmıştır. Araştırmanın çalışma grubunu, Trabzon ilinde bulunan bir ortaokulun altıncı sınıfında öğrenim gören 54 öğrenci oluşturmaktadır. Öğrencilerin akademik başarılarını belirlemek amacıyla İnsanlar, Yerler ve Çevreler Akademik Başarı Testi (İYÇABT), mekânsal düşünme beceri düzeylerini belirlemek için Mekânsal Düşünme Beceri Testi (MDBT) ve öğrenci görüşlerini belirlemek için ise yarı yapılandırılmış görüşme formu kullanılmıştır. Araştırmada kullanılan veri toplama araçlarından İYÇABT ve MDBT kapsamında elde edilen nicel veriler, bağımsız örneklemler t testi ve eşleştirilmiş örneklemler t testi kullanılarak çözümlenmiştir. Yarı yapılandırılmış görüşme formu aracılığıyla toplanan nitel veriler ise içerik analizi yöntemiyle incelenmiştir. Elde edilen bulgular doğrultusunda, deney ve kontrol gruplarının ön test sonuçları arasında akademik başarı ve mekânsal düşünme becerileri bakımından anlamlı bir farklılık bulunmadığı belirlenmiştir. Buna karşılık, son test sonuçlarında her iki değişken açısından deney grubu lehine istatistiksel olarak anlamlı bir fark ortaya çıktığı tespit edilmiştir. Bu sonuca dayanarak, dijital oyun ve animasyon yazılımlarının kullanımının mevcut öğretim programına göre öğrencilerin akademik başarılarını ve mekânsal düşünme becerilerini olumlu yönde etkilediği; ayrıca öğrencilerin dijital oyun ve animasyonların kullanımına ilişkin görüşlerinin de genel olarak olumlu olduğu sonucuna ulaşılmıştır.
Anahtar Kelimeler: Dijital oyun; Dijital animasyon; Mekânsal düşünme becerisi; Sosyal bilgiler; Scratch.

Introduction

Spatial skills are an indispensable part of human life because all human activities are performed in a spatial context. Therefore, people need spatial skills at every moment of their lives. Spatial thinking skills are so deeply embedded in daily routines that people unconsciously perform all their actions using spatial thinking. Examples range from choosing a suitable time to call someone living in another time zone, to estimating daylight hours, packing boxes when moving, maximizing space while placing items in a car trunk, or planning a route to an unfamiliar address. All these seemingly simple actions in everyday life involve using spatial thinking skills (National Research Council [NRC], 2006). Many technological tools can be used to help students acquire these indispensable skills of daily life (e.g., Google Earth, GIS, and Bing Maps). In addition to these tools used to develop spatial thinking skills, new educational tools that are appropriate for the level of middle school students and attract their interest have recently begun to be used in educational settings. Digital game and animation tools are among these tools.

In today's world, the focus has shifted from what something is to how it is designed. With the widespread use of technological tools in education, design software that allows users to design their games themselves has been used in educational settings. Among the recent technologies that appeal to students' interests, digital game and animation design software not only offer enjoyable activities but also foster a sense of discovery (Bisson and Luckner, 1996). These tools also enable students to take control of their own learning processes. Because games reinforce skills and engage multiple learning styles and intelligences, they can be especially empowering for students who struggle with low self-efficacy (De Grove et al., 2012). In short, the use of digital games and animations is believed to boost motivation and engagement, support permanent learning, and foster the development of various social and cognitive skills (Mitchell and Savill-Smith, 2004).

The effective implementation of digital game and animation software in educational settings by adapting them to curricula and students' grade levels, developmental traits, and age has become a significant focus in educational research. Computer programs tailored to students' needs have been developed, aiming to both capture their attention and support the achievement of learning outcomes and goals. One widely used example is Scratch, developed for educational purposes and suitable for learners of all ages. With

Scratch, users can create and code interactive stories, games, and animations, and then share them online. The software encourages creative thinking while also helping students gain essential 21st-century skills such as reasoning and collaboration (Scratch, n.d.). Beyond promoting the effective integration of technology into education, Scratch is also expected to enhance student engagement and foster spatial thinking skills. This view is further strengthened by the compatibility of Scratch with representation tools commonly used in teaching spatial thinking skills, such as sketches, maps, graphs, and visuals.

A review of the literature yielded a limited volume of research focusing on the development of spatial thinking skills (Akbaş and Sönmez, 2019; Bednarz and Bednarz, 2008; Kim, 2011; Seyhan and Delibalta, 2024; Tosun and Gökçe, 2025; Yayla, 2019). The use of digital game and animation design software to enhance spatial thinking skills has been explored among young children (Polinsky et al., 2021), primary school students (Yuda, 2011), and university students (Özcan et al., 2016). However, no research has been found that targets middle school students within the context of social studies education. Scratch, a globally used tool well-suited for middle school students, contains various technical and educational features that can be used to foster spatial thinking skills. However, studies assessing middle school students' spatial thinking skills have reported that their levels are often below the desired standard (Gönülaçar, 2019; Gönülaçar and Öztürk, 2020). Given that spatial thinking is a lifelong cognitive skill essential for interpreting and interacting with the environment, students' acquisition of spatial thinking skills can be effectively supported through software that allows them to design their own games and animations. Against this background, this study aimed to investigate the effects of using digital game and animation software on middle school students' academic achievement and spatial thinking skills, and explore their views on using these tools in classes. Accordingly, the main research problem was "Does the use of digital game and animation software affect middle school students' spatial thinking skills?". In line with this main problem, the following sub-problems were also addressed:

1. Does the use of digital game and animation software significantly influence students' academic achievement?
2. Does the use of digital game and animation software significantly influence students' spatial thinking skills?
3. What are students' views on the use of digital game and animation

software?

Methods

Research Design

This study employed a mixed-methods approach. Mixed-methods research involves collecting and integrating both quantitative and qualitative data, incorporating various designs, philosophical assumptions, and theoretical perspectives. The main assumption of this design is that combining qualitative and quantitative approaches offers a more complete understanding of a research problem than either approach used alone (Creswell, 2014). Following an embedded design, the study used a quasi-experimental pretest-posttest control group design for the quantitative part. In this design, the experimental and control groups are administered the same pretest simultaneously. The experimental group then undergoes the treatment, while the control group does not. A key aspect of this design is ensuring that the independent variable, methods, or activities used in the experimental group are excluded from the control group and that this situation is monitored. Both groups are then administered the same posttest simultaneously (Sönmez and Alacapınar, 2011). To complement the quantitative findings, the qualitative part involved semi-structured interviews with 15 students from the experimental group.

Sample

The research sampled 54 sixth-grade students attending two separate classes at a middle school in Akçaabat, Trabzon, during the 2018–2019 academic year. The study group was determined through convenience sampling, a non-probability sampling technique in which participants are selected based on their accessibility to the researcher. One class was designated as the experimental group (n=27), where the digital game and animation software was integrated into instruction, while the other was designated as the control group (n=27), where the standard curriculum was followed. Table 1 shows the demographic characteristics of the sample.

Table 1. Demographics of the Sample

Groups	Gender	Frequency	Percentage
Experimental	Female	13	24.07
	Male	14	25.92
Control	Female	15	27.78
	Male	12	22.23
Total		54	100

For the qualitative part of the research, 15 interviewees were selected from the experimental group using maximum variation sampling, a purposive sampling strategy to ensure diversity.

Data Collection Instruments

Three instruments were used to collect data. The qualitative data were collected using the People, Places, and Environments Academic Achievement Test (PPEAAT) to assess the effect of using digital game and animation software on students' academic achievement and the Spatial Thinking Skills Test (STST) to explore its effect on their spatial thinking skills. The quantitative data were collected using a semi-structured interview form to capture students' views on using the software in classes.

People, Places, and Environments Academic Achievement Test

The PPEAAT was developed by the researcher to determine how the digital game and animation software affect students' academic achievement. To ensure the alignment of test items with the learning objectives and measurement and assessment principles, expert feedback was sought, and revisions were made accordingly. A draft version containing 28 questions was piloted with 87 seventh-grade students at a different school. The data obtained from the pilot study were digitized, and item analysis was performed using the TESTAN item analysis tool. Item difficulty and item discrimination indices were computed for each question. Test items with a difficulty index between .40 and .68 and those with a discrimination index above .30 were retained. Items with a difficulty index below .40 (items 10, 19, 21, and 26) and those with a discrimination index below .30 (items 1, 6, 15, and 18) were removed from the final version. The finalized academic achievement test consisted of 20 items with an average difficulty index of .53.

After the item analysis, the reliability coefficient of the test was computed using the Kuder-Richardson 20 (KR-20) method, which assesses the internal consistency among the test items. The assumption of this method is that all items measure the same variable, indicating that the test is homogeneous. A KR-20 value of .70 or higher is generally considered acceptable for reliable tests (Öncü, 1999). The KR-20 reliability coefficient for the academic achievement test was computed as .75.

Spatial Thinking Skills Test

The STST was developed by the researcher to measure students' spatial thinking skills. To construct the test, the social studies curriculum was first examined to identify how spatial thinking skills were represented and categorized. The dimensions of spatial thinking were then aligned with curriculum standards, and a pool of questions was created accordingly.

Table 2. Learning Outcomes of the 6th-Grade Social Studies "People, Places, and Environments" Unit across Spatial Thinking Dimensions

	Learning Outcomes	**Spatial Thinking Dimensions**
6.3.1.	Defines the geographical location of the continents, oceans, and our country by using location concepts.	Regionality, Pattern
6.3.2.	Explores Türkiye's key physical geography features, including landforms, climate patterns, and vegetation, on relevant maps.	Regionality, Analogy, Spatial Association, Pattern
6.3.3.	Demonstrates Türkiye's basic human geography features on relevant maps.	Regionality, Analogy, Spatial Association, Pattern
6.3.4.	Makes inferences about climate features based on human life in various natural environments around the world.	Comparison, Spatial Association

The draft test items created were submitted for expert review. Experts were asked to rate each item as "appropriate", "not appropriate", or "needs revision". The data were analyzed using the Lawshe method. Based on the feedback and analysis results, necessary revisions were made. A draft version containing 20 questions was piloted with 87 seventh-grade students at a different school. The data obtained from the pilot study were digitized, and item analysis was performed using the TESTAN item analysis tool. Test items with a difficulty index between .40 and .69 and those with a discrimination index above .27 were retained. Items with a difficulty index below .40 and a discrimination index below .27 (items 4, 9, 17, and 20) were removed from the final version. The finalized STST consisted of 16 items with an average difficulty index of .46.

After the item analysis, the internal consistency of the test was computed using the KR-20 method. The KR-20 value of the test was computed as .71. Table 3 presents the descriptions of the items in the STST and the associated dimensions of spatial thinking.

Table 3. STST Items and Descriptions

Item No	Description	Components for Assessing Spatial Thinking Skills	Spatial Thinking Skills
1, 2, 5, 6	Respondents find the described location based on the given directions and instructions.	These questions measure spatial orientation skills, particularly the ability to understand and use directions (e.g., forward-backward, left-right, up-down, front-back, horizontal-vertical, and north-south-east-west) and to navigate and find locations.	Spatial Orientation
3	Respondents visualize the shape that would emerge after folding a two-dimensional figure.	This question assesses the spatial visualization dimension of spatial thinking, particularly the ability to mentally manipulate, rotate, bend, or invert visual information.	Spatial Visualization/Mental Imagery
4	Respondents identify the rotated version of a given shape.	This question assesses mental rotation skills, a key aspect of spatial visualization.	
7, 8	Respondents mentally visualize a three-dimensional image based on two-dimensional information.	These questions measure the ability to translate perceptions, representations, and images from one dimension to another and vice versa, assessing three-dimensional thinking skills (Golledge, 2002).	
9	Respondents combine given pieces to form a new shape.	This question assesses spatial visualization. It measures the ability to mentally manipulate visual stimuli and assemble and integrate parts into a whole.	
10	Respondents identify the information of the area located at specific coordinates using coordinatdata.	This question assesses spatial visualization skills, focusing on defining spatial boundaries and overlaying different layers of map information.	
11, 12	Respondents find the optimal location on the map by considering the given spatial information.	These questions measure spatial relations skills, particularly the ability to overlay and interpret multiple map layers.	Spatial Relations
13, 14	Respondents find spatial correlations between maps.	These questions assess the ability to relate and correlate spatially distributed phenomena, an essential skill within the spatial relations dimension.	
15	Respondents convert a map model into a two-dimensional line graph.	This question assesses the ability to recognize spatial patterns, graph spatial transitions (Gersmehl, 2005), and express spatial information by converting it into different representational formats.	
16	Respondents find the profile corresponding to the distance between two points on a region with given elevation contours.	This question assesses the ability to express spatial information by converting it into different formats, to transform perceptions, representations, and images from a single object to another dimension (Golledge, 2002), and to graph spatial transitions.	

Semi-Structured Interview Form

A semi-structured interview form was used to support the quantitative findings and explore students' views on the digital game and animation software used in the experimental procedure. A draft version was developed based on a review of the relevant literature. The draft was submitted for expert review, revised based on their feedback, and finalized following necessary adjustments. The interviews were held with 15 students selected from the experimental group using maximum variation sampling.

Designing Activities

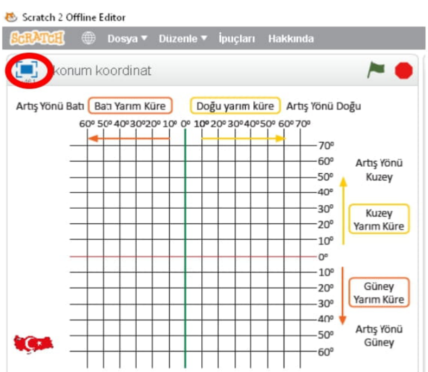
To assist the teacher in conducting the implementation, a guide was prepared explaining how to use the software and activities during the experimental procedure. This guide was designed based on the ADDIE instructional design model, following the stages of analyze, design, develop, implement, and evaluate (Şimşek, 2017).

During the analysis phase, digital games and animations were first reviewed to gather insights, and their applicability to social studies education was investigated. Given that spatial thinking skills are explicitly targeted in the social studies curriculum, the decision was made to teach the 6th-grade "People, Places, and Environments" unit using the digital game and animation software. During the design phase, activities were designed addressing the learning objectives and topics within the selected unit. These activities were then presented to three subject-matter experts in social studies education and two practicing social studies teachers. Based on their feedback, revisions were made, and the activities were moved to the development stage. For the sixth-grade Social Studies Unit "People, Places, and Environments", the following activities were developed: Coordinate Plane Puzzle, Continents' Location Puzzle, Landforms-Climate-Vegetation Relations, Human Elements, and Who Lives in Our Environment? These activities aimed to facilitate students' understanding of the topics and enhance their spatial thinking skills. An example activity is presented in the table below.

After the activities were developed for the experimental group, a 'teacher's material guide' was prepared to instruct the teacher on how to conduct the lessons. This guide, created to assist the teacher with the teaching of the "People, Places, and Environments" unit using the digital game and animation software, first explains digital games and animations. It then introduces the Scratch software used in the activities. Following the information on how to use the software, it provides step-by-step instructions for conducting each weekly activity. The guide was reviewed by three subject-matter experts, and revisions were made based on their feedback.

Table 4. Example Activity Used in the Implementation

Where Am I in the World? Coordinate Plane Puzzle	
Grade: 6	
Learning Outcomes: **SS.6.3.1**. Defines the geographical location of the continents, oceans, and our country by using location concepts. • Draws conclusions about Türkiye's absolute and relative location in terms of geopolitical, climatic, and transportation characteristics.	
Steps to Follow	
Information	The system, composed of parallels and meridians, is called the **geographic coordinate system (GCS)**. To determine the geographical coordinates of a place, a three-step process is followed: **Step 1:** Find which hemisphere the place is located in. If the degree of parallels increases toward the north, it is in the Northern Hemisphere. If it increases toward the south, it is in the Southern Hemisphere. **Step 2:** Determine its location relative to Greenwich. If the degree increases eastward, it is in the Eastern Hemisphere; if it increases westward, it is in the Western Hemisphere. **Step 3:** Determine the degrees of parallels and meridians passing through the endpoints of the place to find its coordinates.
Instruction	Design a game to determine Türkiye's geographical location using the coordinate system. Türkiye is located between the 36° and 42° North parallels and the 26°and 45° East meridians. Develop the game by positioning Türkiye's image correctly on the coordinate plane. Check the final version of your game.



Experimental Implementation Process

After the development of the activities was completed, the implementation phase was initiated. This study was conducted during the 2018-2019 academic year with 54 sixth-grade students from two different classes (experimental and control groups) at a middle school in Akçaabat, Trabzon. The implementation lasted for seven weeks, with three class hours per week for both groups. In the experimental group, lessons were conducted using digital game and animation software, whereas in the control group, no such software was used. The same teacher delivered the lessons to both groups. Figure 1 displays an overview of the implementation process.

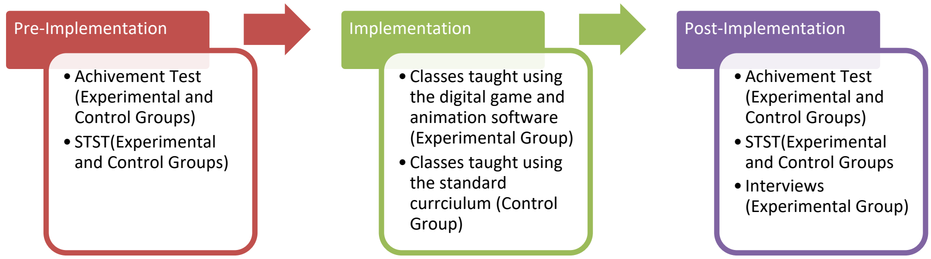


Figure 1. Implementation Procedure

To ensure a structured implementation, the researcher developed a weekly lesson plan aligned with the topics and objectives of the relevant unit. During the first week, students were informed about the purpose of the research and the implementation procedure, and the PPEAAT and the STST were administered as pretests to both groups. Afterward, the teaching of the relevant unit began in both groups. After the teaching of the learning area was completed, the same tests were administered to both groups as posttests. Finally, interviews were conducted with 15 students from the experimental group to gather views on their experiences with using the digital game and animation software. The implementation process was completed.

Classes in the Experimental Group

In the experimental group, the selected unit was taught using the digital game and animation software. Table 5 presents the weekly lesson plan, outlining the activities prepared for this phase.

Table 5. Weekly Lesson Plan

Weeks	Topics	Activities
1	Informing about the implementation process	PPEAAT and STST pretests
2	Where am I in the world?	Coordinate plane puzzle, continents' location puzzle
3	The beauties of my country on the map	Landforms-climate-vegetation relations
4	The riches of my country on the map	Human Elements
5	Who lives around us?	Who lives around us?
6	Evaluation	PPEAAT and STST Posttests

The activities designed for the "People, Places, and Environments" unit were implemented in the experimental group over seven weeks, with three class hours per week. The first week was reserved for administering the pre-tests, and the final week for the post-tests; thus, the actual instruction using digital game and animation software lasted for five weeks. This duration was determined proportionally to the time allocated for the relevant unit in the social studies curriculum. Before starting the activities in the experimental group, students were informed about the Scratch software. After the pretests were completed in the first week, the lessons continued in the information technology classroom. At the start of each week, students received worksheets outlining instructions for the weekly activities. They followed these guidelines to create their own digital games or animations. After students completed their activity, the teacher projected each student's work and conducted the lesson based on the completed activities. Visuals showing the implementation are presented below.

Figure 2. Visuals from the Implementation Process

Classes in the Control Group

In the control group, the pretests were administered in the first week and the posttests in the final week. The relevant unit was taught over five weeks by the teacher following the standard curriculum. No alternative teaching methods were used, and the textbook was used as the primary instructional material. Expert opinions were sought at each stage of the research process, and evaluations and revisions were made accordingly.

Data Analysis

The quantitative data were analyzed using descriptive statistics on the SPSS 21.0 Statistics software. After data entry, a normality test was conducted to determine whether the data were normally distributed. Because the number of students in each group was fewer than 30, the Shapiro-Wilk test was used. The analysis revealed that the data followed a normal distribution; thus, a t-test was used for further analysis. Additionally, to assess students' perspectives on the implementation process, content analysis was applied to the interview data. The findings obtained from the analysis process are presented in tabular form, and student statements are quoted directly without any modifications. While presenting the student responses, codes such as S1, S2, ... S15 were used to identify individual participants.

Findings

Findings on the Effect of Digital Game and Animation Software on Students' Academic Achievement

The suitability of the pre-test data of the PPEAAT for the normal distribution was examined using the Shapiro-Wilk Normality test because the number of students participating in the research was below 30 in both groups. The results of the Shapiro-Wilk Normality and Levene's tests are presented in Table 6 and Table 7.

Table 6. Shapiro-Wilk Normality Test Results of the Scores Obtained from the Pre-Test Data of PPEAAT

Groups	Statistics	SD	p
Experimental	.909	27	.21
Control	.909	27	.22

When examining the results of the Shapiro-Wilk normality test for the pre-test scores obtained from the PPEAAT data, it was determined that the pre-test data of the experimental and control groups (EG (*p=.21; p>.05*), CG (*p=.22; p>.05*) showed a normal distribution. The results of Levene's test for the PPEAAT pre-test data are presented in Table 7.

Table 7. Results of Levene's Test for Scores Obtained from PPEAAT's Pre-Test Data

	Levene's	Sd1	Sd2	p
Pre-test	.832	1	52	.366

As the PPEAAT pretest data demonstrated a normal distribution, an independent samples t-test was applied for analysis. Table 8 shows the analysis results.

Table 8. Independent Samples T-Test Results for the PPEAAT Pretest Scores

Groups	N	$\underline{X}$	SD	df	t	p
Experimental	27	8.62	2.84	52	-1.01	.317
Control	27	7.88	2.53			

The analysis results comparing the PPEAAT pretest scores of the experimental and control groups before the implementation revealed no statistically significant difference between the experimental and control groups *($t_{(52)}$ =-1.01; p>.05)*. As the PPEAAT posttest data also demonstrated a normal distribution, an independent samples t-test was applied for analysis. Table 9 shows the analysis results.

Table 9. Independent Samples T-Test Results for the PPEAAT Posttest Scores

Groups	N	$\underline{X}$	SD	df	t	p
Experimental	27	15.03	4.22	52	-3.18	.02
Control	27	11.11	4.82			

According to the analysis results comparing the PPEAAT posttest scores of the experimental and control groups after the implementation, the experimental group had a mean score of $\underline{X}$ = 15.03, whereas the control group had a mean score of $\underline{X}$ =11.11. This indicates a statistically significant difference between the experimental and control groups *($t_{(52)}$=-3.18; p<.05)*.

According to Figure 3, both the experimental and control groups showed an increase in their mean scores from pretest to posttest. However, the increase in the experimental group was notably greater than that in the control group.

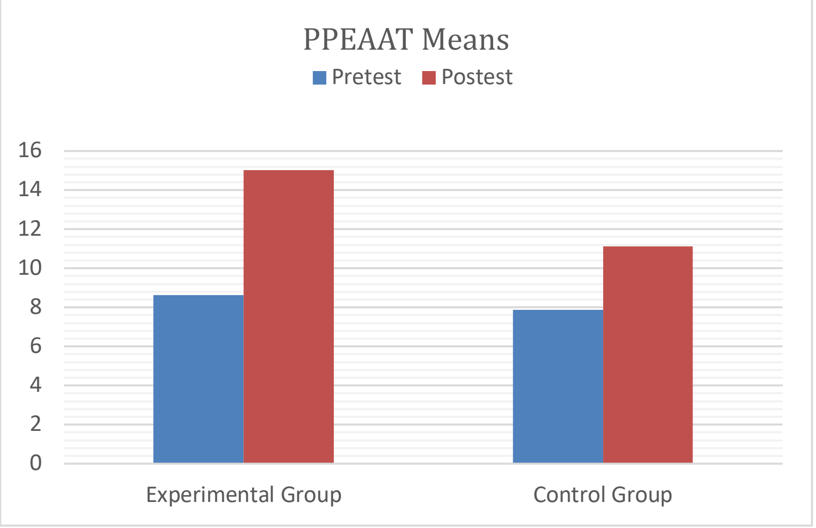


Figure 3. Pretest and Posttest Means on the PPEAAT

Findings on the Effect of Digital Game and Animation Software on Students' Spatial Thinking Skills

As the STST pretest data demonstrated a normal distribution, an independent samples t-test was applied for analysis. Table 10 shows the analysis results.

Table 10. Independent Samples T-Test Results for the STST Pretest Scores

Groups	N	$\bar{X}$	SD	df	t	p
Experimental	27	6.74	2.56	52	-1.288	.204
Control	27	5.92	2.05			

The analysis results comparing the STST pretest scores of the experimental and control groups before the implementation revealed no statistically significant difference between the experimental and control groups ($t_{(52)} = -1.28; p > .05$).

As the STST posttest data also demonstrated a normal distribution, an independent samples t-test was applied for analysis. Table 11 shows the analysis results.

Table 11. Independent Samples T-Test Results for the STST Posttest Scores

Groups	N	$\bar{X}$	SD	df	t	p
Experimental	27	9.25	2.75	52	-4.140	.00
Control	27	6.22	2.63			

According to the analysis results comparing the STST posttest scores of the experimental and control groups after the implementation, the experimental group had a mean score of $\underline{X}$ = 9.25, whereas the control group had a mean score of $\underline{X}$ = 6.22. This indicates a statistically significant difference between the experimental and control groups $(t_{(52)} = -4.140; p < .05)$.

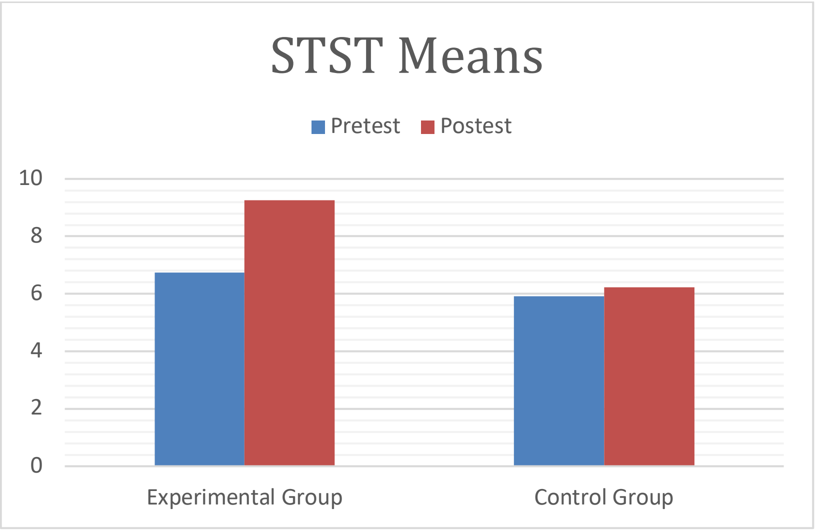


Figure 4. Pretest and Posttest Means on the STST

According to Figure 4, both the experimental and control groups showed an increase in their mean scores from pretest to posttest. However, the increase in the experimental group was notably greater than that in the control group.

Findings on Students' Views on the Use of Digital Game and Animation Software

To explore the experimental group students' views on the use of digital game and animation software, semi-structured interview questions were posed. Their responses were subjected to content analysis, codes were generated, which were then grouped under appropriate categories. The findings were then presented in tables.

Students' Views of Digital Game and Animation Software

The students were initially asked: "Did the use of the Scratch software in social studies classes create any difference in the way lessons were conducted? If so, could you explain these differences?". Their responses are summarized in Table 12.

Table 12. Students' Views on the Differences Resulting from Using the Software

Categories	**Students**
Learning by having fun	$S_2 S_3\ S_7 S_8 S_9 S_{12} S_{13} S_{14}$
Learning the Scratch software	$S_1 S_5 S_6 S_{15}$
Learning the lesson better	$S_1 S_4 S_8 S_{11}$
Learning through educational games	$S_7 S_{12} S_{13} S_{14}$
Acquiring computer skills	$S_7 S_{10} S_{14}$

As seen in Table 12, students most frequently stated that the Scratch software made lessons more enjoyable, helped them learn Scratch, enhanced their lesson comprehension, supported their learning, and improved their computer skills. Some direct quotes from students' responses are presented below.

S_7 highlighted that the software provided fun learning, stating, "*Yes. Lessons aren't boring anymore; they are more fun, and it's easier to learn this way. I learned in a more enjoyable way.*"

S_1 noted that the implementation helped them learn how to use Scratch, saying, "*Yes, it taught me how to use Scratch and helped me better understand the social studies topics. I grasped them better.*"

S_{11} stated that the implementation improved their understanding of the lesson, saying, "*Yes, it made a difference. I saw things I had never seen before, and it helped us learn better. It allowed us to understand the lesson more thoroughly.*"

S_{10} emphasized the development of computer skills, expressing, "*Yes. I think it's great. Kids love computers after all. We are learning to use a computer. We are taking lessons about it. We are trying to enjoy social studies more. We are learning things using the computer. It is a very nice thing.*"

Students' Views on the Positive Aspects of Using Digital Game and Animation Software in Lessons

Students were asked: "What do you think are the positive aspects of using the Scratch software in social studies lessons?". Their responses are summarized in Table 13.

Table 13. Students' Views on the Positive Aspects of Using the Software

Categories	**Students**
Developing skills in using computers/applications and in creating games/animations	$S_1S_2S_3S_4S_5S_8S_{11}$
Learning by having fun/playing games	$S_7S_{11}S_{13}S_{14}S_{15}$
Enhancing lesson comprehension	$S_1S_4S_8S_{12}$
Permanent learning	S_1
Active learning	S_{10}
Learning through activities	S_1

As shown in Table 13, students recognized several positive aspects of using the digital game and animation software, including developing skills in using computer applications and creating games and animations, learning through fun and play, better understanding lessons, achieving lasting learning, engaging in active learning, and learning through activities. Some direct quotes from students' responses are presented below.

S_1 shared that the software helped develop their skills in using computer applications and preparing games, saying, "*I understood social studies better. The topics stayed in my mind longer. Besides, I used to struggle with computers, but now I can use them more effectively. I also completed an activity.*"

S_7 stated that the implementation promoted learning by having fun and playing games, saying:
"*We learned new information more enjoyably in the lessons. It also developed our hand skills. Our knowledge increased through playing games, in both ways.*"

S_8 mentioned that the implementation contributed to a better understanding of the lesson, noting, "*With this application, I can both use Scratch and better understand and grasp some social studies topics.*"

S_{10} emphasized that the implementation enabled active learning, stating, "*We can learn by seeing and understanding. For example, we do not just watch on the projector. We try to do it ourselves on the computer. We try to find the correct answer about the topic.*"

Students' Views on the Negative Aspects of Using Digital Game and Animation Software in Lessons

Students were asked: "What do you think are the negative aspects of using the Scratch software in social studies lessons?”. Their responses are summarized in Table 14.

Table 14. Students’ Views on the Negative Aspects of Using the Software

Categories	Students
No negative experiences reported	$S_3S_4S_5S_6S_7S_8$
Prolonged exposure to computers	$S_{10}S_{11}S_{12}S_{13}S_{14}$
Finding it difficult	S_1S_{15}
Finding it tiring or challenging	S_2S_9

As seen in Table 14, students primarily identified prolonged exposure to computers as a negative aspect of using the digital game and animation software. Additionally, they cited the difficulty and exhausting nature of the software as negative aspects. Notably, six students reported experiencing no negative effects. Some direct quotes from students’ responses are presented below.

S_{10} commented on the issue of prolonged exposure to computers, explaining, “*Computer. We spend a lot of time on it. But since it is for the lesson, there is no other downside*.”

S_{15} noted the difficulty of using the software, stating, “*I find it difficult because I am not very good with computers. Using that application is kind of hard.*”

S_9 highlighted the exhausting and challenging nature of the software, saying, “*The only negative part is that it’s tiring. We put a lot of effort into preparing activities. Writing the codes get very exhausting.*”

Students’ Views on the Effect of the Lessons Taught Using the Software on Their Achievement

Students were asked: “Do you think the lesson process involving the Scratch software affected your success in social studies? What do you think?”. Their responses are summarized in Table 15.

Table 15. Students’ Views on the Effect of Using the Software on Their Achievement

Categories	Students
Easier learning	$S_3S_4S_5S_6S_7S_9S_{13}$
Better understanding of the lesson	$S_8S_{11}S_{12}S_{15}$
Exam success	$S_1S_2S_{10}S_{14}$

As seen in Table 15, students expressed that the use of digital game and animation software positively influenced their success by making learning easier, improving their understanding of lessons, and enhancing their exam performance.

S_7 commented that using the software made learning easier, saying, "*Yes. I didn't understand some topics in social studies. When we did these activities, I learned them more easily.*"

S_{15} noted that using the software contributed to a better understanding of the lesson, saying: "*Yes. For example, I struggled with the coordinate system and hadn't understood it well. But when we worked with these activities, I grasped and understood it much better.*"

S_1 highlighted the improvement in exam success, saying, "*Yes, it did. I got 92 on my first exam and 100 on the second.*"

Students' Views on the Effect of the Lessons Taught Using the Software on Their Interest and Attitudes Toward the Social Studies Course

Students were asked the following question: "Did the lesson process involving the Scratch software create a change in your interest and attitude toward the social studies course? What do you think?". Their responses are summarized in Table 16.

Table 16. Students' Views on the Effect of Using the Software on Their Interest and Attitudes Toward the Course

Categories	**Students**
Experienced positive changes	
Finding the lesson enjoyable	$S_2 S_3 S_4 S_6 S_8 S_{10} S_{11} S_{12} S_{13} S_{14} S_{15}$
Being active during lessons	$S_7 S_9$
Experienced no change	$S_1 S_5$

As seen in Table 16, most students experienced a positive change in their interest and attitudes toward social studies after the implementation. They mainly attributed this change to the lessons being enjoyable and their active participation in the lessons. Two students, however, reported no significant change in their interest or attitude toward the course.

S_{10} mentioned a positive change in their interest and attitude toward social studies, stating, "*Yes, there was. Lessons have become more enjoyable. We learn by playing games. That's why I like the course even more.*"

S_7 also emphasized a positive change, explaining, "*Yes, I already liked the course, but now I like it even more. Before, we just listened to lessons. But now we create and play games during class.*"

Students' Views on the Skills Acquired Through the Lessons Taught Using the Software

Students were asked: "What skills do you think you gained from the lesson process involving the Scratch software?" Their responses are summarized in Table 17.

Table 17. Students' Views on the Skills Developed Using the Software

Categories	**Students**
Computer usage skills	$S_1S_2S_3S_5S_7S_8S_9S_{10}S_{11}S_{12}S_{14}$
Social studies course skills	
Map skills	$S_6S_{10}S_{13}$
Orientation skills	$S_1S_7S_{10}S_{14}$
Animation and game development skills	$S_2S_4S_7S_{11}S_{14}S_{15}$

As seen in Table 17, students reported gaining computer usage skills, social studies skills (including map and orientation skills), and skills in creating animations and games through the lesson process involving the digital game and animation software.

S_{11} noted that the lesson process enhanced their computer skills, explaining, "*Before these lessons, I couldn't use the computer very well. Now, I can even use the F keyboard*."

S_{10} emphasized the development of social studies course skills, stating, "*I learned things I did not know before through the activities. Since we used maps, I learned things related to them as well.*"

Discussion, Conclusion and Recommendations

This study examined the effect of using digital game and animation software in social studies classes on academic achievement and spatial thinking skills, and also incorporated students' views. The findings revealed a significant difference in academic achievement in favor of the experimental group over the control group. This result aligns with previous studies suggesting that using digital games enhances academic achievement (Ağırgöl, 2020; Ceylan, 2020; Dinçer, 2018; Kaynar, 2020; Okuducu, 2020; Şahbaz, 2021; Woo, 2014). Previous research indicates that digital games improve academic achievement because they are more engaging (Huang and Johnson, 2008; Kaynar, 2020; Prensky, 2001), more enjoyable (Gee, 2003; Kirriemuir and McFarlane, 2004; Prensky, 2001), and promote greater active participation (Becta, 2001; Gros, 2007; Spires, 2015) than standard curricula and traditional teaching methods. Prensky (2001) argues that integrating learning content with the motivational aspects of games can make learning far more engaging for today's digital natives, who grow up in the era of advanced technology, emphasizing that games are not only attention-grabbing but also effective learning tools. In a study on the effect of digital game-based activities in life sciences classes on academic performance, attitudes, and learning retention, Kaynar (2020) also highlights that the presence of more engaging stimuli could be a key factor in the effectiveness of digital games.

The findings also revealed a significant difference in spatial thinking skills in favor of the experimental group. This finding aligns with previous studies suggesting that digital games positively influence spatial skills (Aydoğan, 2020; Gros, 2007; McClurg and Chaillé, 1987; Özcan et al., 2016; Polinsky et al., 2021; Yuda, 2011). The higher spatial thinking skills scores observed among students in the experimental group taught using the software may be explained by several factors: the motivating nature of digital games, the capacity of the software to concretize the abstract concept of spatial thinking, the frequent use of visual-spatial elements, and the activation of spatial thinking components such as mental rotation during gameplay. As Polinsky et al. (2021) state, digital environments foster spatial skills because digital games are inherently visual-spatial and enable children to manipulate shapes in ways that highlight spatial relations. Spatial play plays a critical role in spatial skill development. Similarly, Yuda (2011) emphasizes that digital educational games have several positive effects, including improving spatial thinking, broadening perspectives, and supporting geography education.

It can be concluded that concretizing certain actions, topics, and concepts within the abstract notion of spatial thinking through the use of technological materials plays a significant role in developing spatial thinking skills. In parallel with this view, Merç (2017) used Google Earth to enhance spatial perception skills in social studies and found that the use of modern technological materials, distinct from traditional teaching methods and tools, boosted students' learning and motivation, making the teaching of the abstract spatial perception concept more concrete. Similarly, in a study using animation-supported maps, Şengül Bircan (2013) reported that students found animated materials to be memorable, engaging, entertaining, capable of enabling mental visualization, concrete, and instructive; thus, they perceived the learning process as more enjoyable, interesting, long-lasting, efficient, and encouraging for using and developing map skills, and useful for spatial perception. The findings from the student interviews in this study also support this conclusion. Among the experimental group students, 40% stated that the skills acquired from the digital game and animation-supported lessons were related to social studies skills, especially map and orientation skills.

The study found that students in the experimental group generally had positive views on using the digital game and animation software. They stated that the lessons conducted using the software ensured learning through fun and contributed to better learning. Supporting these findings, Öztürk (2021) reported that students found games designed using digital game software fun and engaging. Similarly, Li (2010) noted that students described the process of creating digital game creations as enjoyable. Regarding the positive aspects of the lessons taught using the software, students stated that they helped them gain skills in using computers and applications and developing games and animations, learn by having fun and playing games, better understand the content of lessons, achieve learning retention, and engage in active learning. However, they noted that spending prolonged periods on the computer was a drawback.

After attending classes supported by digital game and animation activities, students reported that using the software had a positive impact on their academic achievement by promoting fun learning, easier comprehension, better understanding of course content, and higher exam performance. Based on the analysis results of the PPEAAT, there may be a correlation between the experimental group's better performance in achieving the learning outcomes of the People, Places, and Environments unit and their positive perceptions of the lesson process. In line with these positive opinions, Şengül Bircan (2013) found that students who learned history through animation-supported instruction described the animated materials used in the teaching process as memorable, engaging, fun, visually stimulating, concrete, and instructive. Similarly, Aktürk (2012) reported that students described the use of animations and digital maps as contributing to more enjoyable, effective, and lasting learning experiences. During the interviews, 73% of students reported that they developed a more positive attitude toward the social studies course because the lessons became more enjoyable. The fun nature of games and their capacity to encourage active participation (Becta, 2001; Spires, 2015), which contributes to academic achievement, may also have positively influenced students' attitudes. These findings align with previous studies that suggest the use of computer games positively influences students' attitudes toward their courses (Akın and Atıcı, 2015; Kaynar, 2020).

Regarding the lessons taught using the digital game and animation software, students reported improvements not only in their computer skills but also in their social studies skills, particularly in map reading and spatial orientation. Similarly, Şengül Bircan (2013) found that students who learned history through animation-supported materials found them beneficial for developing map skills and enhancing spatial perception. In the present study, the scores on the STST, which aimed to measure spatial thinking skills, were consistent with students' views. The experimental group achieved higher average scores than the control group, indicating that the digital game and animation software effectively fostered spatial thinking skills, including map and orientation skills.

Based on these findings, the following recommendations are offered:

• The software used in this study could be applied to different topics within the social studies curriculum. Moreover, similar research could be conducted with students from different grade levels and with a larger sample size.

• Future research could explore the impact of digital game software on other thinking skills such as problem-solving, decision-making, and creative thinking. Additionally, considering that digital games and animation software can enhance the learning of geographic concepts and skills through audio, visuals, and shapes, future research may also focus on the acquisition of other geographical skills.

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